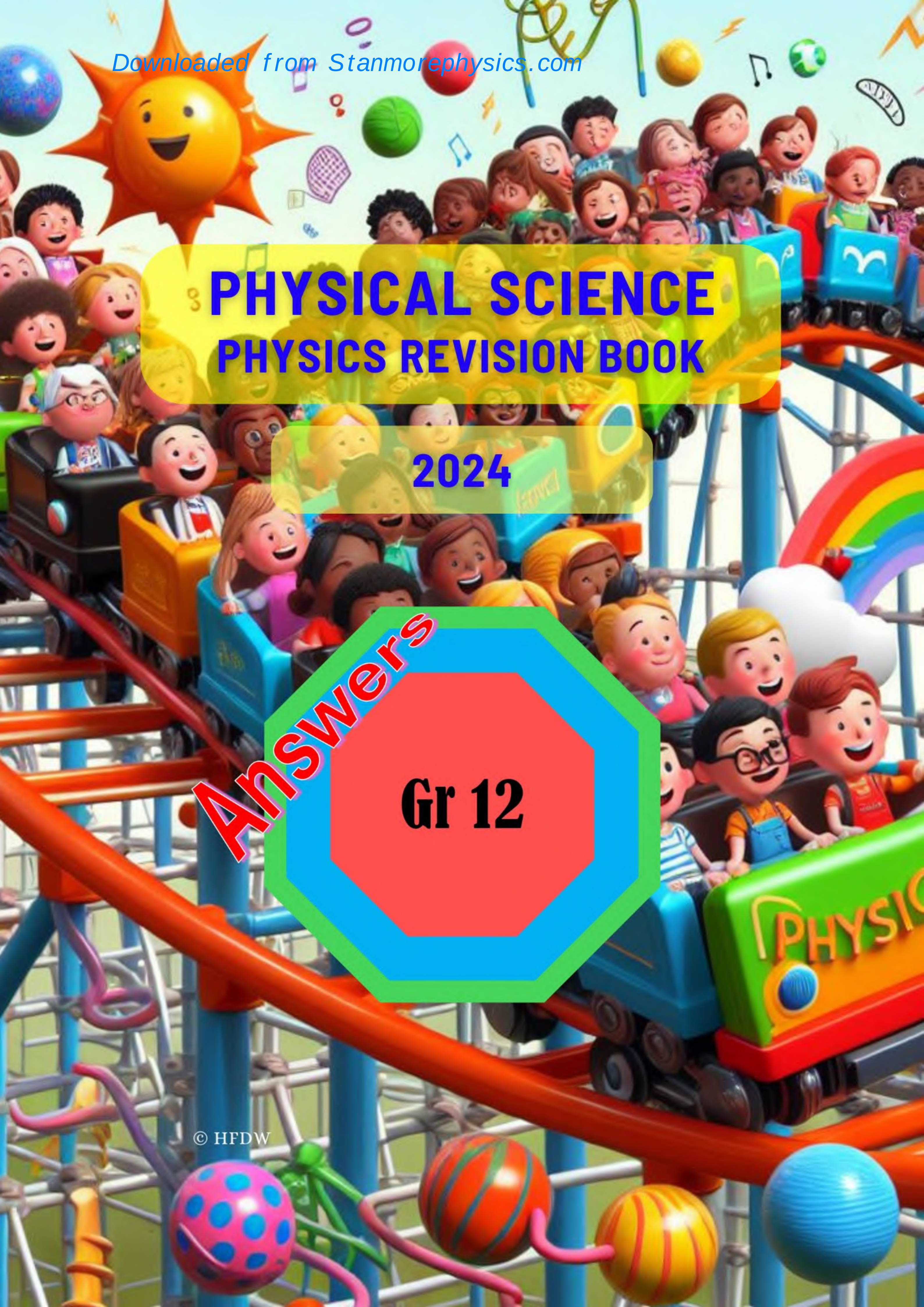
PHYSICAL SCIENCE
PHYSICS REVISION BOOK

2024

Answers

Gr 12



Secondary Schools Directorate

education
Department of Education
FREE STATE PROVINCE

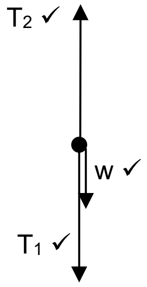
TABLE OF CONTENTS

NEWTON'S LAWS

QUESTION 1

1.1 When a <u>resultant (net) force</u> acts on an object, the object will accelerate in the direction of the force with an <u>acceleration which is directly proportional to the force</u> ✓ and <u>inversely proportional to the mass of the object</u>.✓ (2)

1.2



Accepted labels	
w	F_g / F_w/ force of earth on block / weight / 49 N / mg / gravitational force
T_2	Tension 2 / F_Q / 250 N / F_{T2} / F_{app}
T_1	Tension 1 / F_{T1} / F_P

(3)

1.3 $F_{net} = ma$ ✓

<u>For 5 kg block:</u>

$T_2 + (-mg) + (-T_1) = ma$

<u>$250 - (5)(9,8) - T_1$</u> ✓ $= 5a$

$201 - T_1 = 5a$

$T_1 = 201 - 5a$...... .(1) ✓for either 5a or 20a

<u>For 20 kg block:</u>

$T_1 + (-mg) = ma$.......(2)

<u>$T_1 + [-20(9,8)]$</u> ✓ $= 20a$

$5 = 25a \quad \therefore \quad a = 0,2 \text{ m·s}^{-2}$ upwards

$\therefore$ T_1 = <u>$201 - 5(0,2)$</u> ✓ = 200 N ✓ **OR** T_1 = <u>$20(9,8) + 20(0,2)$</u> ✓ = 200 N ✓ (6)

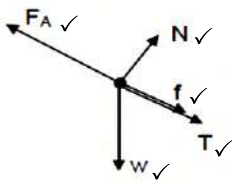
1.4 **Q** ✓ (1)

[12]

QUESTION 2

2.1 When body A exerts a force on body B, body B exerts a <u>force of equal magnitude</u> ✓ in the <u>opposite direction</u> ✓on body A. (2)

2.2



Accepted labels	
w	F_g / F_w /force of earth on block / weight / mg / gravitational force
N	Normal force/F_N
T	Tension / F_T
F_A	F / $F_{applied}$/40 N
f	Frictional force / F_f

(5)

2.3.1 **<u>OPTION 1/*OPSIE 1*</u>**

For the 1 kg block/*Vir die 1 kg blok*;

$f_k = \mu_k N$

$= \mu_k\, mg\cos\theta$✓

$= 0,29\ (1 \times 9,8 \cos 30°)$ ✓

$= 2,46$ N✓

<u>OPTION 2/*OPSIE 2*</u>

BY PROPORTION:/*DEUR EWEREDIGHEID*

The smaller mass = ¼ of the larger mass✓

Die kleiner massa = ¼ die groter massa

∴frictional force/*wrywingskrag* = ¼ (10) ✓

= 2,5 N✓

(3)

2.3.2 $F_{net} = ma$✓

For 1 kg block/*Vir 1 kg blok*

<u>$F_A - \{(T+f_k) + mg\sin\theta\} = ma$</u>

<u>$40 - \{T + 2,46 + 1(9,8)(\sin 30°)\}$</u>✓$= (1 \times)\ a$ ✓

$40 - T - 7,36 = a$

$32,64 - T = a$........(1)

For 4 kg block/*Vir 4 kg blok*

<u>$T - (mg\sin\theta + f_k) = 4a$</u>

<u>$T - (4 \times 9,8 \sin 30° + 10) = 4a$</u>✓

$T - 29,6 = 4a$.........(2)

From (1) and (2)/*Vanaf (1) en (2)*

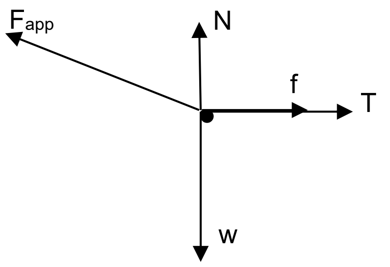
$a = 0,61 \text{ m·s}^{-2}$

$T = 29,6 + (4(0,61))$ ✓ (6)

$T = 32,04$ N✓ **[16]**

QUESTION 3

3.1



Accepted labels		
w	✓	F_g / F_w / weight / mg / gravitational force
T	✓	F_T / tension
F	✓	F_a / F_{60} / 60 N / $F_{applied}$ / F_t /
N	✓	F_N
f	✓	F_f

(5)

3.2.1 $F_{60y} = F_{60}\sin\theta$, $F_{60y} = 60\sin 10°$ ✓ **OR** $F_{60Y} = F_{60}\cos\theta$, $F_{60y} = 60\cos 80°$ ✓
$= 10,42$ N ✓ (2)

3.2.2 $F_{60x} = F_{60}\cos\theta$, $F_{60x} = 60\cos 10°$ ✓ **OR** $F_{60x} = F_{60}\sin\theta$, $F_{60x} = 60\sin 80°$ ✓
$= 59,09$ N ✓ (2)

3.3 When a resultant/net force acts on an object, the object will accelerate in the direction of the force at an acceleration directly proportional to the force ✓ and inversely proportional to the mass of the object. ✓ (2)

3.4

$N = mg - F_{60y}$ $N = \{5(9,8) - 10,42\}$ ✓ $= 38,58$ N ✓	**OR**	$F_y + N = w$ $N = w - F_y = mg - F_y$ $= [(5)(9,8) - 10,42]$ ✓ $= 38,58$ N ✓

(2)

3.5

$F_{net} = ma$ ✓ **OR** $T - m_2g = m_2a$ **OR** $T - 2(9,8) = 2a$
$T - 19,6$ ✓$= 2a$……………………(1)
$F_{60x} - (f + T) = m_8a$
$60\cos 10° - (f + T) = 5a$. ✓ **OR** $60 \sin 80° - [f + T] = 5a$
$60\cos 10° - [(\mu_kN)$ ✓ $+T)] = 5a$
$59,09 - (0,5 \times 38,58) - T$ ✓$= 5a$
$39,8 - T = 5a$......................(2)
$a = 2,886$ ms^{-2}
$T - 19,6 = 2(2,886)$ ✓ ∴ $T = 25,37$ N ✓
OR From equation (2): $T = 25,37$ N
OR $T - 19,6 = 2a$ …………………..(1) x 5
$59,09 - 19,29 - T = 5a$ …… …(2) x 2
$7T - 177,6 = 0$ ✓ ∴ $T = 25,37$ N ✓ (7)

[20]

QUESTION 4

4.1.1 When body A exerts a force on body B, body B exerts a force of equal magnitude ✓ in the opposite direction ✓on body A. (2)

4.1.2

For 2,5 kg block $T = mg$ ✓ ∴$T = (2,5)(9,8)$ ✓ $= 24,5$ N ✓	**OR** $F_{net} = ma$ $T - mg = (2,5)(0)$ ✓ $T - (2,5)(9,8)$ ✓ $= 0$ $T = 24,5$ N ✓	**OR** $F_{net} = ma$ $mg - T = (2,5)(0)$ ✓ $(2,5)(9,8) - T$✓ $= 0$ $T = 24,5$ N ✓

(3)

4.1.3

For mass M: $f_s = \mu_sN$ ✓ ∴ $N = \frac{24,5✓}{0,2✓} = 122,5$ N $N = Mg = 122,5$ N ∴ $M(9,8) = 122,5$ N ✓ ∴ $M = 12,5$ kg ✓	**OR** μ_sN ✓ $= \mu_sMg$ $24,5$ ✓$= (0,2)$ ✓$M(9,8)$ ✓ $M = 12,5$ kg ✓

(5)

4.1.4 For the 5 kg block:
$f_k = \mu_kN$
$f_k = (0,15)(5)(9,8)$ ✓$= 7,35$ N
$F_{net} = ma$
$T - f_k = ma$ ✓
∴ $T - 7,35 = 5a$ ✓

For the 2,5 kg block:
$w - T = ma$
$(2,5)(9,8) - T = 2,5a$ ✓ ∴ $17,15 = 7,5$
∴ $a = 2,29$ $m{\cdot}s^{-2}$ ✓ (5)

4.2

$F = G\frac{m_1m_2}{r^2}$ ✓

$F = \frac{(6,67\times10^{-11})(6,5\times10^{20})(90)}{(550\times10^3)^2}$ ✓ ✓ $= 12,90$ N ✓ (12,899 N)

OR

$g = \frac{Gm}{r^2}$ ✓

$g = \frac{(6,67\times10^{-11})(6,5\times10^{20})}{(550\times10^3)^2}$ ✓ — Any one

$= 0,143...\text{m·s}^{-2}$

w = mg

= (90)(0,143..) ✓ = 12,89 N ✓ (downwards) (Accept 12,6 N - 12,90 N) (4)

[19]

QUESTION 5

5.1.1 **For the 5 kg mass/*Vir die 5 kg massa*:**

T – f = ma

T - μ_k(mg) = ma✓

T – (0,4)(5)(9,8)✓ = 5a✓.........(1)

For the 20 kg mass/*Vir die 20 kg massa*

mg – T = ma

20(9,8) – T = 20a✓..........(2)

176,4 = 25a (1) + (2)

∴a = 7,06 (7,056) m·s^{-2}✓ (5)

5.1.2

OPTION 1/*OPSIE 1*	**OPTION 2/*OPSIE 2***
$v_f^2 = v_i^2 + 2a\Delta y$✓ = 0✓ + (2)(7,056)(6)✓ v_f = 9,20 m·s^{-1}✓	The 5 kg mass travels as fast as the 20 kg mass *Die 5 kg massa beweeg net so vinnig soos die 20 kg massa* $W_{net} = \Delta K$✓ (5)(7,056)(6cos0º)✓ = ½(5)(v_f^2 - 0)✓ v_f = 9,20 m·s^{-1}✓

(4)

5.1.3 6 m ✓ (1)

5.2.1 Each body in the universe attracts every other body with a force that is directly proportional to the product of their masses ✓ and inversely proportional to the square of the distance between their centres. ✓ (2)

5.2.2 $F = \frac{Gm_1m_2}{r^2}$ ✓

On the mountain/*Op die berg*

$F_g = \frac{(6,67\times10^{-11})(5,98\times10^{24})(65)}{(6,38\times10^6 + 6\times10^3)^2}$ ✓ ✓

= 627,2 N

On the ground/*Op die grond*

F_g = W = mg

= (65 x 9,8)✓

= 637 N

$F_g = \frac{(6,67\times10^{-11})(5,98\times10^{24})(65)}{(6,38\times10^6)^2}$

= 636,94 N

Difference/*Verskil* = (637 – 627,2)✓

= 9,8 N✓ (6)

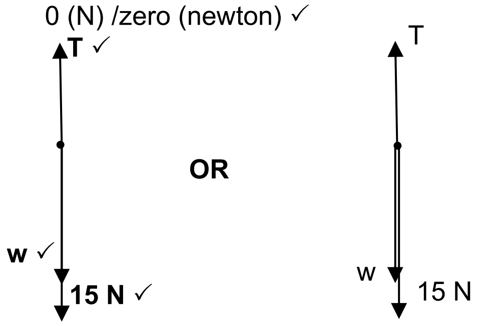
[18]

QUESTION 6

6.1 A body will remain in its state of rest or motion at constant velocity ✓ unless a resultant/net force ✓ acts on it. (2)

6.2 0 (N) /zero (newton) ✓ (2)

6.3



Accepted labels	
w	F_g / F_w / weight / mg / gravitational force
T	F_T / tension
15 N	F_a / F_{15N} / $F_{applied}$ / F_t / / F

(3)

6.4 **2 kg block**

$F_{net} = ma$
$F_a + F_g + (-T) = ma$ ✓
$F_a + mg + (-T) = ma$
[15 + (2)(9,8) – T] ✓ = (2)(1,2) ✓
T = 32,2 N

10 kg block

$T + (-f_k) = ma$
$T - \mu_k N = ma$ ✓
$T - \mu_k mg = ma$
32,2 - (μ_k)(10)(9,8) ✓ = (10)(1,2) ✓
$\therefore \mu_k = 0,21$ ✓ (7)

6.5 Smaller than ✓ (1)

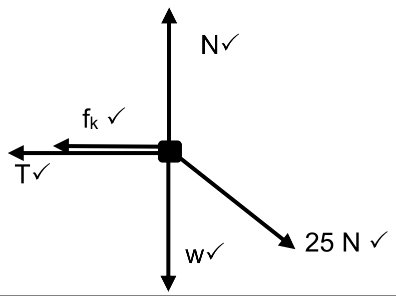
6.6 Remains the same ✓
The coefficient of kinetic friction is independent of the surface areas in contact. ✓
OR: The coefficient of kinetic friction depends only on type of materials used. ✓ (2)

QUESTION 7

7.1 When a resultant/net force acts on an object, the object will accelerate in the (direction of the net/resultant force). The acceleration is directly proportional to the net force ✓and inversely proportional to the mass ✓of the object. (2)

7.2 $f_k = \mu_k N$ ✓= $\mu_k mg$ = (0,15)(3)(9,8) ✓ = 4,41 N✓ (3)

7.3



Accepted Labels	
w	F_g/ F_w/force of earth on block / weight /14,7 N / mg /gravitational force
N	F_N / F_{normal} / normal force
T	Tension/F_T
f_k	$f_{kinetic\ friction}$ / f / F_f / kinetic friction
25 N	$F_{applied}$ / F_A / F

(5)

7.4.1

OPTION 1	**OPTION 2**
$f_k = \mu_k N = \mu_k(25\sin 30° + mg)$ = 0,15[(25sin30°) ✓ + (1,5)(9,8) ✓] = 4,08 N ✓	$f_k = \mu_k N = \mu_k(25\cos 60° + mg)$ = 0,15[(25cos60°) ✓ + (1,5)(9,8) ✓] = 4,08 N ✓

(3)

7.4.2 For the 1,5 kg block
$F_{net} = ma$ ✓
$F_x + (-T) + (-f_k) = ma$
25 cos 30° – T – f_k = 1,5a
(25 cos 30° – T) – 4,08 ✓= 1,5a
17,571 – T = 1,5a ……….(1)

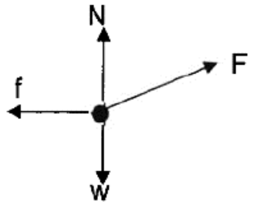
✓either one

For the 3 kg block
T – f_k = 3a
T – 4,41✓ = 3a ………….(2)
13,161 = 4,5 a ∴ a = 2,925 m·s^{-2} and T = 13,19 N ✓ (13,17 N – 13,19 N) (5)

[18]

QUESTION 8

8.1.1



Accepted labels/*Aanvaarde benoemings*		
w	F_g/F_w/weight/mg/gravitational force *F_g/F_w/gewig/mg/gravitasiekrag*	✓
f	Friction/F_f/f_k/3 N/*wrywing*/F_w	✓
N	Normal (force)/$F_{nomal}/F_N/F_{normaal}/F_{reaction/reaksie}$	✓
F	$F_A/F_{applied/toegepas}$	✓

(4)

8.1.2 $f_k = \mu_k N$ ✓
$3 = (0,2)N$ ✓
$N = 15$ N ✓ (3)

8.1.3
$F_{net} = ma$
$N + F_{vert} - w = 0$
$N + F_{vert} = w$ } ✓ Any one

$F\sin20°$ ✓ $= (2)(9,8) - 15$ ✓
$F = 13.45$ N✓ (4)

8.1.4
$F_{net} = ma$
$F\cos 20° - f = ma$ } ✓ Any one

$13.45\cos20° - 3 = 2a$✓
$a = 4,82$ m.s^{-2} ✓ (3)

8.2.1 Each body in the universe attracts every other body with a force that is directly proportional to the product of their masses ✓and inversely proportional to the square of the distance between their centres. ✓ (2)

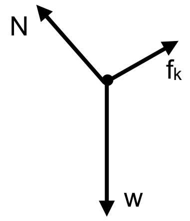
8.2.2 Increases ✓
Gravitational force is inverely proportional to the square of the distance between the centres of the objects. ✓ OR $F \alpha \frac{1}{r^2}$ (2)

[18]

QUESTION 9

9.1 0 N/zero ✓ (1)

9.2



Accepted labels	
w	F_g/F_w/weight/mg/gravitational force/N/19,6 N
f	$F_{friction}/F_f$/friction/f_k
N	F_N/F_{normal}/normal force
	Deduct 1 mark for any additional force.
	Mark is given for both arrow and label

(3)

9.3.1
$F_{net} = ma$
$f_k - mg\sin\theta = 0$
$f_k = mg\sin\theta$ } ✓ 1 mark for any of these
$f_k = (2)(9,8)\sin7°$ ✓ ∴ $f_k = 2,39$ N ✓ (2,389) N (3)

9.3.2
$f_k = \mu_k N$
$= \mu_k mg\cos7°$ } ✓ any one
$2,389 = \mu_k(2)(9,8)\cos7°$ ✓ ∴ $\mu_k = 0,12$ ✓ (3)

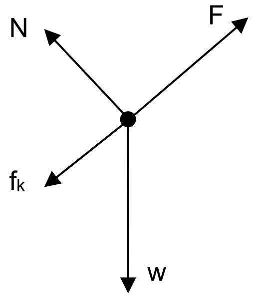
9.3.3 $F_{net} = ma$ OR $-f_k = ma$ OR $\mu_k N = ma$ ✓
$-\mu_k(mg) = ma$
$-(0,12)(2)(9,8)$ ✓$= 2a$ ✓ ∴ $a = -1,176$ m.s^{-2} (-1,18)
$v_f^2 = v_i^2 + 2a\Delta x$
$0 = (1,5)^2 + 2(-1,176)\Delta x$✓ ∴ $\Delta x = 0,96$ m ∴ Distance = 0,96 m✓ (5)

[15]

QUESTION 10

10.1.1 An object continues in its state of rest or uniform motion (moving with constant velocity) unless it is acted upon by an unbalanced (resultant/net) force.✓✓ (2)

10.1.2



Accepted labels	
w	F_g / F_w/weight/mg /78,4 N/gravitational force
F	F_{app}/F_A / applied force (Accept T / tension)
f_k	(kinetic) friction/F_f/f/F_w
N	F_N/Normal (force)/ 67,9 N

(4)

10.1.3 $F_{net} = ma$
$F_{net} = 0$
$F+(-f_k) + (-F_{g\parallel}) = ma$
$F- (f_k + F_{g\parallel}) = ma$
} ✓Any one

F - 20,37✓ - (8)(9,8)sin30°✓ = 0 ✓ ∴ F = 59,57 N ✓

OR

F - 20,37✓- (8)(9,8)cos60°✓ = 0 ✓ ∴ F = 59,57 N ✓

OR

F - 20,37✓ - 39,2✓ = 0 ✓
F = 59,57 N ✓

OR

F = {20,37 ✓ + (8)(9,8)sin30°✓}✓

(5)

10.1.4

OPTION 1	OPTION 2
$F_{net} = ma$ $(F_{g\parallel} - f_k) = ma$ } ✓ (8)(9,8)sin30° - 20,37✓ = 8a ✓ ∴magnitude a = 2,35 m·s⁻²✓	$F_{net} = ma$ $(f_k - F_{g\parallel}) = ma$ } ✓ 20,37 + [-(8)(9,8)sin30°]✓ = 8a ✓ ∴ a = -2,35 m·s⁻² ∴ magnitude a = 2,35 m·s⁻²✓

(4)

MOTION OF BLOCK MOVING UP PLANE IMMEDIATELY AFTER FORCE IS REMOVED:

OPTION 1	OPTION 2
Downward positive $F_{net} = ma$ $(F_{g\parallel} + f_k) = ma$ } ✓ (8)(9,8)sin30° + 20,37✓ = 8a ✓ ∴magnitude a = 7,45 m·s⁻²✓	**Upwards positive** $F_{net} = ma$ $(F_{g\parallel} + f_k) = ma$ } ✓ -(8)(9,8)sin30° – 20,37 ✓ = 8a ✓ ∴ a = -7,45 m·s⁻² ∴ magnitude a = 7,45 m·s⁻² ✓

(4)

10.2.1 Each body in the universe attracts every other body with a force that is directly proportional to the product of their masses ✓ and inversely proportional to the square of the distance between their centres. ✓ (2)

10.2.2

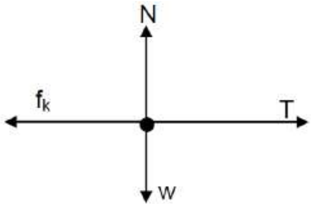
OPTION 1	OPTION 2
$g = \frac{GM}{r^2}$ ✓ ✓ $6 = \frac{(6,67\times10^{-11})M}{(700\times10^3)^2}$ ✓ M = 4,41 x 10²² kg ✓	$F = G\frac{m_1m_2}{r^2}$ $mg = \frac{GmM}{r^2}$ } ✓Any one $(200)(6)$✓ $= \frac{(6,67\times10^{-11})(200)M}{(700\times10^3)^2}$✓ ∴ M = 4,41 x 10²² kg ✓

(4)
[21]

QUESTION 11

11.1 An object continues in its state of rest or uniform motion (moving with constant velocity) unless it is acted upon by a resultant/net force.✓✓ (2)

11.2



Accepted labels	
w	F_g/F_w/weight/mg/gravitational force ✓
f	Friction/F_f/f_k /27 N ✓
N	Normal (force)/F_{normal}/F_N /$F_{reaction}$ ✓
T	F_T/tension ✓

(4)

11.3

Object Q:	Object P:
$F_{net} = ma$ $F_{net} = 0$ } ✓ $T + (f_k) = ma$ T – 3 ✓ = 0 ✓ T = 3 N	$F_{net} = ma$ $F_{hor} – (f_k + T) = ma$✓ (Fcos 30°) – 5 – 3 = 0 ✓ F = 9,24 N✓ (9,238 N)

(6)

11.4 3 s ✓ (1)

11.5 Y ✓

Graph Y represents motion of Q after the string breaks and shows a decreasing velocity ✓with a negative acceleration, ✓ because the net force (friction) on Q is in opposite direction to its motion.✓ (4)
[17]

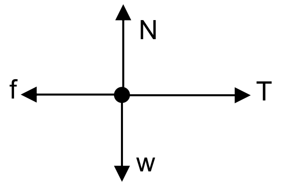
QUESTION 12

12.1 The <u>rate</u> of <u>change of velocity</u>. ✓✓ (2)

12.2 $\Delta y = v_i\Delta t + \frac{1}{2} a\Delta t^2$ ✓
<u>$0,5 = (0)(3) + \frac{1}{2}(a)(3^2)$</u> ✓ ∴ $a = 0,11\ m\cdot s^{-2}$ ✓ (3)

12.3 For the 3 kg mass:
$F_{net} = ma$ OR $(mg – T) / (mg + T) = ma$ ✓ ∴ <u>$(3)(9,8) – T = (3)(0,11)$</u> ✓ ∴ $T = 29,07\ N$ ✓ (3)

12.4



Accepted labels		
w	F_g / F_w / weight / mg / gravitational force	✓
f	Friction/ F_f / f_k / 27 N	✓
N	Normal (force) / F_{normaL} / F_N / /$F_{reaction}$	✓
T	F_T/tension	✓

(4)

12.5

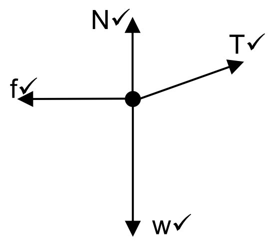
For P:	OR For P:
$F_{net} = ma$ / $T - f = ma$ } ✓	$F_{net} = ma$ / $T - f = ma$ } ✓
<u>$29,07 - 27 = m(0,11)$</u> ✓	<u>$29,72 - 27 = m(0,11)$</u> ✓ ∴ $m = 24,73$ kg ✓
$m = 18,82$ kg ✓ (Range: 18,60 – 18,82)	

(3)
[15]

QUESTION 13

13.1 When a (non-zero) <u>resultant/net force</u> acts on an object, the object will accelerate in the direction of the force with an <u>acceleration that is directly proportional to the force</u> and <u>inversely proportional to the mass of the object</u>. ✓✓ (2)

13.2



Accepted labels		
N	F_N; Normal, normal force	✓
f	F_f / f_k / frictional force/kinetic frictional force	✓
w	F_g; mg; weight;$F_{Earth\ on\ block}$;Fw / 78,4 N	✓
T	Tension; F_T /F_A, F /16,96 N	✓

(4)

13.3.1 The 2/8 kg block /system is accelerating. ✓ (1)

13.3.2 <u>**For 2 kg:**</u>
$F_{net} = ma$
$mg - T = ma$ } ✓ Any one
<u>$(2)(9,8) – T = 2(1,32)$</u> ✓ ∴ $T = 16,96$ N ✓

OR: $F_{net} = ma$ ∴ $mg + T = ma$
<u>$(2)(-9,8) + T = 2(-1,32)$</u> ✓ ∴$T = 16,96$ N ✓

(3)

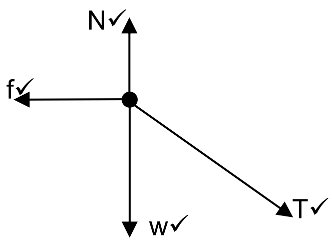
13.3.3 $F_{net} = ma$
$T\cos15° - f = ma$
$T_x = T\cos15°$ } ✓any one
$= 16,96 \cos15° = 16,38$ N (16,382 N)
<u>$16,382 – f$</u> ✓ = <u>$(8)(1,32)$</u> ✓ ∴ $f = 5,82$ N (to the left) ✓ (4)

13.4 <u>**ANY ONE**</u>
Normal force changes/decreases ✓
The angle (between string and horizontal) changes/increases.
The vertical component of the tension changes/increases. (1)

13.5 Yes ✓
The frictional force (coefficient of friction) depends on the nature of the surfaces in contact. ✓ (2)
[17]

QUESTION 14

14.1.1



Accepted labels		
N	F_N/Normal/normal force	✓
f	F_f/f_k/frictional force/kinetic frictional force	✓
w	F_g/mg/weight;F_w/gravitational force	✓
F	F_A/90 N/F_{90}	✓

(4)

14.1.2 Since it is moving at constant speed, the <u>acceleration is zero/</u> the net force acting on it is zero. ✓ (1)

14.1.3

$F_{net} = ma$
$F_{net} = 0$
$F_x = f$
$F_x - f = 0$
$F\cos 40° - f = 0$
} ✓ any one
$90 \cos 40° - f = 0$ ✓
$f = 68{,}94$ N ✓

OR

$F_{net} = ma$
$F_{net} = 0$
$F_x = f$
$F_x - f = 0$
$F\cos 320° - f = 0$
} ✓ any one
$90 \cos 320° - f = 0$ ✓
$f = 68{,}94$ N ✓

(3)

14.1.4

OPTION 1
$v_f = v_i + a\Delta t$
$2 = 0$ ✓ $+ a(3)$ ✓
$a = 0{,}67 \text{ m·s}^{-2}$
$F_{net} = ma$ ✓
$F\cos40°$ ✓ $- 68{,}94$ ✓ $= 15 (0{,}67)$
F = 103,11 N ✓ (103,05 N – 103,11N)

OPTION 2
$F_{net}.\Delta t = \Delta p$ ✓
$F\cos 40°$ ✓ $- (68{,}94)$ ✓ (3) ✓ $= 15(2 - 0)$ ✓
F = 103,11 N ✓

(6)

14.2

OPTION 1
$F = G\frac{m_1 m_2}{r^2}$ ✓
20 ✓ $= (6{,}67 \times 10^{-11})\frac{m_{planet}(10)}{(6 \times 10^5)^2}$ ✓
$m_{planet} = 1{,}08 \times 10^{22}$ kg ✓

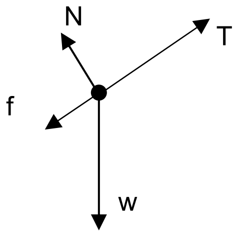
OPTION 2
$w = mg$
$20 = (10)(g)$ ✓
$g = 2 \text{ m·s}^{-2}$
$g = \frac{GM}{R^2}$
✓ Any one
$2 = \frac{(6{,}67 \times 10^{-11})M}{(6 \times 10^5)^2}$ ✓
$M = 1{,}08 \times 10^{22}$ kg ✓

(4)
[18]

QUESTION 15

15.1 When a resultant/net force acts on an object, the object will accelerate in the direction of the force with an acceleration that is directly proportional to the force ✓ and inversely proportional to the mass of the object. ✓ (2)

15.2



	Accept the following symbols
N ✓	F_N/Normal/Normal force
F ✓	F_f/f_k/frictional force/kinetic frictional force
w ✓	F_g,/mg/weight/$F_{\text{Earth on block}}$/19,6 N/gravitational force
T ✓	Tension/F_T/F_A/F

(4)

15.3 For the 2 kg block:
$F_{net} = ma$
$T + (-w_{II}) + (-f_k) = ma$
$T - (w_{II} + f_k) = ma$
} ✓Any one
$T - (2)(9{,}8)\sin30°$ ✓ $- 2{,}5$ ✓ $= 2a$ ✓
$T - 9{,}8 - 2{,}5 = 2a$
$T - 12{,}3 = 2a$ ……….(1)

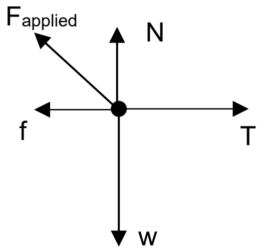
For the 3 kg block:
$F_x + (-T) + (-w_{II}) = ma$
$F_x - (T + w_{II}) = ma$
$[40 \cos 25°$ ✓ $- T - (3)(9{,}8)\sin30°$ ✓$]$ ✓ $= 3a$
$36{,}25 - T - 14{,}7 = 3a$
$21{,}55 - T = 3a$ ………….(2)
$9{,}25 = 5a$ $\therefore a = 1{,}85 \text{ m·s}^{-2}$ ✓ (8)

15.4 Greater than ✓
F_{net} increases. ✓ (2)
[16]

QUESTION 16

16.1 The <u>perpendicular force exerted by a surface on an object</u> in contact with the surface. ✓✓ (2)

16.2



(5)

16.3

For the 20 kg:

$F_{net} = ma$
$T - f - F_{Ax} = ma$ } ✓
$T - 5 - 35\cos 40°$ ✓ = 0 ✓
T = 31,81 N

For m:

$F_{net} = ma$
$mg - T = ma$
m(9,8) – 31,81 ✓ = 0
m = 3,25 kg ✓

(5)

16.4.1 Decreases ✓ (1)

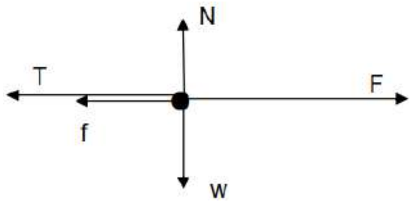
16.4.2 Velocity decreases ✓
Accelerates/Net force to left ✓✓
OR
As the tension decreases, the net force/acceleration acts in the opposite direction of motion /to the left. ✓✓ (3)

[16]

QUESTION 17

17.1 When a (non-zero) resultant/net force acts on an object, the object will accelerate in the direction of the force with an acceleration that is directly proportional to the force ✓ and inversely proportional to the mass of the object.✓ OR
The (non-zero) resultant/net force acting on an object is equal to the rate of change of momentum of the object in the direction of the resultant/net force. (2)

17.2



Acceptable labels		
N	F_N/Normal/normal force	✓
f	F_f/f_k/frictional force/kinetic frictional force	✓
w	F_g/mg/weight/F_w/gravitational force	✓
F	F_A	✓
T	Tension	✓

(5)

17.3

<u>8 kg</u>	**<u>2 kg</u>**
F_{net} = ma ✓ **OR**	F_{net} = ma ✓ **OR**
F_{net} = 0 **OR**	F_{net} = 0 **OR**
F – (f + T) = ma	T – w = 0
29,6 – 10 – T = 0 ✓	T – (2)(9,8) = 0 ✓
T = 19,6 N ✓	T = 19,6 N ✓

(3)

17.4.1

<u>8 kg</u>	**<u>2 kg</u>**
F_{net} = ma ✓ **OR/OF**	F_{net} = ma
F– (f + T) = ma	T – mg = ma
50 – 10 – T ✓= 8a ✓	T – 2(9,8) ✓= 2a
40 – T = 8a	a = 2,04 m·s^{-2} ✓

(5)

17.4.2

T – 2(9,8) = 2a		40 – T = 8a
T – 19,6 = 2(2,04) ✓	**OR**	T = 40 – 8(2,04) ✓
T = 23,68 N ✓		T = 23,68 N ✓

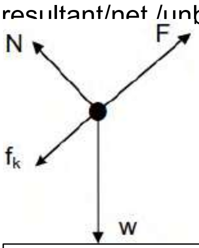
(2)

[17]

QUESTION 18

18.1 A body will remain in its state of rest or motion at constant velocity unless a non-zero resultant/net force/unbalanced force acts on it. ✓✓ **OR**
A body will remain in its state of rest or uniform motion in a straight line unless a (non-zero) resultant/net /unbalanced force acts on it. ✓✓ (2)

18.2



Acceptable labels		
N	F_N/Normal/normal force	✓
f_k	frictional force/kinetic frictional force	✓
w	F_g/mg/weight;F_w/gravitational force	✓
F	F_A / Applied force	✓
T	Tension	✓

(4)

18.3

Positive up the incline
$F_{net} = ma$ ✓ **OR**
$F + f_k + w_{II} = ma$ **OR**
F - [18 + (20)(9,8)(sin30°)] ✓ = 0 ✓
F = 116 N ✓
OR
$W_{net} = \Delta Ek$ ✓
FΔxcos0° + fΔxcos180° + wΔxcos120° ✓= 0 ✓
FΔx = 18Δx + (20)(9,8)Δx(0,5)
F = 116 N ✓

(4)

18.4 116 N / f + w|| ✓ Down the incline/opposite to direction of motion. ✓ (2)

18.5

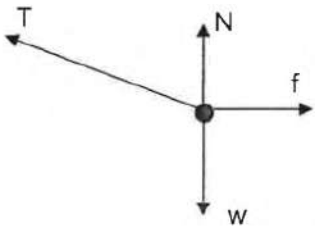
Up the incline positive			
$F_{net} = ma$	$v_f^2 = v_i^2 + 2a\Delta x$ ✓		$W_{net} = \Delta E_K$ ✓ **OR**
-116 = 20a ✓	0 =(2)2 + (2)(-5,8)Δx ✓	**OR**	$F_{net}\Delta x\cos\theta = ½m(v_f^2 - v_i^2)$
a = -5,80 m·s^{-2}	Δx = 0,34 m ✓		(116)Δxcos180° ✓= ½(20)(02 – 22) ✓
			Δx = 0,34 m ✓

(4)
[16]

QUESTION 19

19.1 A body will remain in its state of rest or motion at constant velocity unless a (non-zero) resultant/net force/unbalanced force acts on it. ✓✓ (2)

19.2



Acceptable labels		
N	F_N/Normal/normal force	✓
f	F_f/f_k/frictional force/kinetic frictional force/300 N	✓
w	F_g/mg/weight/F_w/$F_{Earth\ on\ man}$/gravitational force/686 N	✓
T	Tension/$F_{Tension}$/F_T/F_S	✓

(4)

19.3

OPTION 1	**OPTION 2**
$F_{net} = ma$ ✓	$W_{net} = \Delta K$ ✓
Tcos50° - F_f = ma	TΔxcos0° +fΔxcos180° = 0 ✓
Tcos50° - 300 ✓ = 0 ✓	Tcos50° - 300 ✓ = 0
T = 466,72 N ✓	T = 466,72 N ✓

(4)

19.4 Increases ✓
F_{net} increases / F_{net} is not zero / T_x > f / Tcos50° > f ✓ (2)

19.5

OPTION 1
DOWNWARDS POSITIVE
$v_f^2 = v_i^2 + 2a\Delta y$
$0 = 16^2 + 2a(0,8)$ ✓
$a = -160\ m \cdot s^{-2}$

$F_{net} = ma$ ✓
$F_g - F_{up} = ma$
$(4)(9,8) - F_{up}$✓ $= (4)(-160)$ ✓
$F_{up} = -679,20\ N$
$F_{up} = 679,20\ N$ ✓

OPTION 2
UPWARDS POSITIVE
$v_f^2 = v_i^2 + 2a\Delta y$
$0 = (-16)^2 + 2a(-0,8)$ ✓
$a = 160\ m \cdot s^{-2}$

$F_{net} = ma$ ✓
$-F_g + F_{up} = ma$
$-(4)(9,8) + F_{up}$✓ $= (4)(160)$ ✓
$F_{up} = 679,20\ N$ ✓

The acceleration in options 1 and 2 may also be calculated with other equations of motion.

OPTION 3

$W_{net} = \Delta K$ ✓

$F_{net}\Delta x cos\Theta = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

$(4)(9,8)(0,8)cos0°$ ✓ $+ F_{up}(0,8)cos180°$ ✓ $= \frac{1}{2}(4)(0 - 16^2)$ ✓

$F_{up} = 679,20\ N$ ✓

OPTION 4

$W_{nc} = \Delta K + \Delta U$ ✓

$F_{up}\Delta x cos\Theta = \frac{1}{2}m(v_f^2 - v_i^2) + mg(h_f - h_i)$

$F_{up}(0,8)cos180°$ ✓ $= \frac{1}{2}(4)(0 - 16^2)$ ✓ $+ (4)(9,8)(0 - 0,8)$ ✓

$F_{up} = 679,20\ N$ ✓

OPTION 5

$\Delta x = \left(\frac{v_i + v_f}{2}\right)\Delta t$

$0,8 = \left(\frac{16 + 0}{2}\right)\Delta t$

$\Delta t = 0,1\ s$

$F_{net}\Delta t = \Delta p$ ✓

$[(4)(9,8)$ ✓ $- F_{up}](0,1)$ ✓ $= (4)(0 - 16)$ ✓

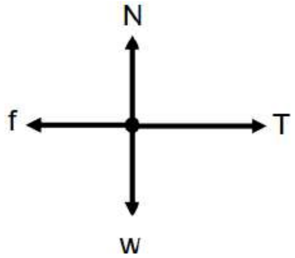
$F_{up} = 679,20\ N$ ✓

(5)
[17]

QUESTION 20

20.1 When a resultant/net force acts on an object, the object will accelerate in the direction of the force. The acceleration is directly proportional to the resultant/net force and inversely proportional to the mass of the object. ✓✓ **OR**
The resultant/net force acting on an object is equal to the rate of change of momentum of the object. (2)

20.2



Acceptable labels		
w	F_g/mg/weight/F_w/$F_{Earth\ on\ P}$/gravitational force/12,25 N	✓
T	F_T/F_{string}/Tension/$F_{Tension}$	✓
f	F_f/f_k/(kinetic) friction/frictional force/kinetic frictional force/1,8 N	✓
N	F_N/Normal/F_{normal}/normal force	✓

(4)

20.3.1

FOR P: RIGHT AS POSITIVE

$F_{net} = ma$ ✓

$T + f = ma$

$T + (-1,8)$ ✓ $= (1,25)(0,1)$ ✓

$T = 1,925\ N$ ✓

FOR P: LEFT AS POSITIVE

$F_{net} = ma$ ✓

$T + f = ma$

$T + (+1,8)$ ✓ $= (1,25)(-0,1)$ ✓

$T = -1,925\ N$ ✓

(4)

20.3.2

FOR Q: RIGHT AS POSITIVE

$F_{net} = ma$

$Fcos\Theta + T + f = ma$

$7,5cos\Theta + (-1,93) + (-2,2)$ ✓ $= (2)(0,1)$ ✓

$\Theta = 54,74°$ ✓ (Range: 54,55° – 54,78°)

FOR Q: LEFT AS POSITIVE

$F_{net} = ma$

$Fcos\Theta + T + f = ma$

$-7,5cos\Theta + (+1,93) + (+2,2)$ ✓ $= (2)(-0,1)$ ✓

$\Theta = 54,74°$ ✓ (Range: 54,55° – 54,78°)

(3)
[13]

QUESTION 21

21.1

DOWNWARDS AS POSITIVE

$v_f^2 = v_i^2 + 2a\Delta y$ ✓

$3,41^2$ ✓ $= 0^2 + 2a(1,5)$ ✓

$a = 3,88\ m \cdot s^{-2}$

UPWARDS AS POSITIVE

$v_f^2 = v_i^2 + 2a\Delta y$ ✓

$(-3,41)^2$ ✓ $= 0^2 + 2a(-1,5)$ ✓

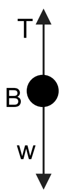
$a = -3,88\ m \cdot s^{-2}$

$\therefore a = 3,88\ m \cdot s^{-2}$

Other equations of motion may be used.

(3)

21.2



	Accepted symbols
w ✓	F_g/F_w/weight/mg/gravitational force/$F_{Earth\ on\ block}$/*73,5 N*
T ✓	Tension/$F_{Tension}$/F_T/*F*

(2)

21.3 When a resultant/net force acts on an object, the object will accelerate in the direction of the force with an acceleration that is directly proportional to the force and inversely proportional to the mass of the object. ✓✓ **OR**
The resultant/net force acting on an object is equal to the rate of change of momentum of the object in the direction of the resultant/net force. (2)

21.4

$F_{net} = ma$ ✓
$m_B g - T = m_B a$
$(7,5)(9,8) - T$ ✓ $= (7,5)(3,88)$ ✓
$T = 44,4\ N$

$F_{net} = ma$
$T - mg = ma$
$44,4 - 9,8m = 3,88m$ ✓
$m = 3,25\ kg$ ✓

(5)

21.5

<u>OPTION 1</u>

UPWARD AS POSITIVE
$v_f^2 = v_i^2 + 2a\Delta y$ ✓
$0^2 = 3,41^2$ ✓ $+ 2(-9,8)\Delta y$ ✓
$\Delta y = 0,59\ m$

$Maximum\ height = 0,59 + 1,5$ ✓
$= 2,09\ m$ ✓

DOWNWARD AS POSITIVE
$v_f^2 = v_i^2 + 2a\Delta y$ ✓
$0^2 = (-3,41)^2$ ✓ $+ 2(+9,8)\Delta y$ ✓
$\Delta y = -0,59\ m$

$Maximum\ height = 0,59 + 1,5$ ✓
$= 2,09\ m$ ✓

<u>OPTION 2</u>

UPWARD AS POSITIVE
$v_f = v_i + a\Delta t$
$0 = 3,41 + (-9,8)\Delta t$
$\Delta t = 0,348\ s$

$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓
$= (3,41)(0,348)$ ✓ $+ \frac{1}{2}(-9,8)(0,348^2)$ ✓
$= 0,59\ m$

$Maximum\ height = 0,59 + 1,5$ ✓
$= 2,09\ m$ ✓

DOWNWARD AS POSITIVE
$v_f = v_i + a\Delta t$
$0 = -3,41 + (+9,8)\Delta t$
$\Delta t = 0,348\ s$

$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓
$= (-3,41)(0,348)$ ✓ $+ \frac{1}{2}(+9,8)(0,348^2)$ ✓
$= -0,59\ m$

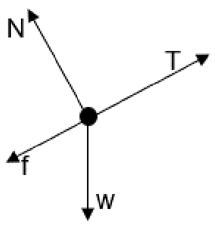
$Maximum\ height = 0,59 + 1,5$ ✓
$= 2,09\ m$ ✓

(5)
[17]

QUESTION 22

22.1 When a resultant/net force acts on an object, the object will accelerate in the direction of the force. The acceleration is directly proportional to the resultant/net force and inversely proportional to the mass of the object. ✓✓ **OR**
The resultant/net force acting on an object is equal to the rate of change of momentum of the object in the direction of the resultant/net force. (2)

22.2



Accepted labels	
N	F_N/Normal/F_{Normal}
f	(kinetic) friction/F_f/f_k/5,88 N
w	F_g/F_w/weight/mg/gravitational force/39,2 N
T	F_T/F_{string}/tension

(4)

22.3.1

<u>For block A</u>
Up the incline positive
$F_{net} = ma$ ✓
$T + f + w_{par} = ma$
$T - 5,88 - (4)(9,8)(sin35°)$ ✓ $= (4)(2)$ ✓
$T = 36,364\ N$ ✓

(4)

22.3.2

<u>For block B</u>
Up the incline positive
$F_{net} = ma$
$T + f + w_{par} + F = ma$
$-36,364 - 13,23 - (9)(9,8)(sin35°) + F$ ✓ $= (9)(2)$ ✓
$T = 118,18\ N$ ✓

(3)

22.4.1 Increase ✓ (1)

22.4.2 As θ decreases, the normal force increases. ✓
The frictional force is directly proportional to the normal force. ✓ **OR** f α N / f = μN (2)
[16]

VERTICAL PROJECTILE MOTION

QUESTION 1

1.1 Motion under the influence of the gravitational force/weight ONLY. ✓✓ (2)

1.2

OPTION 1 **Upwards positive:** $\Delta y = v_i\Delta t + ½ a\Delta t^2$ ✓ 0 ✓ = 15 Δt + ½ (-9,8) Δt² ✓ Δt = 3,06 s ∴ It takes 3,06 s ✓	**Downwards positive:** $\Delta y = v_i\Delta t + ½ a\Delta t^2$ ✓ 0 ✓ = -15 Δt + ½ (9,8) Δt² ✓ Δt = 3,06 s ∴It takes 3,06 s ✓
OPTION 2 **Upwards positive:** $v_f = v_i + a\Delta t$ ✓ 0 ✓ = 15 +(-9,8)Δt ✓ Δt = 1,53 s It takes (2)(1,53) = 3,06 s ✓	**Downwards positive:** $v_f = v_i + a\Delta t$ ✓ 0✓ = -15 +(9,8)Δt ✓ Δt = 1,53 s It takes (2)(1,53) = 3,06 s ✓

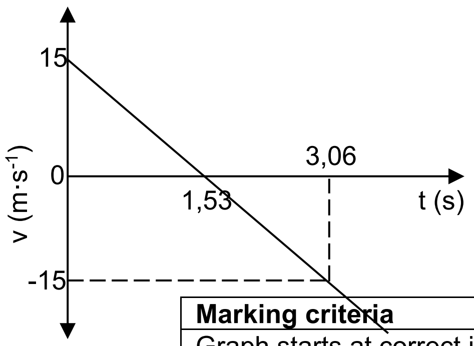
(4)

1.3

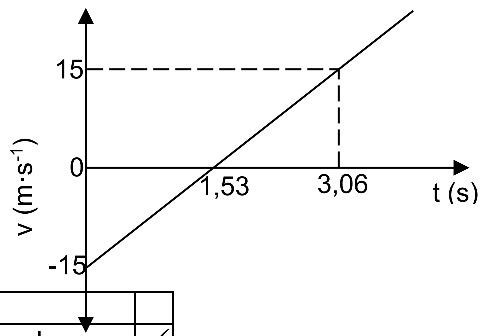
Upwards positive: $v_f^2 = v_i^2 + 2a\Delta y$ ✓ For ball A 0 = (15)²✓ + 2 (-9,8)Δy ✓ ∴ Δy_A = 11,48 m When A is at highest point: $\Delta y_B = v_i\Delta t + ½ a\Delta t^2$ = 0 + ½ (-9,8) (1,53)² ✓✓ Δy_B = -11,47 m ∴ Δy_B = 11,47 m downward Distance = $y_A + y_B$ = 11,47 + 11,48 ✓ = 22,95 m ✓	**Downwards positive:** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ For ball A 0 = (-15)²✓ + 2 (9,8)Δy✓ ∴ Δy_A = -11,48 m When A is at highest point: $\Delta y_B = v_i\Delta t + ½ a\Delta t^2$ = 0 + ½ (9,8) (1,53)² ✓✓ Δy_B = 11,47 m ∴ Δy_B = 11,47 m downward Distance = $y_A + y_B$ = 11,48 + 11,47 ✓ = 22,95 m ✓

(6)

1.4 **UPWARD AS POSITIVE**



DOWNWARD POSITIVE



Marking criteria	
Graph starts at correct initial velocity shown.	✓
Time for maximum height shown (1,53 s).	✓
Time for return shown (3,06 s)	✓
Shape: Straight line extending beyond 3,06 s	✓

(4)
[17]

QUESTION 2

2.1 Free fall ✓ (1)

2.2

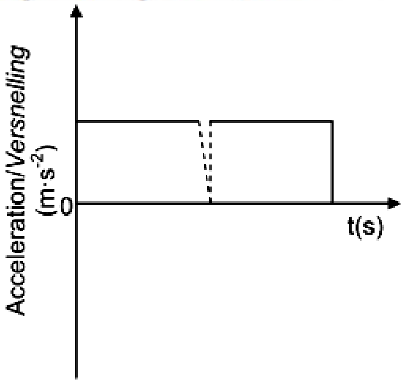
Upward positive:	**Downward positive:**
$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓	$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓
-30 ✓ $= v_i(1,5) + \frac{1}{2}(-9,8)(1,5)^2$ ✓	30 ✓ $= v_i(1,5) + \frac{1}{2}(9,8)(1,5)^2$ ✓
$v_i = 12,65\ m\cdot s^{-1}$ ✓	$v_i = 12,65\ m\cdot s^{-1}$ ✓

(4)

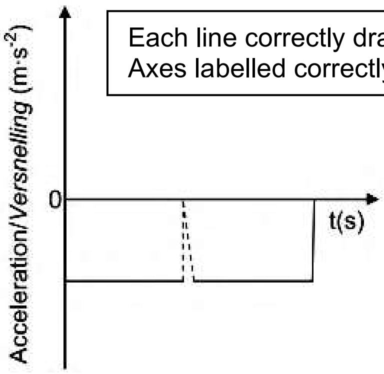
2.3 **Downwards as positive**

$v_f^2 = v_i^2 + 2a\Delta y$ ✓
$12,65^2$ ✓ $= 0 + 2(9,8)\Delta y$ ✓
$\Delta y = 8,16$ m ✓
Height/*Hoogte* **XC = XB + BC**
(30 + 8,16) = 38,16 m
Height is/*Hoogte is* 38,16 m ✓ (5)

2.4



OR



Each line correctly drawn: ✓✓
Axes labelled correctly: ✓

(3)
[13]

QUESTION 3

3.1 $5,88\ m\cdot s^{-1}$ ✓ (1)

3.2

OPTION 1	**OPTION 2**
$v_f^2 = v_i^2 + 2a\Delta y$ ✓ $(-19,6)^2 = (5,88)^2 + 2(-9,8)\Delta y$ ✓ $\Delta y = -17,84$m Height above ground = 17,84 m ✓	Area between graph and t-axis for 2,6 s $\Delta y = \frac{1}{2}bh + \frac{1}{2}bh$ $= \frac{1}{2}(0,6)(5,88)$ ✓ $+ \frac{1}{2}(2,6 - 0,6)(-19,6)$ ✓ $= -17,84$ m ∴Height above ground = 17,84 m ✓
OPTION 3	**OPTION 4**
By symmetry ball returns to A at 1,2 s downward and $v = -5,88\ m\cdot s^{-1}$ Δy = Area of trapezium = ½(sum of parallel sides)(h) ✓ $= \frac{1}{2}\{(-5,88) + (-19,6)\}(2,6 - 1,2)$ ✓ $= -17,84$m ∴Height above ground = 17,84 m ✓	$\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓ $\Delta y = \left(\frac{5,88 + (-19,6)}{2}\right)2,6$ ✓ $= -17,836$ m ∴Height above ground =17,84 m ✓

(3)

3.3

OPTION 1	**OPTION 2**
$t_p = \left(\frac{3,2-2,6}{2}\right) + 2,6$ ✓ Time at P (tp) = 2,9 s ✓	$v_f = v_i + a\Delta t$ $0 = 2,94 + (-9,8)\Delta t$ ✓ $\Delta t = 0,3s \therefore t_p = 2,6 + 0,3 = 2,9s$ ✓
OPTION 3 Gradient = -9,8 $\frac{\Delta y}{\Delta t} = -9,8 \therefore \frac{0-2,94}{\Delta t} = -9,8$ ✓ $\therefore \Delta t = 0,3$ s Time at P (tp) = <u>(2,6 + 0,3)</u> = 2,9 s ✓	

(2)

3.4

OPTION 1	**OPTION 2**	**OPTION 3**
Δy = area under graph ✓ = ½ (0,3)(2,94) ✓ = 0,44 m✓	$\Delta y = v_i\Delta t + ½a\Delta t^2$✓ = (2,94)(0,3) + ½(-9,8)(0,3)^2 ✓ = 0,44 m ✓	$v_f^2 = v_i^2 + 2a\Delta y$ ✓ $0 = 2,94^2 + 2(-9,8)\Delta y$ ✓ Δy = 0,44m ✓

(3)

3.5 For t =2,9 s t_p = 2,9 s
Distance travelled by balloon since ball was dropped
$\Delta y = v\Delta t$ = (5,88)(2,9) ✓ = 17,05 m
Height of balloon when ball was dropped = 17,84 m
Height of balloon after 2,9 s = (17,05 + 17,84) ✓ = 34,89 m
Maximum height of ball above ground = 0,44 m
∴distance between balloon and ball = (34,89 – 0,44) ✓ = 34,45 m ✓ (4)

[13]

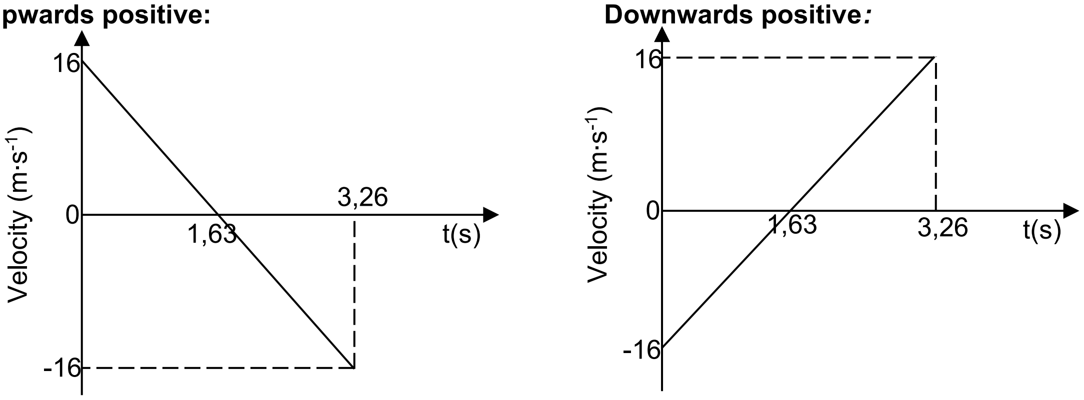
QUESTION 4

4.1

Upwards positive	**Downwards positive**
$v_f = v_i + a\Delta t$ ✓ -16✓ = <u>16 – 9,8(Δt)</u> ✓ Δt = 3,27s ✓	$v_f = v_i + a\Delta t$ ✓ 16 ✓ = -<u>16 +9,8(Δt)</u> ✓ Δt = 3,27s ✓

(4)

4.2 **Upwards positive:** **Downwards positive:**



Criteria for graph	
Correct shape for line extending beyond t = 1,63 s.	✓
Initial velocity correctly indicated as shown.	✓
Time to reach maximum height and time to return to the ground correctly shown.	✓

(3)

4.3

Marking criteria:

- Both equations ✓
- Equation for distance/displacement covered by A. ✓
- Equation for distance/displacement covered by B. ✓
- One of equations to have time as ($\Delta t + 1$) or ($\Delta t - 1$). ✓
- Solution for t = 2,24 s. ✓
- Final answer: 11,25 m ✓

Upwards positive:	**Downwards positive:**
Take y_A as height of ball A from the ground: $\Delta y_A = v_i\Delta t + ½ a\Delta t^2$ $y_A - 0 = 16\Delta t + ½(-9,8)\Delta t^2 = 16\Delta t - 4,9\Delta t^2$ ✓ Take y_B as height of ball B from the ground: $\Delta y_B = v_i\Delta t + ½ a\Delta t^2$ $y_B - 30 = (v_i\Delta t + ½ a\Delta t^2)$ $y_B = 30 - [-9(\Delta t - 1) + ½(-9,8)(\Delta t - 1)^2$ ✓ $= 34,1 + 0,8\Delta t - 4,9\Delta t^2$ ✓ $y_A = y_B$ $\therefore 16\Delta t - 4,9\Delta t^2 = 34,1 + 0,8\Delta t - 4,9\Delta t^2$ $15,2\Delta t = 34,1 \therefore \Delta t = 2,24$ s ✓ $y_A = 16(2,24) - 4,9(2,24)^2 = 11,25$ m ✓	Take y_A as height of ball A from the ground. $\Delta y_A = v_i\Delta t + ½ a\Delta t^2$ $y_A - 0 = -16\Delta t + ½(9,8)\Delta t^2$ $= -16\Delta t + 4,9\Delta t^2$ ✓ Take y_B as height of ball B from the ground. $\Delta y_B = v_i\Delta t + ½ a\Delta t^2$ ✓Both $y_B - 30 = -(v_i\Delta t + ½ a\Delta t^2)$ $y_B = 30 - [9(\Delta t - 1) + ½(9,8)(\Delta t - 1)^2$✓ $= 34,1 + 0,8\Delta t - 4,9\Delta t^2$ ✓ $y_A = y_B \therefore 16\Delta t - 4,9\Delta t^2 = 34,1 + 0,8\Delta t - 4,9\Delta t^2$ $\therefore 15,2\Delta t = 34,1 \therefore \Delta t = 2,24$ s ✓ $\Delta y_A = (-16(2,24) + 4,9(2,24)^2) = 11,25$ m ✓

(6)
[13]

QUESTION 5

5.1.1

OPTION 1/*OPSIE 1* **Upwards positive/*Opwaarts positief*:** $v_f^2 = v_i^2 + 2a\Delta y$✓ $v_f^2 = (-2)^2 + 2(-9,8)(-45)$✓ $v_f = 29,76$ m·s^{-1}✓	**Downwards positive/*Afwaarts positief*:** $v_f^2 = v_i^2 + 2a\Delta y$✓ $v_f^2 = (2)^2 + 2(9,8)(45)$✓ $v_f = 29,76$ m·s^{-1}✓ (29,77 m·s^{-1})
OPTION 2/*OPSIE 2* **Upwards positive/*Opwaarts positief*:** $\Delta y = v_i\Delta t + ½a\Delta t^2$ ✓ for either equation/*vir beide vergelykings* $-45 = -2\Delta t + ½(-9,8)\Delta t^2$ $-4,9\Delta t^2 - 2\Delta t + 45 = 0$ $4,9\Delta t^2 + 2\Delta t - 45 = 0$ ✓ $\Delta t = 2,83$ $v_f = v_i + a\Delta t$ $v_f = 0 + (-9,8)(2,83)$ $v_f = -29,73$ m s^{-1}✓	**Downwards positive/*Afwaarts positief*:** $\Delta y = v_i\Delta t + ½a\Delta t^2$ ✓ for either equation/*vir beide vergelykings* $45 = 2\Delta t + ½(9,8)\Delta t^2$ $4,9\Delta t^2 + 2\Delta t - 45 = 0$ ✓ $\Delta t = 2,83$ $v_f = v_i + a\Delta t$ $v_f = 0 + (9,8)(2,83)$ $v_f = 29,73$ m s^{-1} ✓

(4)

5.1.2

OPTION 1/*OPSIE 1* **Upwards positive/*Opwaarts positief*:** The balls hit the water at the same instant./*Die balle tref die water gelyktydig* $v_f = v_i + a\Delta t$ ✓ Ball/*Bal* **A** $-29,76 = -2 + (-9,8)\Delta t$ $\Delta t = 2,83$ s ✓ ∴ for ball/*vir bal* **B** $\Delta t_B = 2,83 - 1 = 1,83$ s ∴ for ball/*vir bal* **B** $\Delta t_B = 2,83 - 1 = 1,83$ s ✓	**Downwards positive/*Afwaarts positief*** The balls hit the water at the same instant./*Die balle tref die water gelyktydig* $v_f = v_i + a\Delta t$ ✓ Ball/*Bal* **A** $29,76 = 2 + (9,8)\Delta t$ $\Delta t = 2,83$ s ✓ ∴ for ball/*vir bal* **B** $\Delta t_B = 2,83 - 1 = 1,83$ s ∴ for ball/*vir bal* **B** $\Delta t_B = 2,83 - 1 = 1,83$ s ✓

OPTION 2 **Upwards positive/*Opwaarts positief*:** Ball/*Bal* A $\Delta y = v_i\Delta t + ½a\Delta t^2$ ✓ $-45 = -2\Delta t + ½(-9,8)\Delta t^2$ $-4,9\Delta t^2 - 2\Delta t + 45 = 0$ $4,9\Delta t^2 + 2\Delta t - 45 = 0$ $\Delta t = 2,83$ ✓ ∴ for ball/*vir bal* **B** $\Delta t_B = 2,83 - 1 = 1,83$ s ✓	**Downwards positive/*Afwaarts positief:*** $\Delta y = v_i\Delta t + ½a\Delta t^2$ ✓ $45 = 2\Delta t + ½(9,8)\Delta t^2$ $4,9\Delta t^2 + 2\Delta t - 45 = 0$ $\Delta t = 2,83$ ✓ ∴ for ball/*vir bal* **B** $\Delta t_B = 2,83 - 1 = 1,83$ s ✓

(4)

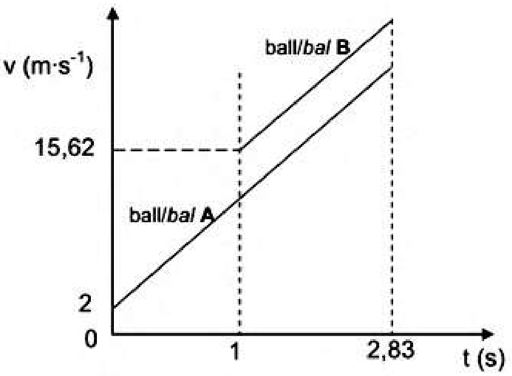
5.1.3

Upwards positive/*Opwaarts positief*: $\Delta t_B = 1.83$s ✓ $\Delta y = v_i\Delta t + ½a\Delta t^2$ ✓ -45 ✓ $= v_i(1,83) + ½(-9.8)(1,83)^2$ ✓ $v_i = -15,62$ m·s^{-1} ✓	**Downwards positive:** $\Delta t_B = 1,83$ s $\Delta y = v_i\Delta t + ½a\Delta t^2$ $45 = v_i(1,83) + ½(9,8)(1,83)^2$ $v_i = 15,62$ m·s^{-1}

(4)

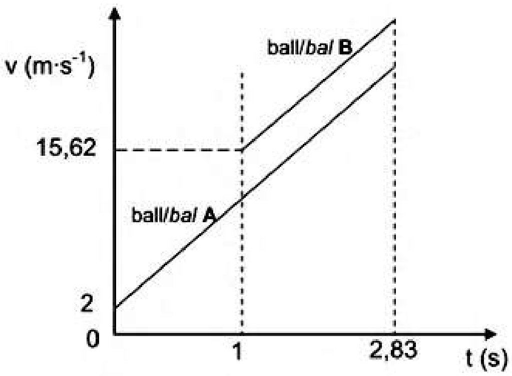
5.2

Upward positive



Marking criteria	
One mark for each intial velocity 2 m·s^{-1} & 15,62 m·s^{-1}	✓✓
Release time of ball B: t = 1 s	✓
Flight time for both balls indicated as the same on time axis. (2,83 s)	✓
Shape – parallel lines	✓

Downward positive



Marking criteria	
One mark for each intial velocity - 2 m·s^{-1} & - 15,62 m·s^{-1}	✓✓
Release time of ball B: t = 1 s	✓
Flight time for both balls indicated as the same on time axis.	✓
Shape – parallel lines	✓

(4)
[16]

QUESTION 6

6.1 An object which has been given an intial velocity ✓ and then moves under the influence of the force of gravity only. ✓ (2)

6.2

OPTION 1 **Upward positive** $v_f = v_i + a\Delta t$ ✓ $\underline{-30 = 30}$✓ + $(-9,8)\Delta t$ ✓ $\Delta t = 6,12$ s ✓	 **Downward positive** $v_f = v_i + a\Delta t$ ✓ $\underline{30 = -30}$✓ + $(9,8)\Delta t$ ✓ $\Delta t = 6,12$ s ✓
OPTION 2 **Upward positive** $v_f = v_i + a\Delta t$ ✓ ∴ $\underline{0 = 30}$ ✓ + $(-9,8)\Delta t$ ✓ $\Delta t = 3,06$ s ∴ total time = (2)(3,06) = 6,12 s ✓	 **Downward positive** $v_f = v_i + a\Delta t$ ✓ ∴ $\underline{0 = -30}$ ✓ + $(9,8)\Delta t$ ✓ ∴ $\Delta t = 3,06$ s ∴ total time = (2)(3,06) = 6,12 s ✓

(4)

6.3 **Upward positive**

$\Delta y = v_i\Delta t + ½a\Delta t^2$
$\Delta y_{last} = \Delta y_{(6,12)} - \Delta y_{(5,12)}$ } ✓

$= \{30(6,12) + ½(-9,8)(6,12)^2\}$✓ $- \{30\underline{(5,12) + ½(-9,8)(5,12)^2}\}$✓

$= -25,076$

Distance = |Δy| = 25,08 m ✓

Downward positive

$\Delta y = v_i\Delta t + ½a\Delta t^2$
$\Delta y_{last} = \Delta y_{(6,12)} - \Delta y_{(5,12)}$ } ✓

$= \{-30(6,12) + ½(9,8)(6,12)^2\}$✓ $- \{-30(5,12) + ½(9,8)(5,12)^2\}$ ✓

$= 25,076$

Distance = |Δy| = 25,08 m ✓ (4)

.6.4

Upward positive

$\Delta y = v_i\Delta t + \frac{1}{2} a\Delta t^2$ ✓

-50✓$= \underline{[v_i (4,12)] + [\frac{1}{2} (-9,8)(4,12)^2]}$ ✓

$v_i = 8,05 \text{ m·s}^{-1}$

speed $= 8,05 \text{ m·s}^{-1}$ ✓

Downward positive

$\Delta y = v_i\Delta t + \frac{1}{2} a\Delta t^2$ ✓

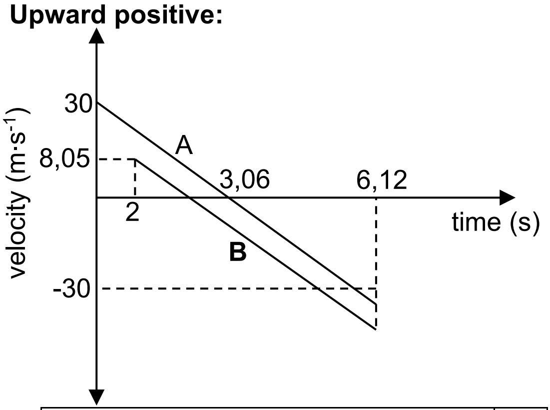
50✓$= \underline{v_i (4,12) + [\frac{1}{2} (9,8)(4,12)^2]}$ ✓

$v_i = - 8,05 \text{ m·s}^{-1}$

speed $= 8,05 \text{ m·s}^{-1}$ ✓

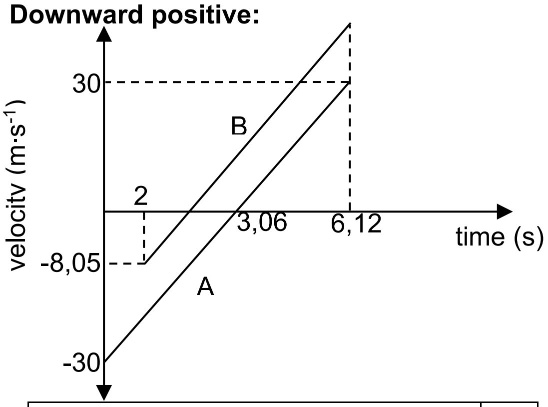
6.5

Upward positive:



Marking criteria	
Correct shape of A.	✓
Correct shape of Graph B parallel to A below A.	✓
Time at which both A and B reach the ground (6,12 s).	✓
Time for A to reach the maximum height (3,06 s) shown.	✓

Downward positive:



Marking criteria	
Correct shape of A.	✓
Correct shape of Graph B parallel to A above A.	✓
Time at which both A and B reach the ground (6,12 s).	✓
Time for A to reach the maximum height (3,06 s) shown.	✓

(4)
[18]

QUESTION 7

7.1 The motion of an <u>object under the influence of weight/ gravitational force only</u> / Motion in which the only force acting is the gravitational force. ✓✓ (2)

7.2

<u>OPTION 1: Upwards positive</u>

$v_f^2 = v_i^2 + 2a\Delta y$ ✓

$= 0^2 + (2)(-9,8)$ ✓ (-20) ✓

$v_f = 19,80 \text{ m·s}^{-1}$ ✓

<u>OPTION 1: Downwards positive</u>

$v_f^2 = v_i^2 + 2a\Delta y$ ✓

$= 0^2 + (2)(9,8)$ ✓ (20) ✓

$v_f = 19,80 \text{ m·s}^{-1}$ ✓

<u>OPTION 2: Upwards positive</u>

$\Delta y = v_i\Delta t + \frac{1}{2} a\Delta t^2$

$-20 = 0 + \frac{1}{2} (-9,8) \Delta t^2$✓

$\Delta t = 2,02$ s

$v_f = v_i + a\Delta t$

✓either one

$= 0 + (-9,8)(2,02)$ ✓

$= -19,80 \text{ m·s}^{-1}$ $\therefore$ $v_f = 19,80 \text{ m·s}^{-1}$ ✓

<u>OPTION 2: Downwards positive</u>

$\Delta y = v_i\Delta t + \frac{1}{2} a\Delta t^2$

$20 = 0 + \frac{1}{2} (9,8) \Delta t^2$✓

$\Delta t = 2,02$ s

$v_f = v_i + a\Delta t$

✓either one

$= 0 + (9,8)(2,02)$ ✓

$= 19,80 \text{ m·s}^{-1}$ ✓

(4)

7.3

<u>OPTION 1: Upwards positive</u>

$v_f = v_i + a\Delta t$ ✓

$\underline{-19,80 = 0 + (-9,8)\Delta t}$ ✓ $\therefore$ $\Delta t = 2,02$ s ✓

<u>OPTION 1: Downwards positive</u>

$v_f = v_i + a\Delta t$ ✓

$\underline{19,80 = 0 + (9,8)\Delta t}$ ✓ $\therefore$ $\Delta t = 2,02$ s ✓

<u>OPTION 2: Upwards positive:</u>

$\Delta y = v_i\Delta t + \frac{1}{2} a\Delta t^2$✓

$\underline{-20 = 0 + \frac{1}{2} (-9,8) \Delta t^2}$✓ $\therefore$ $\Delta t = 2,02$ s ✓

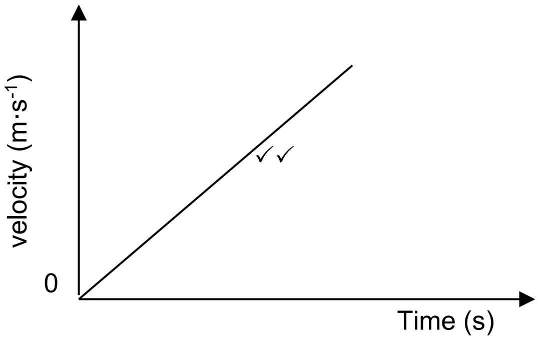
<u>OPTION 2: Downwards positive:</u>

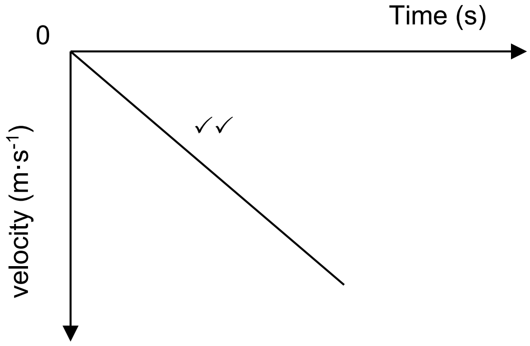
$\Delta y = v_i\Delta t + \frac{1}{2} a\Delta t^2$✓

$\underline{20 = 0 + \frac{1}{2} (9,8) \Delta t^2}$✓ $\therefore$ $\Delta t = 2,02$ s ✓

(3)

7.4 **Downward positive** **Upward positive**





✓✓	Straight line through the origin.
	Deduct 1 mark if axes are not labelled correctly.

(2)
[11]

QUESTION 8

8.1 The only force acting on the ball is the gravitational force. ✓✓

8.2.1

OPTION 1	
Upwards as positive $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= \underline{(10)(3) + \frac{1}{2}(-9{,}8)(3^2)}$ ✓ $= -14{,}10$ Height of building = 14,10 m ✓	**Downwards as positive** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= \underline{(-10)(3) + \frac{1}{2}(9{,}8)(3^2)}$ ✓ $= 14{,}10$ Height of building = 14,10 m ✓
OPTION 2	
Upward as positive For maximum height: $v_f = v_i + a\Delta t$ $0 = 10 + (-9{,}8)\Delta t \ \therefore\ \Delta t = 1{,}02$ s Time taken from point A to ground: 3 - 2(1,02) = 0,96 s $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= \underline{(-10)(0{,}96) + \frac{1}{2}(-9{,}8)(0{,}96)^2}$ ✓ $= -14{,}1184$ ∴ Height = 14,12 m ✓	**Downwards as positive** For maximum height: $v_f = v_i + a\Delta t$ $0 = -10 + (9{,}8)\Delta t \ \therefore\ \Delta t = 1{,}02$ s Time taken from point A to ground: 3 - 2(1,02) = 0,96 s $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= \underline{(10)(0{,}96) + \frac{1}{2}(9{,}8)(0{,}96)^2}$ ✓ $= 14{,}1184$ ∴ Height = 14,12 m ✓

(3)

8.2.2

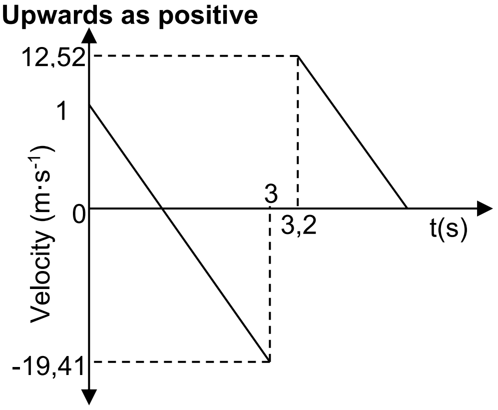
Upwards as positive: $v_f = v_i + a\Delta t$ ✓ $= \underline{(10) + (-9{,}8)(3)}$ ✓ $= -19{,}41$ Speed = 19,41 m·s^{-1} ✓	**Downwards as positive:** $v_f = v_i + a\Delta t$ ✓ $= \underline{(-10) + (9{,}8)(3)}$ ✓ $= 19{,}41$ Speed = 19,41 m·s^{-1} ✓

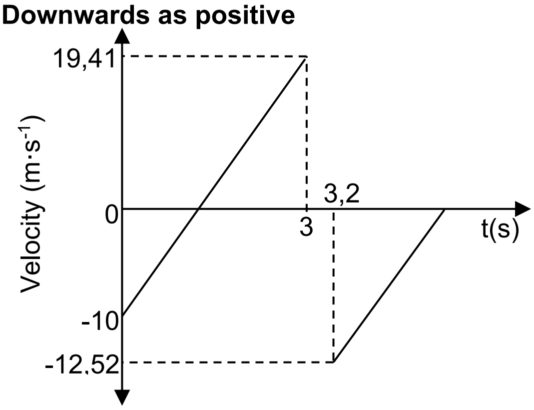
8.2.3

Upwards as positive: $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $0 = v_i^2 \underline{+ (2)(-9{,}8)(8)}$ ✓ ∴ $v_i = 12{,}52$ m·s^{-1} Speed = 12,52 m·s^{-1} ✓	**Downwards as positive:** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $0 = v_i^2 \underline{+ (2)(9{,}8)(-8)}$ ∴ $v_i = -12{,}52$ Speed = 12,52 m·s^{-1} ✓

(3)

8.3 **Upwards as positive** **Downwards as positive**





Marking criteria	
Two parallel lines correctly drawn.	✓✓
Mark for velocity calculated in Q8.2.2.	✓
Mark for velocity calculated in Q8.2.3.	
Times 3 s and 3,2 s correctly shown.	✓

(4)
[15]

QUESTION 9

9.1 (Motion of) an object which has been given an initial velocity and then moves under the influence of the gravitational force/weight only. ✓✓ (2)

9.2 No ✓ The balloon is <u>not accelerating</u>./The balloon is <u>moving with constant velocity</u>./The net force acting on the balloon is zero.✓ (2)

9.3

<u>OPTION 1</u> Upward positive:	**Downward positive:**
$\Delta y = v_i\Delta t + ½ a\Delta t^2$✓ -22✓ = <u>(-1,2) Δt + ½ (-9,8)Δt²</u> ✓ ∴ Δt = 2 s ✓	$\Delta y = v_i\Delta t + ½ a\Delta t^2$✓ 22✓ = <u>(1,2) Δt + ½ (9,8)Δt²</u> ✓ ∴ Δt = 2 s ✓
<u>OPTION 2</u> **Upward positive:** $v_f^2 = v_i^2 + 2a\Delta y$ $v_f^2 = (-1,2)^2 + (2)(-9,8)(-22)$ ✓Both v_f = -20,8 m·s⁻¹ $v_f = v_i + a\Delta t$ <u>-20,8 = -1,2 + -9,8Δt</u> ✓ ∴ Δt = 2 s ✓	**Downward positive:** $v_f^2 = v_i^2 + 2a\Delta y$ $v_f^2 = (1,2)^2 + (2)(9,8)(22)$ ✓Both v_f = 20,8 m·s⁻¹ $v_f = v_i + a\Delta t$ <u>20,8 = 1,2 + 9,8Δt</u> ✓ ∴ Δt = 2 s ✓

(4)

9.4

Upward positive:	**Downward Positive:**
$v_f = v_i + a\Delta t$ ✓∴ 0 = 15 + (-9,8)Δt ✓ ∴ Δt = 1,53 s Total time elapsed = <u>2 + 1,53 + 0,3</u> ✓ = 3,83 s Displacement of the balloon: $\Delta y = v_i\Delta t + ½ a\Delta t^2$ = -(1,2)(3,83) ✓= - 4,6 m Height = <u>22 - 4,6</u> ✓ = 17,4m ✓ **OR** $y_f = y_i + \Delta y$ = [22 – (1,2)(3,83)] ✓✓ = 17,4 m ∴ Height = 17,4 m✓	$v_f = v_i + a\Delta t$ ✓ ∴ 0 = -15 + (9,8)Δt ✓ ∴ Δt = 1,53 s Total time elapsed = <u>2 + 1,53 + 0,3</u>✓ = 3,83 s Displacement of the balloon: $\Delta y = v_i\Delta t + ½ a\Delta t^2$ = (1,2)(3,83) ✓ = 4,6 m Height = <u>22 - 4,6</u> ✓ = 17,4m ✓ **OR** $y_f = y_i + \Delta y$ = [-22 + (1,2)(3,83)] ✓✓ = -17,4 m ∴ Height = 17,4 m ✓

(6)
[14]

QUESTION 10

10.1

<u>OPTION 1</u> **Upwards positive:**	**Downwards positive:**
$v_f = v_i + a\Delta t$✓ ∴ 0 = (12) + (-9,8)(Δt) ✓ ∴ Δt = 1,22 s✓	$v_f = v_i + a\Delta t$✓ ∴ 0 = (-12) + (9,8)(Δt) ✓ ∴ Δt = 1,22 s✓
<u>OPTION 2</u> **Upwards positive:** $v_f^2 = v_i^2 + 2a\Delta y$ 0 = 12² + 2(-9,8)Δy✓ ∴ Δy = 7,35 $\Delta y = v_i\Delta t + ½ a\Delta t^2$✓ 7,35 =12Δt + ½ (-9,8)Δt² ∴ Δt = 1,22 s✓	**Downwards positive:** $v_f^2 = v_i^2 + 2a\Delta y$ 0 = (-12)² + 2(9,8)Δy✓ ∴ Δy = -7,35 $\Delta y = v_i\Delta t + ½ a\Delta t^2$✓ -7,35 = -12Δt + ½ (9,8) Δt² ∴ Δt = 1,22 s✓

(3)

10.2

<u>OPTION 1</u> **Upwards positive:**	**Downwards positive:**
$v_f = v_i + a\Delta t$ ✓ ∴ <u>-3v = -v</u> ✓ + <u>(-9,8)(1,22)</u> ✓ v = 5,98 m·s⁻¹ ✓ (5,978 to 6,03 m·s⁻¹)	$v_f = v_i + a\Delta t$ ✓ ∴ <u>3v = v</u> ✓ + <u>(9,8)(1,22)</u> ✓ v = 5,98 m·s⁻¹ ✓ (5,978 to 6,03 m·s⁻¹)
<u>OPTION 2</u> **Upwards positive:** $F_{net}\Delta t = m(v_f - v_i)$ ✓ $mg\Delta t = m(v_f – v_i)$ (-9,8)(1,2245) ✓ = <u>-3v – (-v)</u> ✓ ∴ v = 6,00 m·s⁻¹ ✓	**Downwards positive:** $F_{net}\Delta t = m(v_f - v_i)$ ✓ $mg\Delta t = m(v_f – v_i)$ (9,8)(1,2245) ✓ = 3v - v✓ v = 6,00 m·s⁻¹ ✓

(4)

10.3

<u>OPTION 1</u> **Upwards positive:**	**Downwards positive:**
$\Delta y = v_i\Delta t + ½a\Delta t^2$✓ = <u>(-5,98)(2,44) + ½(-9,8)(2,44)²</u>✓ = - 43,764 ∴h = 43,76 m✓ (43,764 to 44,08 m)	$\Delta y = v_i\Delta t + ½a\Delta t^2$✓ = <u>(5,98)(2,44) + ½(9,8)(2,44)²</u> ✓ = 43,764 ∴h = 43,76 m✓(43,764 to 44,08)
<u>OPTION 2</u> **Upwards positive:** $v_f = v_i + a\Delta t$ v_f = - 5,98 + (-9,8)(2,44) = - 29,892 m·s⁻¹ $v_f^2 = v_i^2 + 2a\Delta y$ ✓ <u>(-29,892)² = (- 5,98)² + 2(-9,8)Δy</u> ✓ Δy = - 43, 763 m	**Downwards positive:** $v_f = v_i + a\Delta t$ v_f = 5,98 + 9,8(2,44) = 29,892 m·s⁻¹ $v_f^2 = v_i^2 + 2a\Delta y$ ✓ <u>(29,892)² = (5,98)² + 2(9,8)Δy</u> ✓ Δy = 43,76 m

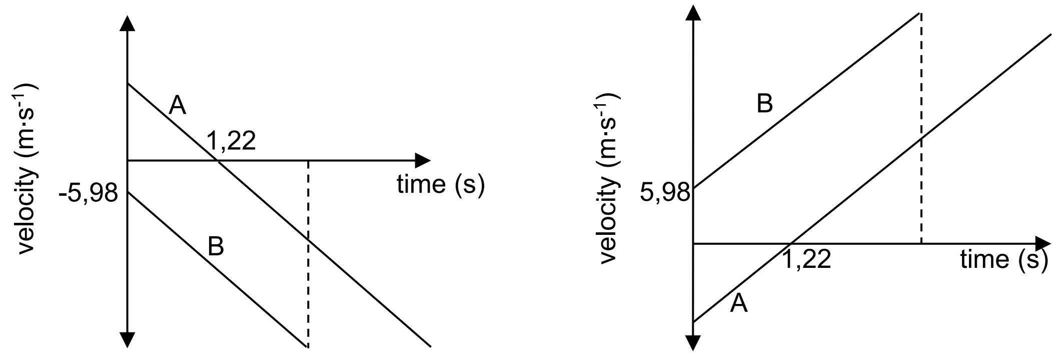
∴ h = 43,76 m✓(43,764 to 44,08)	∴ h = 43,76 m✓(43,764 to 44,08)

OPTION 3

Upwards positive:	**Downwards positive:**
For A: $v_f = v_i + a\Delta t$	**For A:** $v_f = v_i + a\Delta t$ ∴ 12 = -12 + (9,8)Δt
-12 = 12 + (-9,8)Δt ∴ Δt = 2,45 s	∴ Δt = 2,45 s
For B: $\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓	**For B:** $\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓
= (-5,98)(2,45) + ½ (-9,8)(2,45)² ✓	= (5,98)(2,45) + ½ (9,8)(2,45)² ✓
= - 44,06 m ∴ h = 44,06 m ✓	= 44,06 m ∴ h = 44,06 m ✓

(3)

10.4 **Upwards as positive** **Downwards as positive**



Criteria for graph	
Time 1,22 s shown **correctly**	✓
Initial velocity for stone B at time t = 0 correctly shown with correct signs	✓
Two sloping parallel lines with A **crossing** the time axis	✓
Straight line graph for A parallel to graph B, extending beyond the time when B hits ground	✓

(4)
[14]

QUESTION 11

11.1 10 m·s⁻¹ ✓ (1)

11.2 The gradient represents the acceleration due to gravity (g) ✓ which is constant for free fall. ✓ (1)

11.3 **OPTION 1**

$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓	$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓
= (10)(2) + ½ (9,8)(2²) ✓	= (-10)(2) + ½ (-9,8)(2²) ✓
= 39,6 m	= -39,6 m
Height/*Hoogte*= 39,6 m ✓	Height/*Hoogte* = 39,6 m ✓

OPTION 2/*OPSIE 2*	**OPTION 3/*OPSIE 3***
$\Delta x = \frac{(v_i + v_f)}{2}\Delta t$ ✓	$v_f^2 = v_i^2 + 2a\Delta x$ ✓
$\Delta x = \left(\frac{10 + 29{,}6}{2}\right)(2)$ ✓	$(29{,}6)^2 = (10)^2 + 2(9{,}8)a\Delta x$ ✓
$\Delta x = 39{,}6\ m$ ✓	$\Delta x = 39{,}6\ m$ ✓

(3)

11.4

OPTION 1	**OPTION 2**
$v_f = v_i + a\Delta t$ ✓	$v_f = v_i + a\Delta t$ ✓
0 = -25 + (9,8)(Δt) ✓	0 = 25 + (-9,8)(Δt) ✓
Δt = 2,55 s	Δt = 2,55 s
Total time T/*Totale tyd* = 8 +2,55 ✓	Total time T/*Totale tyd* = 8 +2,55 ✓
= 10,55 s✓	= 10,55 s✓

(4)

11.5.1 0,2 s ✓ (1)

11.5.2 4,955 s ✓✓ (2)

11.5.3 - 27 m·s⁻¹ ✓ (1)

11.6 Inelastic ✓ The speeds at which it strikes and leaves the ground are not the same/The kinetic energies will not be the same. ✓ (2)

[16]

QUESTION 12

12.1 Motion under the influence of gravity/weight/gravitational force only. ✓✓ (2)

12.2 **OPTION 1**

UPWARDS AS POSITIVE	**DOWNWARDS AS POSITIVE**
$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ = (0)(1) + ½ (-9,8)(1²) ✓	$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ = (0)(1) + ½ (9,8)(1²) ✓
= - 4,9 m	= 4,9 m
Height = 2Δy = (2)(4,9)	Height = 2Δy = (2)(4,9)
= 9,8 m ✓	= 9,8 m ✓

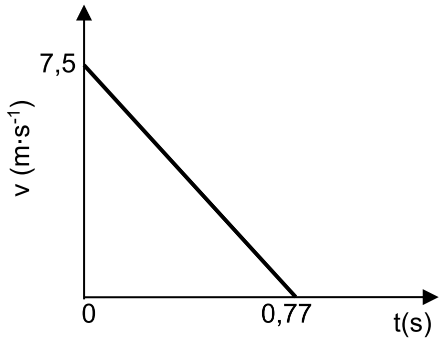
	OPTION 2 **UPWARD POSITIVE** $v_f = v_i + a\Delta t = 0 + (-9{,}8)(1) = -9{,}8\ m\cdot s^{-1}$ $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $(-9{,}8)^2 = 0 + (2)(-9{,}8)\Delta y$ ✓ $\Delta y = -4{,}9\ m$ Height/*hoogte* = $2\Delta y = (2)(4{,}9)$ $= 9{,}8\ m$ ✓	**DOWNWARD POSITIVE** $v_f = v_i + a\Delta t = 0 + (9{,}8)(1) = 9{,}8\ m\cdot s^{-1}$ $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $(9{,}8)^2 = 0 + (2)(9{,}8)\Delta y$ ✓ $\Delta y = 4{,}9\ m$ Height/*hoogte* = $2\Delta y = (2)(4{,}9)$ $= 9{,}8\ m$ ✓	(3)
12.3	**UPWARDS AS POSITIVE** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $= 0 + (2)(-9{,}8)(-9{,}8)$ ✓ $v_f = 13{,}86\ m\cdot s^{-1}$ ✓	**DOWNWARDS AS POSITIVE** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $= 0 + (2)(9{,}8)(9{,}8)$ ✓ $v_f = 13{,}86\ m\cdot s^{-1}$ ✓	
	OR **FROM POINT B** **UPWARDS AS POSITIVE** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $= (-9{,}8)^2 + (2)(-9{,}8)(-4{,}9)$ ✓ $v_f = -13{,}86\ m\cdot s^{-1}$ Magnitude = $13{,}86\ m\cdot s^{-1}$ ✓	**OR** **FROM POINT B** **DOWNWARDS AS POSITIVE** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $= (9{,}8)^2 + (2)(9{,}8)(4{,}9)$ ✓ $v_f = 13{,}86\ m\cdot s^{-1}$ ✓	(3)
12.4	**UPWARDS AS POSITIVE** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $0 = v_i^2 + (2)(-9{,}8)(4{,}9)$ ✓ $\therefore\ v_i = 9{,}8\ m\cdot s^{-1}$ $F_{net}\Delta t = m\Delta v$ $F_{net}\Delta t = m(v_f - v_i)$ } ✓ 1 mark for any $F_{net}(0{,}2)$ ✓ $= 0{,}4[9{,}8 - (-13{,}86)]$ ✓ $F_{net} = 47{,}32\ N$ ✓	**DOWNWARDS AS POSITIVE** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $0 = v_i^2 + (2)(9{,}8)(-4{,}9)$ ✓ $\therefore v_i = -9{,}8\ m\cdot s^{-1}$ $F_{net}\Delta t = m\Delta v$ $F_{net}\Delta t = m(v_f - v_i)$ } ✓ 1 mark for any $F_{net}(0{,}2)$ ✓ $= 0{,}4[-9{,}8 - (13{,}86)]$ ✓ $F_{net} = -47{,}32\ N\ \therefore\ F_{net} = 47{,}32\ N$ ✓	(6) **[14]**

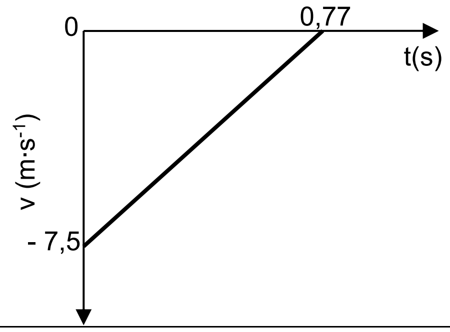
QUESTION 13

13.1 Downwards ✓
The only force acting on the object is the gravitational force/weight which acts downwards. ✓ (2)

13.2	**OPTION 1** **Upward positive** $v_f = v_i + a\Delta t$ ✓ $0 = 7{,}5 + (-9{,}8)\Delta t$ ✓ $\Delta t = 0{,}77\ s$ ✓	**Downward positive** $v_f = v_i + a\Delta t$ ✓ $0 = -7{,}5 + (9{,}8)\Delta t$ ✓ $\Delta t = 0{,}77\ s$ ✓	
	OPTION 2 **Upward positive** $F_{net}\Delta t = m(v_f - v_i)$ ✓ $mg\Delta t = m(v_f - v_i)$ $(-9{,}8)\Delta t = 0 - 7{,}5$ ✓ $\therefore \Delta t = 0{,}76531\ s\ (0{,}77\ s)$ ✓	**Downward positive** $F_{net}\Delta t = m(v_f - v_i)$ ✓ $mg\Delta t = m(v_f - v_i)$ $(9{,}8)\Delta t = 0 - (-7{,}5)$ ✓ $\therefore \Delta t = 0{,}76531\ s\ (0{,}77\ s)$ ✓	(3)
13.3	**OPTION 1** **Upward positive -** At highest point $v_f = 0$ $v_f^2 = v_i^2 + 2a\Delta y$ ✓ 0 ✓ $= (7{,}5)^2 + (2)(-9{,}8)\Delta y$ ✓ $\Delta y = 2{,}87\ (2{,}869)\ m$ ✓ It is higher than height needed to reach point **T** (2,1 m) ✓ therefore ball will pass point **T**. ✓	**Downward positive -** At highest point $v_f = 0$ $v_f^2 = v_i^2 + 2a\Delta y$ ✓ 0 ✓ $= (-7{,}5)^2 + (2)(9{,}8)\Delta y$ ✓ $\Delta y = -2{,}87\ (-2{,}869)\ m$ ✓ It is higher than height needed to reach point **T** (2,1 m) ✓ therefore ball will pass point **T**. ✓	
	OPTION 2 **Upward positive** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $\Delta y = (7{,}5)(0{,}77)$ ✓ $+ \frac{1}{2}(-9{,}8)(0{,}77)^2$ ✓ $\Delta y = 2{,}87\ m\ (2{,}86\ m)$ ✓ It is higher than height needed to reach point **T** (2,1 m) ✓ therefore ball will pass point **T**. ✓	**Downward positive** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $\Delta y = (-7{,}5)(0{,}77)$ ✓ $+ \frac{1}{2}(9{,}8)(0{,}77)^2$ ✓ $\Delta y = -2{,}87\ m\ (2{,}869\ m)$ ✓ It is higher than height needed to reach point **T** (2,1 m) ✓ therefore ball will pass point **T**. ✓	(6)

13.4





Marking criteria
Initial velocity and time for final velocity shown. ✓
Correct straight line (including orientation) drawn. ✓

(2)
[13]

QUESTION 14

14.1 (Motion during which) the only force acting is the force of gravity. ✓✓ (2)

14.2.1

OPTION 1/ **UPWARDS AS POSITIVE:** $v_f = v_i + a\Delta t$ ✓ $0 = \underline{v_i + (-9,8)(1,53)}$ ✓ $\therefore v_i = 14,99\ m\cdot s^{-1}$ $(15\ m\cdot s^{-1})$ ✓ **DOWNWARDS AS POSITIVE:** $v_f = v_i + a\Delta t$ ✓ $0 = \underline{v_i + (9,8)(1,53)}$ ✓ $\therefore v_i = -14,99\ m\cdot s^{-1}$ $\therefore v_i = 14,99\ m\cdot s^{-1}$ $(15\ m\cdot s^{-1})$ ✓	**OPTION 2** $F_{net} = ma$ $= 9,8\ (m)$ $F_{net}\Delta t = m\Delta v$ ✓ $\underline{(9,8)(m)(1,53) = (m)(v_f - 0)}$ ✓ $v_f = 14,99\ m\cdot s^{-1}$ $(15\ m\cdot s^{-1})$ ✓

(3)

14.2.2

OPTION 1/ **UPWARDS AS POSITIVE:** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= \underline{14,99(1,53) + \frac{1}{2}(-9,8)(1,53)^2}$ ✓ $= 11,47\ m$ ✓ (11,46-11,48) Maximum height is 11,47 m	**DOWNWARDS AS POSITIVE:** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= \underline{-14,99(1,53) + \frac{1}{2}(9,8)(1,53)^2}$ ✓ $= -11,47\ m$ (11,46-11,48) Maximum height is 11,47 m ✓
OPTION 2 **UPWARDS AS POSITIVE:** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $\underline{0 = (14,99)^2 + 2(-9,8)(\Delta y)}$ ✓ $\Delta y = 11,47\ m$ ✓ (11,46-11,48) Maximum height reached is 11,47 m	**DOWNWARDS AS POSITIVE:** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $\underline{0 = (-14,99)^2 + 2(9,8)(\Delta y)}$ ✓ $\Delta y = -11,47\ m$ (11,46-11,48) Maximum height reached is 11,47 m ✓

(3)

14.3

OPTION 1 **UPWARDS AS POSITIVE:** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= (14,99)(4) + \frac{1}{2}(-9,8)(4)^2$ ✓ $= -18,4\ m$ Position is 18,4 m downwards (below the edge of the roof) ✓	**DOWNWARDS AS POSITIVE:** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= (-14,99)(4) + \frac{1}{2}(9,8)(4)^2$ ✓ $= 18,4\ m$ Position is 18,4 m downwards (below the edge of the roof) ✓
OPTION 2 **UPWARDS AS POSITIVE:** $v_f = v_i + a\Delta t = (14,99) + (-9,8)(4) = -24,2\ m\cdot s^{-1}$ $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $\underline{(-24,2)^2 = (14,99)^2 + 2(-9,8)(\Delta y)}$ ✓ $\Delta y = -18,4\ m$ Ball is 18,4 m downwards (below the edge of the roof) ✓	**DOWNWARDS AS POSITIVE:** $v_f = v_i + a\Delta t = (-14,99) + (9,8)(4) = 24,2\ m\cdot s^{-1}$ $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $(24,2)^2 = (-14,99)^2 + 2(9,8)(\Delta y)$ ✓ $\Delta y = 18,4\ m$ Ball is 18,4 m downwards (below the edge of the roof) ✓

(3)

14.4 No ✓
The motion of the ball is only dependent on its initial velocity. ✓✓
OR: The initial velocity depends on the time taken to reach maximum height. (3)
[14]

QUESTION 15

15.1 (Motion during which) the only force acting is the force of gravity. ✓✓ (2)

15.2

<u>OPTION 1/</u> **UPWARDS AS POSITIVE:** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ <u>$0 = (10)^2 + (2)(-9,8)\Delta y$</u> ✓ $\Delta y = 5,10$ m (5,102) Height = <u>40 +</u> 5,10 ✓ = 45,10 m ✓	**DOWNWARDS AS POSITIVE:** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ <u>$0 = (-10)^2 + (2)(9,8)\Delta y$</u> ✓ $\Delta y = -5,10$ m (5,102) Height = <u>40 +</u> 5,10 ✓ = 45,10 m ✓
<u>OPTION 2</u> **UPWARDS AS POSITIVE:** $\Delta y = v_i\Delta t + ½ a\Delta t^2$ $0 = (10)\Delta t + ½(-9,8)\Delta t^2$ $\Delta t = 2,04$ s $\Delta y = v_i\Delta t + ½ a\Delta t^2$✓ $= (10)(1,02) + ½(-9,8)(1,02)^2$✓ $= 5,103$ Height = <u>40 +</u> 5,10 ✓ = 45,10 m ✓	**DOWNWARDS AS POSITIVE:** $\Delta y = v_i\Delta t + ½ a\Delta t^2$ $0 = (-10)\Delta t + ½(9,8)\Delta t^2$ $\Delta t = 2,04$ s $\Delta y = v_i\Delta t + ½ a\Delta t^2$✓ $= (-10)(1,02) + ½(9,8)(1,02)^2$✓ $= -5,103$ Height = <u>40 +</u> 5,10 ✓ = 45,10 m ✓

(4)

15.3 $9,8\ m\cdot s^{-2}$ ✓ downwards ✓ (2)

15.4

<u>OPTION 1/</u> **UPWARDS AS POSITIVE:** Displacement from roof to meeting point = -40+29,74 = - 10,26 m ✓ **Stone A** $\Delta y_A = v_i\Delta t + ½a\Delta t^2$ ✓ $-10,26 = 10\Delta t + ½(-9,8)\Delta t^2$ ✓ $\Delta t = 2,79$ s **Stone B** $\Delta y_B = v_i\Delta t + ½a\Delta t^2$ $-10,26 = 0 + ½(-9,8)\Delta t^2$ ✓ $\Delta t = 1,45$ s (1,447 s) x = 2,79 – 1,45 ✓ = 1,34 (s) ✓	**DOWNWARDS AS POSITIVE:** Displacement from roof to meeting point = 40 - 29,74 = 10,26 m ✓ **Stone A** $\Delta y_A = v_i\Delta t + ½a\Delta t^2$ ✓ $10,26 = -10\Delta t + ½(9,8)\Delta t^2$ ✓ $\Delta t = 2,79$ s **Stone B** $\Delta y_B = v_i\Delta t + ½a\Delta t^2$ $10,26 = 0 + ½(9,8)\Delta t^2$ ✓ $\Delta t = 1,45$ s (1,447 s) x = 2,79 – 1,45 ✓ = 1,34 (s) ✓
<u>OPTION 2</u> **UPWARDS AS POSITIVE:** Displacement from roof to meeting point = - 40 + 29,74 = - 10,26 m ✓ Displacement of ball A from max height to meeting point = -15,36 m **Stone A** $v_f = v_i + a\Delta t$ $0 = 10 + (-9,8)\Delta t$ $\Delta t = 1,02$ s $\Delta y_A = v_i\Delta t + ½a\Delta t^2$ ✓ $-15,36 = 0 + ½(-9,8)\Delta t^2$ ✓ $\Delta t = 1,77$ s $\Delta t_{tot} = 1,77 + 1,02 = 2,79$s **StoneB** $\Delta y_B = v_i\Delta t + ½a\Delta t^2$ $-10,26 = 0 + ½(-9,8)\Delta t^2$ ✓ $\Delta t = 1,45$ s (1,447 s) x = 2,79 – 1,45✓ = 1,34 (s) ✓	**DOWNWARDS AS POSITIVE:** Displacement from roof to meeting point = 40 - 29,74 = 10,26 m ✓ Displacement of ball A from max height to meeting point = 15,36 m **Stone A** $v_f = v_i + a\Delta t$ $0 = -10 + (9,8)\Delta t$ $\Delta t = 1,02$ s $\Delta y_A = v_i\Delta t + ½a\Delta t^2$ ✓ $15,36 = 0 + ½(9,8)\Delta t^2$ ✓ $\Delta t = 1,77$ s $\Delta t_{tot} = 1,77 + 1,02 = 2,79$s **StoneB** $\Delta y_B = v_i\Delta t + ½a\Delta t^2$ $10,26 = 0 + ½(9,8)\Delta t^2$ ✓ $\Delta t = 1,45$ s (1,447 s) x = 2,79 – 1,45 ✓ = 1,34 (s) ✓

(6)

15.5.1 d ✓ (1)
15.5.2 a ✓ (1)
15.5.3 f ✓ (1)
15.5.4 c ✓ (1)

[18]

QUESTION 16

16.1 (Motion of an object) under the influence of <u>gravity (weight) only</u>. ✓✓ (2)

16.2.1 $\Delta t = 0{,}67 - 0{,}64 = 0{,}03$ s ✓✓ (2)

16.2.2

<u>OPTION 1</u>	**<u>OPTION 2</u>**
$\Delta t = \frac{1{,}90 - 0{,}67}{2}$ ✓ $= 0{,}62\ s$ ✓ $(0{,}615\ s)$	$\Delta x = v_i\Delta t + \frac{1}{2} a\Delta t^2$ $(-1{,}8) = 0 + \frac{1}{2}(-9{,}8)\Delta t^2$ ✓ $\Delta t = 0{,}61$ s ✓ (0,606 s)
<u>OPTION 3</u>	**<u>OPTION 4</u>**
$\Delta t = \frac{1{,}90 + 0{,}67}{2} = 1{,}285\ s$ $\Delta t = 1{,}285 - 0{,}67$ ✓ $= 0{,}62$ s ✓ (0,615 s)	$v_f^2 = v_i^2 + 2a\Delta x$ $0 = v_i^2 + 2(-9{,}8)(1{,}8)$ $v_i = 5{,}94\ m\cdot s^{-1}$ $v_f = v_i + a\Delta t$ $0 = 5{,}94 + (-9{,}8)\Delta t$ ✓ $\Delta t = 0{,}61$ s ✓

(2)

16.2.3

<u>OPTION 1</u>	**<u>OPTION 2</u>**
Upwards positive $v_f = v_i + a\Delta t$ ✓ <u>$0 = v_i + (-9{,}8)(0{,}62)$</u> ✓ $v_i = 6{,}08\ m\cdot s^{-1}$ $(6{,}076\ m\cdot s^{-1})$ ✓	Upwards positive $\Delta y = v_i\Delta t + \frac{1}{2} a\Delta t^2$ ✓ <u>$1{,}8 = v_i(0{,}62) + \frac{1}{2}(-9{,}8)(0{,}62)^2$</u> ✓ $v_i = 5{,}94\ m\cdot s^{-1}$ $(5{,}9412\ m\cdot s^{-1})$ ✓
Downwards positive $v_f = v_i + a\Delta t$ ✓ <u>$0 = v_i + (9{,}8)(0{,}62)$</u> ✓ $v_i = -6{,}08$ $\therefore v_i = 6{,}08\ m\cdot s^{-1}$ $(6{,}076\ m\cdot s^{-1})$ ✓	Downwards positive $\Delta y = v_i\Delta t + \frac{1}{2} a\Delta t^2$ ✓ <u>$1{,}8 = v_i(0{,}62) + \frac{1}{2}(9{,}8)(0{,}62)^2$</u> ✓ $v_i = -5{,}94$ $\therefore v_i = 5{,}94\ m\cdot s^{-1}$ $(5{,}9412\ m\cdot s^{-1})$ ✓

<u>OPTION 3</u>	**<u>OPTION 4</u>**
Motion from top to bottom Downwards positive $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $v_f^2 =$ <u>$0 + 2(9{,}8)(1{,}8)$</u> ✓ $v_f = 5{,}94\ m\cdot s^{-1}$ ✓ initial velocity $= 5{,}94\ m\cdot s^{-1}$ Upwards positive $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $v_f^2 =$ <u>$0 + 2(-9{,}8)(-1{,}8)$</u> ✓ $v_f = 5{,}94\ m\cdot s^{-1}$ ✓ initial velocity $= 5{,}94\ m\cdot s^{-1}$ **Motion from bottom to top** Downwards positive $v_f^2 = v_i^2 + 2a\Delta y$ ✓ <u>$0^2 = v_i^2 + 2(9{,}8)(-1{,}8)$</u> ✓ $v_i = 5{,}94\ m\cdot s^{-1}$ ✓ Upwards positive $v_f^2 = v_i^2 + 2a\Delta y$ ✓ <u>$0 = v_i^2 + 2(-9{,}8)(1{,}8)$</u> ✓ $v_i = 5{,}94\ m\cdot s^{-1}$ ✓	Upwards positive $\Delta y = v_i\Delta t + \frac{1}{2} a\Delta t^2$ ✓ <u>$0 = v_i(1{,}23) + \frac{1}{2}(-9{,}8)(1{,}23)^2$</u> ✓ $v_i = 6{,}03\ m\cdot s^{-1}$ ✓ Downwards positive $\Delta y = v_i\Delta t + \frac{1}{2} a\Delta t^2$ ✓ <u>$0 = v_i(1{,}23) + \frac{1}{2}(9{,}8)(1{,}23)^2$</u> ✓ $v_i = -6{,}03\ m\cdot s^{-1}$ speed $= 6{,}03\ m\cdot s^{-1}$ ✓ **<u>OPTION 5</u>** $\Delta y = \left(\frac{v_f + v_i}{2}\right)\Delta t$ ✓ $1{,}8 = \left(\frac{0 + v_i}{2}\right)(0{,}62)$ ✓ $v_i = 5{,}81\ m\cdot s^{-1}$ ✓ **<u>OPTION 6</u>** $F_{net}\Delta t = m\Delta v$ $F_{net}\Delta t = m(v_f - v_i)$ } ✓ <u>$m(9{,}8)(0{,}62) = m(0 - v_i)$</u> ✓ $v_i = 5{,}94\ m\cdot s^{-1}$ ✓
<u>OPTION 7</u> $(E_p + E_k)_{floor} = (E_p + E_k)_{top}$ ✓ $(mgh + \frac{1}{2} mv^2)_{floor} = (mgh + \frac{1}{2} mv^2)_{top}$ <u>$0 + \frac{1}{2} v^2 = (9{,}8)(1{,}8) + 0$</u> ✓ $v = 5{,}94\ m\cdot s^{-1}$ ✓	

(3)

16.2.4

Calculate initial velocity:	**Calculate time Δt**
<u>OPTION 1</u> Downwards positive $v_f^2 = v_i^2 + 2a\Delta y$ ✓ <u>$0 = v_i^2 + 2(9,8)(-1,2)$</u> ✓ $v_i = -4,85\ m\cdot s^{-1}$ Upwards positive $v_f^2 = v_i^2 + 2a\Delta y$ ✓ <u>$0 = v_i^2 + 2(-9,8)(1,2)$</u> ✓ $v_i = 4,85\ m\cdot s^{-1}$ **<u>OPTION 2</u>** $(E_{mech})_{top} = (E_{mech})_{bot}$ $(E_p + E_k)_{top} = (E_p + E_k)_{Bot}$ } ✓Any one/ $(mgh + ½mv^2)_{top} = (mgh + ½mv^2)_{Bot}$ <u>$(9,8)(1,2) + 0 = 0 + (½)v^2$</u> ✓ $v_i = 4,85\ m\cdot s^{-1}$ upwards **<u>OPTION 3</u>** $W_{nc} = \Delta E_p + \Delta E_k$ $0 = (0 – mgh) + ½m(v_f^2 - v_i^2)$ } ✓Any one/ <u>$0 = -(9,8)(1,2) + ½v_i^2$</u> ✓ $v_i = 4,85\ m\cdot s^{-1}$ upwards **<u>OPTION 4</u>** $W_{net} = \Delta E_k$ $w\Delta x\cos180° = ½m((v_f^2 - v_i^2)$ } ✓Any one/ <u>$(9,8)(1,2)\cos180° = ½v_i^2$</u> ✓ $v_i = -4,85\ m\cdot s^{-1}$	<u>Upwards positive</u> $\Delta y = v_i\Delta t + ½a\Delta t^2$ ✓ <u>$1,2 = (4,85)\Delta t + ½(-9,8)\Delta t^2$</u> ✓ $\Delta t = 0,4898\ s / 0,5\ s$ $t = $ <u>$1,97 +$</u> $2(0,4898)$ ✓ $= 2,95\ s / 2,97\ s$ ✓ **OR** $\Delta y = v_i\Delta t + ½a\Delta t^2$ ✓ <u>$0 = (4,85)\Delta t + ½(-9,8)\Delta t^2$</u> ✓ $\Delta t = 0,9898\ s$ (or $\Delta t = 0$) $t = $ <u>$1,97 +$</u> $0,9898$ ✓ $= 2,96\ s$ ✓ <u>Downwards positive</u> $\Delta y = v_i\Delta t + ½a\Delta t^2$ ✓ <u>$1,2 = (-4,85)\Delta t + ½(9,8)\Delta t^2$</u> ✓ $\Delta t = 0,4898\ s / 0,5\ s$ $t = $ <u>$1,97 +$</u> $2(0,4898)$ ✓ $= 2,95\ s / 2,97\ s$ ✓ **OR** $\Delta y = v_i\Delta t + ½a\Delta t^2$ ✓ <u>$0 = (4,85)\Delta t + ½(9,8)\Delta t^2$</u> ✓ $\Delta t = 0,9898\ s$ (or $\Delta t = 0$) $t = $ <u>$1,97 +$</u> $0,9898$ ✓ $= 2,96\ s$ ✓ **OR** $v_f = v_i + a\Delta t$ ✓ <u>$-4,85 = 4,85 + (-9,8)\Delta t$</u> ✓ $\Delta t = 0,9898\ s$ $\Delta t = $ <u>$1,97 +$</u> $0,9898$ ✓ $= 2,96\ s$ ✓ **OR** <u>Upwards positive</u> $v_f = v_i + a\Delta t$ ✓ <u>$0 = 4,85 + (-9,8)\Delta t$</u> ✓ $\Delta t = 0,4949\ s$ $\Delta t = 1,97 + (2)(0,4949)$ ✓ $= 2,96\ s$ ✓ **OR** $\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓ $1,2 = \left(\frac{0 + 4,85}{2}\right)\Delta t$ ✓ $\Delta t = 0,4948\ s$ $\Delta t_{total} = 2(0,4948) = 0,99\ s$ $\Delta t = 1,97 + 0,99$ ✓ $= 2,96\ s$ ✓

OPTION 5
Downwards positive
$\Delta y = v_i\Delta t + \frac{1}{2} a\Delta t^2$ ✓
$1,2$ ✓ $= 0 + \frac{1}{2}(9,8)\Delta t^2$ ✓
$\Delta t = 0,49$ s
t = 1,97 + ✓ 2(0,49) ✓
= 2,96 s ✓
Upwards positive
$\Delta y = v_i\Delta t + \frac{1}{2} a\Delta t^2$ ✓
$-1,2$ ✓ $= 0 + \frac{1}{2}(-9,8)\Delta t^2$ ✓
$\Delta t = 0,49$ s
t = 1,97 + ✓ 2(0,49) ✓
= 2,96 s ✓

(6)
[15]

QUESTION 17

17.1 Weight / gravitational force ✓ (1)
17.2 $9,8\ m\cdot s^{-2}$ ✓ downward ✓ (2)
17.3 3 m (1)
17.4.1
UPWARDS AS POSITIVE
$v_f = v_i + a\Delta t$ ✓
$0 = v_i + (-9,8)(1,02)$ ✓
$v_i = 10\ m\cdot s^{-1}$ ✓ (9,996)
(3)

17.4.2
UPWARDS AS POSITIVE
$v_f^2 = v_i^2 + 2a\Delta y$ ✓
$0^2 = 10^2 + 2(-9,8)\Delta y$ ✓
$\Delta y = -5,1$ m (-5,102)
h = 5,1 + 3 ✓
= 8,1 m ✓ (8,102)
(4)

17.5
UPWARDS AS POSITIVE
$v_f = v_i + a\Delta t$ ✓
$0 = v_i + (-9,8)(1,1)$ ✓
$v_i = 10,78\ m\cdot s^{-1}$

$v_f^2 = v_i^2 + 2a\Delta y$
$= (-10)^2 + 2(-9,8)(-3)$
$v_f = 12,60\ m\cdot s^{-1}$

$W_{nc} = \Delta E_p + \Delta E_k$ ✓
$= 0 + \frac{1}{2}(0,06)(10,78^2$ ✓ $- 12,60^2)$ ✓
$= -1,28\ J$ ✓

(6)
[17]

QUESTION 18

18.1 No ✓
ANY ONE:
- Gravitational force is not the only force acting on the balloon. / There are other forces acting on the balloon. ✓
- Its acceleration is not $9,8\ m\cdot s^{-2}$ / is zero.
- It has constant velocity / no acceleration. (2)

18.2.1

OPTION 1
UPWARDS AS POSITIVE
$v_f^2 = v_i^2 + 2a\Delta y$ ✓
$(-62,68)^2 = v_i^2 + 2(-9,8)(-200)$ ✓
$v_i = 2,96\ m\cdot s^{-1}$
$Speed = 2,96\ m\cdot s^{-1}$ ✓

OPTION 2
UPWARDS AS NEGATIVE
$v_f^2 = v_i^2 + 2a\Delta y$ ✓
$62,68^2 = v_i^2 + 2(9,8)(200)$ ✓
$v_i = -2,96\ m\cdot s^{-1}$
$Speed = 2,96\ m\cdot s^{-1}$ ✓

OPTION 3

$W_{net} = \Delta E_k$ ✓

$F_{net}\Delta y\cos\theta = \frac{1}{2}m(v_f^2 - v_i^2)$

$m(9,8)(200)(\cos 0°) = \frac{1}{2}m(62,68^2 - v_i^2)$ ✓

$v_i = 2,96\ m\cdot s^{-1}$

$Speed = 2,96\ m\cdot s^{-1}$ ✓

Other energy equations may also be used.

(3)

18.2.2

OPTION 1

UPWARDS AS POSITIVE

$v_f = v_i + a\Delta t$ ✓

$-62,68 = 2,96 + (-9,8)\Delta t$ ✓

$\Delta t = 6,70\ s$ ✓

OPTION 2

DOWNWARDS AS POSITIVE

$v_f = v_i + a\Delta t$ ✓

$62,68 = -2,96 + (9,8)\Delta t$ ✓

$\Delta t = 6,70\ s$ ✓

OPTION 3

UPWARDS AS POSITIVE

$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓

$-200 = 2,96\Delta t + \frac{1}{2}(-9,8)\Delta t^2$ ✓

$\Delta t = 6,70\ s$ ✓

OPTION 4

DOWNWARDS AS POSITIVE

$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓

$200 = -2,96\Delta t + \frac{1}{2}(9,8)\Delta t^2$ ✓

$\Delta t = 6,70\ s$ ✓

OPTION 5

UPWARDS AS POSITIVE

$\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓

$-200 = \left(\frac{2,96 + (-62,68)}{2}\right)\Delta t$ ✓

$\Delta t = 6,70\ s$ ✓

OPTION 6

DOWNWARDS AS POSITIVE

$\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓

$200 = \left(\frac{-2,96 + (+62,68)}{2}\right)\Delta t$ ✓

$\Delta t = 6,70\ s$ ✓

(3)

18.2.3

UPWARDS AS POSITIVE

Stone B

$\Delta y = v_i\Delta t + \frac{1}{2}\Delta t^2$ ✓

$= (2,96)(6,7 - 5) + \frac{1}{2}(-9,8)(6,7 - 5)^2$ ✓✓

$= -9,13\ m$

Distance = 9,13 m

Balloon

$\Delta y = v_i\Delta t + \frac{1}{2}\Delta t^2$

$= (2,96)(6,7 - 5)$ ✓ $+ 0$

$= 5,03\ m$

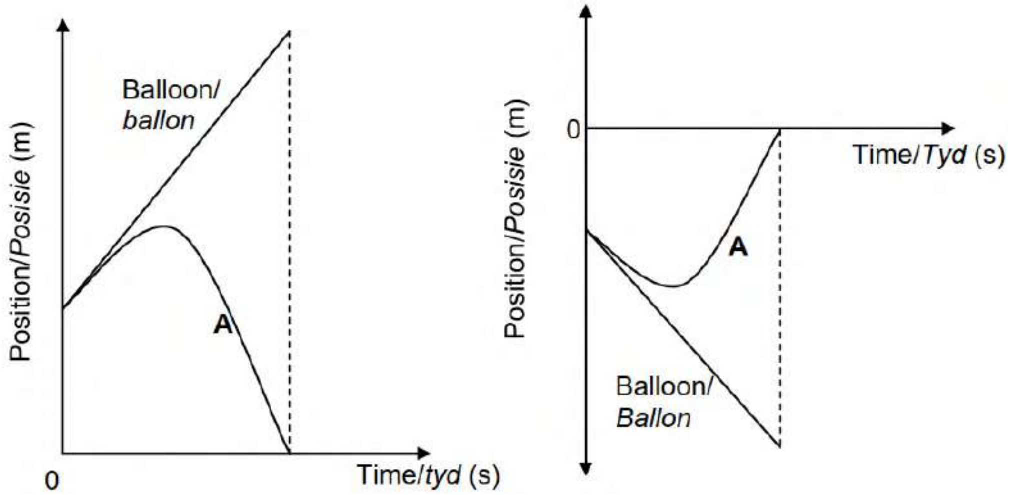
Distance = 5,03 m

Distance between balloon and B = 9,13+5,03 ✓ = 14,16 m ✓

(6)

18.3

UPWARDS POSITIVE **DOWNWARDS POSITIVE**



(4)
[18]

QUESTION 19

19.1 An object which has been given an initial velocity and then it moves under the influence of the gravitational force only / is in free fall. ✓✓ (2)

19.2.1

OPTION 1 **UPWARDS POSITIVE**	**OPTION 2** **DOWNWARDS POSITIVE**
$v_f = v_i + a\Delta t$ ✓	$v_f = v_i + a\Delta t$ ✓
$0 = 15 + (-9{,}8)\Delta t$ ✓	$0 = -15 + (9{,}8)\Delta t$ ✓
$\Delta t = 1{,}53\ s$ ✓	$\Delta t = 1{,}53\ s$ ✓

OPTION 3
UPWARDS POSITIVE

$\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓

$\Delta y = \left(\frac{15 + 0}{2}\right)\Delta t$

$\Delta y = 7{,}5\Delta t$

$v_f^2 = v_i^2 + 2a\Delta y$

$0 = 15^2 + 2(-9{,}8)(7{,}5\Delta t\,)$ ✓

$\Delta t = 1{,}53\ s$ ✓

Other equations of motion and energy formulae may also be used.

OPTION 4

$E_m(top) = E_m(30\ m)$

$\left(mgh + \frac{1}{2}mv^2\right)_{top} = \left(mgh + \frac{1}{2}mv^2\right)_{30\ m}$

$m(9{,}8)h + 0 = 0 + \frac{1}{2}m(15^2)$

$(9{,}8)h = \frac{1}{2}(15^2)$

$h = 11{,}48\ m$

UPWARDS POSITIVE

$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓

$11{,}48 = (15)\Delta t + \frac{1}{2}(-9{,}8)\Delta t^2$ ✓

$\Delta t = 1{,}53\ s$ ✓

(3)

19.2.2

OPTION 1
UPWARD POSITIVE

$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓

$= (15)(1{,}53) + \frac{1}{2}(-9{,}8)(1{,}53^2)$ ✓

$= 11{,}48\ m$

$Height = 11{,}48 + 30$ ✓

$= 41{,}48\ m$ ✓

OPTION 2
UPWARD POSITIVE

$v_f^2 = v_i^2 + 2a\Delta y$ ✓

$0 = 15^2 + 2(-9{,}8)\Delta y$ ✓

$\Delta y = 11{,}48\ m$

$Height = 11{,}48 + 30$ ✓

$= 41{,}48\ m$ ✓

Other equations of motion and energy formulae may also be used.

(4)

19.3 At the meeting point, the displacement of **Y** plus 30 m is the same as the displacement of **B** with Δt the time for **B** to hit **C**. Take upwards as positive.

$\Delta y_C = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓

$= (15)\Delta t + \frac{1}{2}(-9,8)\Delta t^2$ ✓

$= -4,9\Delta t^2 + 15\Delta t$

$\Delta y_B = v_i\Delta t + \frac{1}{2}a\Delta t^2$

$= (40)(\Delta t - 0,5✓) + \frac{1}{2}(-9,8)(\Delta t - 0,5)^2$ ✓

$= -4,9\Delta t^2 + 44,9\Delta t - 21,225$

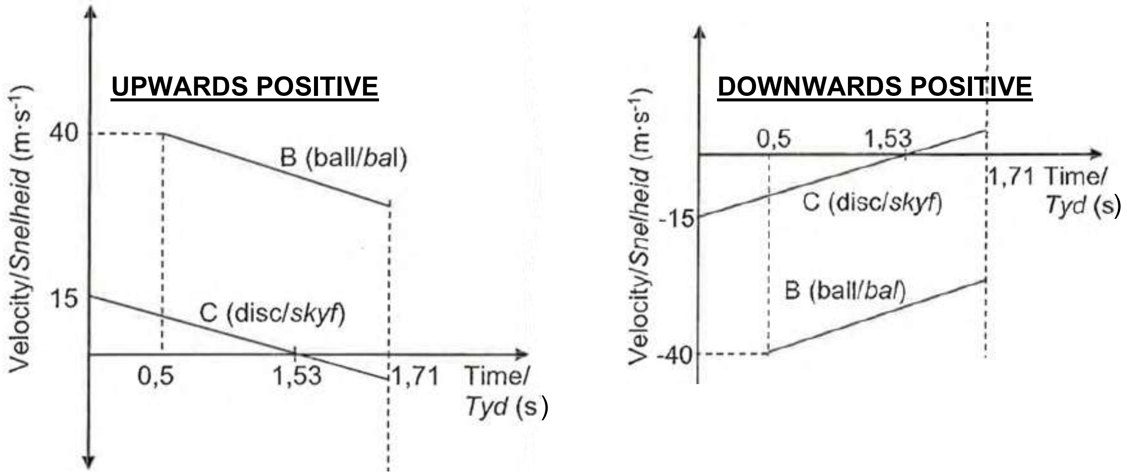
$\Delta y_C + 30 = \Delta y_B$

$-4,9\Delta t^2 + 15\Delta t + 30 = -4,9\Delta t^2 + 44,9\Delta t - 21,225$ ✓

$\Delta t = 1,71\ s$ ✓

(6)

19.4



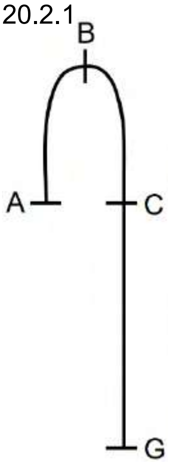
(5)

[20]

QUESTION 20

20.1 Motion in which the only force acting (on an object) is gravity/weight/gravitational force. ✓✓ (2)

20.2.1



OPTION 1 (A to B)

UPWARD AS POSITIVE

$v_f = v_i + a\Delta t$ ✓

$0 = 12 + (-9,8)\Delta t$ ✓

$\Delta t = 1,22\ s$ ✓

DOWNWARD AS POSITIVE

$v_f = v_i + a\Delta t$ ✓

$0 = -12 + (+9,8)\Delta t$ ✓

$\Delta t = 1,22\ s$ ✓

OPTION 2: (A to C)

UPWARD AS POSITIVE

$v_f = v_i + a\Delta t$ ✓

$-12 = 12 + (-9,8)\Delta t$ ✓

$\Delta t = 2,449\ s$

$\Delta t_{up} = 1,22\ s$ ✓

DOWNWARD AS POSITIVE

$v_f = v_i + a\Delta t$ ✓

$12 = -12 + (+9,8)\Delta t$ ✓

$\Delta t = 2,449\ s$

$\Delta t_{up} = 1,22\ s$ ✓

OPTION 3 (A to C)

UPWARD AS POSITIVE

$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓

$0 = 12\Delta t + \frac{1}{2}(-9,8)\Delta t^2$ ✓

$\Delta t = 2,449\ s$

$\Delta t_{up} = 1,22\ s$ ✓

DOWNWARD AS POSITIVE

$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓

$0 = -12\Delta t + \frac{1}{2}(+9,8)\Delta t^2$ ✓

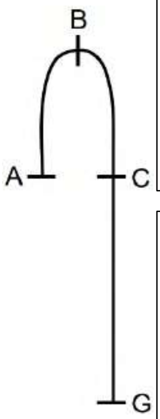
$\Delta t = 2,449\ s$

$\Delta t_{up} = 1,22\ s$ ✓

Other equations of motion and energy equations, and combinations thereof, may also be used.

(3)

20.2.2



OPTION 1: A to G

UPWARD AS POSITIVE

$v_f^2 = v_i^2 + 2a\Delta y$ ✓

$= 12^2 + 2(-9{,}8)(-25)$ ✓

$v_f = -25{,}179\ m\cdot s^{-1}$

$v_f = 25{,}179\ m\cdot s^{-1}$ ✓; *downwards* ✓

DOWNWARD AS POSITIVE

$v_f^2 = v_i^2 + 2a\Delta y$ ✓

$= (-12)^2 + 2(+9{,}8)(+25)$ ✓

$v_f = 25{,}179\ m\cdot s^{-1}$

$v_f = 25{,}179\ m\cdot s^{-1}$ ✓; *downwards* ✓

OPTION 2: A to G

UPWARD AS POSITIVE

$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$

$-25 = 12\Delta t + \frac{1}{2}(-9{,}8)\Delta t^2$

$\Delta t = 3{,}793\ s$

$\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓

$-25 = \left(\frac{12 + v_f}{2}\right)(3{,}793)$ ✓

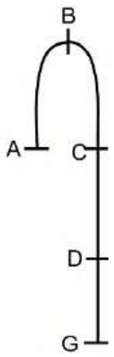
$v_f = -25{,}182\ m\cdot s^{-1}$

$v_f = 25{,}182\ m\cdot s^{-1}$ ✓; *downwards* ✓

Other equations of motion and energy equations, or combinations thereof, may also be used.

(4)

20.2.3



OPTION 1: UPWARD AS POSITIVE

A to D

$v_f^2 = v_i^2 + 2a\Delta y_{door}$

$v_f = 12^2 + 2(-9{,}8)(-25 + 1{,}9)$ ✓

$v_f = -24{,}43\ m\cdot s^{-1}$

D to G

$v_f = v_i + a\Delta t$ ✓

$-25{,}18 = -24{,}43 + (-9{,}8)\Delta t$ ✓

$\Delta t_{D\ to\ G} = 0{,}08\ s$ ✓

OPTION 2: DOWNWARD AS POSITIVE

A to D

$v_f^2 = v_i^2 + 2a\Delta y_{door}$

$v_f = (-12)^2 + 2(+9{,}8)(+25 - 1{,}9)$ ✓

$v_f = +24{,}43\ m\cdot s^{-1}$

D to G

$v_f = v_i + a\Delta t$ ✓

$25{,}18 = 24{,}43 + (+9{,}8)\Delta t$ ✓

$\Delta t_{D\ to\ G} = 0{,}08\ s$ ✓

OPTION 3: UPWARD AS POSITIVE

A to G

$v_f = v_i + a\Delta t_{ground}$

$-25{,}18 = 12 + (-9{,}8)\Delta t_{ground}$ ✓

$\Delta t_{ground} = 3{,}79\ s$ ✓

A to D

$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t_{door}^2$

$(-25 + 1{,}9) = 12\Delta t + \frac{1}{2}(-9{,}8)\Delta t_{door}^2$ ✓

$\Delta t_{door} = 3{,}72\ s$

D to G

$\Delta t_{door-ground} = 3{,}79 - 3{,}72$

$= 0{,}07\ s$ ✓

OPTION 4: DOWNWARD POSITIVE

A to G

$v_f = v_i + a\Delta t_{ground}$

$25{,}18 = -12 + (+9{,}8)\Delta t_{ground}$ ✓

$\Delta t_{ground} = 3{,}79\ s$ ✓

A to D

$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t_{door}^2$

$(+25 - 1{,}9) = -12\Delta t + \frac{1}{2}(9{,}8)\Delta t_{door}^2$ ✓

$\Delta t_{door} = 3{,}72\ s$

D to G

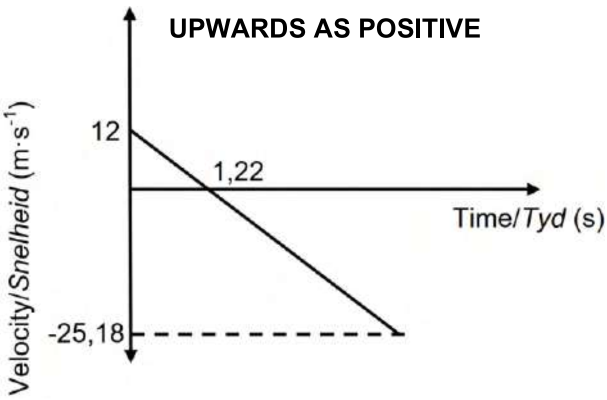
$\Delta t_{door-ground} = 3{,}79 - 3{,}72$

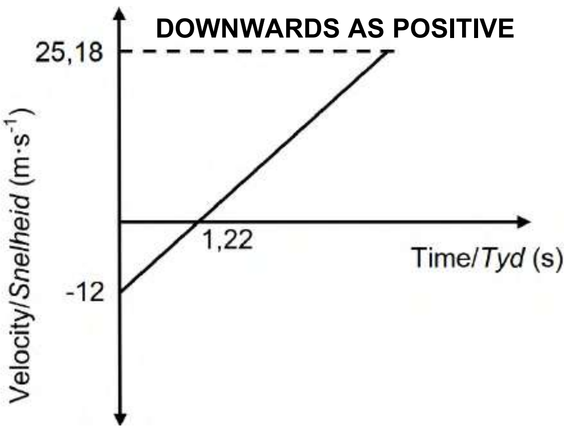
$= 0{,}07\ s$ ✓

Other equations of motion, and energy equations, and combinations thereof, may also be used.

(4)

20.3





(3)

[16]

QUESTION 21

21.1 Motion under the influence of gravity/weight/gravitational force only. ✓✓ **OR**
Motion in which the only force acting is gravity. (2)

21.2.1

<u>OPTION 1</u>

UPWARD AS POSITIVE

$$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2 \checkmark$$
$$-15{,}2 = (0)\Delta t + \frac{1}{2}(-9{,}8)\Delta t^2 \checkmark$$
$$\Delta t = 1{,}76\ s \checkmark$$

DOWNWARD AS POSITIVE

$$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2 \checkmark$$
$$15{,}2 = (0)\Delta t + \frac{1}{2}(+9{,}8)\Delta t^2 \checkmark$$
$$\Delta t = 1{,}76\ s \checkmark$$

<u>OPTION 2</u>

UPWARD AS POSITIVE

$$v_f^2 = v_i^2 + 2a\Delta y$$
$$= 0^2 + 2(-9{,}8)(-15{,}2)$$
$$v_f = -17{,}26\ m\cdot s^{-1}$$

$$v_f = v_i + a\Delta t \checkmark$$
$$-17{,}26 = 0 + (-9{,}8)\Delta t \checkmark$$
$$\Delta t = 1{,}76\ s \checkmark$$

DOWNWARD AS POSITIVE

$$v_f^2 = v_i^2 + 2a\Delta y$$
$$= 0^2 + 2(+9{,}8)(+15{,}2)$$
$$v_f = 17{,}26\ m\cdot s^{-1}$$

$$v_f = v_i + a\Delta t \checkmark$$
$$17{,}26 = 0 + (+9{,}8)\Delta t \checkmark$$
$$\Delta t = 1{,}76\ s \checkmark$$

Other equations of motion and energy formulae may also be used.

<u>OPTION 3</u>

$$E_{mech}(top) = E_{mech}(bottom)$$
$$(E_p + E_k)_{top} = (E_p + E_k)_{bottom}$$
$$\left(mgh + \frac{1}{2}mv^2\right)_{top} = \left(mgh + \frac{1}{2}mv^2\right)_{bottom}$$
$$(m)(9{,}8)(15{,}2) + 0 = 0 + \frac{1}{2}mv_f^2$$
$$v_f = 17{,}26\ m\cdot s^{-1}$$

UPWARD AS POSITIVE

$$v_f = v_i + a\Delta t \checkmark$$
$$-17{,}26 = 0 + (-9{,}8)\Delta t \checkmark$$
$$\Delta t = 1{,}76\ s \checkmark$$

OR

DOWNWARD AS POSITIVE

$$v_f = v_i + a\Delta t \checkmark$$
$$17{,}26 = 0 + (+9{,}8)\Delta t \checkmark$$
$$\Delta t = 1{,}76\ s \checkmark$$

(3)

21.2.2

<u>OPTION 1</u>

UPWARD AS POSITIVE

<u>Δt for **A** for 3,2 m</u>:

$$\Delta y = v_i\Delta t_A + \frac{1}{2}a\Delta t_A^2 \checkmark$$
$$-3{,}2 = (0)\Delta t_A + \frac{1}{2}(-9{,}8)\Delta t_A^2 \checkmark$$
$$\Delta t_A = 0{,}81\ s$$

<u>Δt for **B**</u>:

$$\therefore \Delta t_B = 1{,}76 - 0{,}81 \checkmark = 0{,}95\ s$$

$$\Delta y_B = v_i\Delta t_B + \frac{1}{2}a\Delta t_B^2$$
$$0 = v_i(0{,}95) + \frac{1}{2}(-9{,}8)(0{,}95^2) \checkmark$$
$$v_i = 4{,}66\ m\cdot s^{-1}$$
$$\therefore Magnitude\ of\ v_i = 4{,}66\ m\cdot s^{-1} \checkmark$$

<u>OPTION 2</u>

DOWNWARD AS POSITIVE

<u>Δt for **A** for 3,2 m</u>:

$$\Delta y = v_i\Delta t_A + \frac{1}{2}a\Delta t_A^2 \checkmark$$
$$3{,}2 = 0\Delta t_A + \frac{1}{2}(+9{,}8)\Delta t_A^2 \checkmark$$
$$\Delta t_A = 0{,}81\ s$$

<u>Δt for **B**</u>:

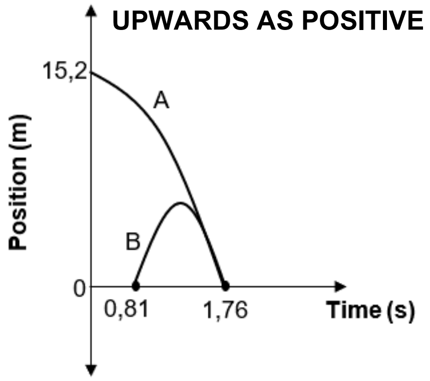
$$\therefore \Delta t_B = 1{,}76 - 0{,}81 \checkmark = 0{,}95\ s$$

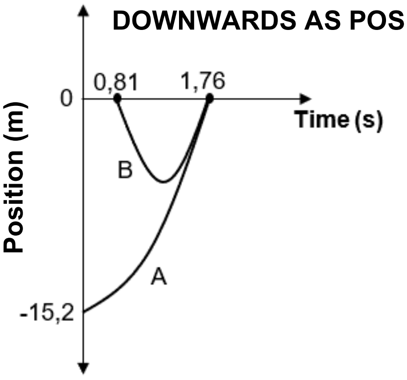
$$\Delta y_B = v_i\Delta t_B + \frac{1}{2}a\Delta t_B^2$$
$$0 = v_i(0{,}95) + \frac{1}{2}(+9{,}8)(0{,}95^2) \checkmark$$
$$v_i = -4{,}66\ m\cdot s^{-1}$$
$$\therefore Magnitude\ of\ v_i = 4{,}66\ m\cdot s^{-1} \checkmark$$

Other equations of motion and energy formulae may also be used.

(5)

21.3





Marking criteria
- Initial position of ball **A** = 15,2 m and **B** = 0 m. ✓
- Starting time for **A** = 0 s and **B** = 0,81 s. ✓
- Both balls strike the ground at t = 1,76 s. ✓
- Shape of graph for ball **A.** ✓
- Shape of graph for ball **B.** ✓

(5)
[15]

QUESTION 22

22.1 Motion under the influence of gravity/weight/gravitational force only. ✓✓
Motion in which the only force acting is gravity/weight/gravitational force. (2)

22.2

UPWARDS AS POSITIVE: A-B

$v_f^2 = v_i^2 + 2a\Delta y$ ✓
$0^2 = v_i^2 + 2(-9,8)(5,89)$ ✓
$v_i = +10,744\ m \cdot s^{-1}$
$Speed = 10,744\ m \cdot s^{-1}$ ✓

DOWNWARDS AS POSITIVE: A-B

$v_f^2 = v_i^2 + 2a\Delta y$ ✓
$0 = v_i^2 + 2(+9,8)(-5,89)$ ✓
$v_i = -10,744\ m \cdot s^{-1}$
$Speed = 10,744\ m \cdot s^{-1}$ ✓

(3)

22.3.1

OPTION 1

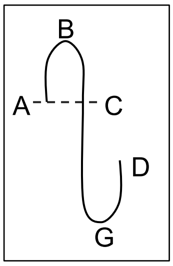
UPWARDS AS POSITIVE: A-G

$v_f^2 = v_i^2 + 2a\Delta y$ ✓
$v_f^2 = 10,744^2 + 2(-9,8)(-15,3)$ ✓
$= 415,3135$
$v_f = -20,379\ m \cdot s^{-1}$

OR

UPWARDS AS POSITIVE: B-G

$v_f^2 = v_i^2 + 2a\Delta y$ ✓
$v_f^2 = 0^2 + 2(-9,8)(-21,19)$ ✓
$= 415,324$
$v_f = -20,379\ m \cdot s^{-1}$



OR

UPWARDS AS POSITIVE: A-G

$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓
$-15,3 = (10,744)\Delta t + \frac{1}{2}(-9,8)\Delta t^2$ ✓
$\Delta t = 3,18\ s$

$v_f = v_i + a\Delta t$
$= 10,744 + (-9,8)(3,18)$
$= -20,42\ m \cdot s^{-1}$

OR

UPWARDS AS POSITIVE: C-G

$v_f^2 = v_i^2 + 2a\Delta y$ ✓
$v_f^2 = (-10,744)^2 + 2(-9,8)(-15,3)$ ✓
$= 415,3135$
$v_f = -20,379\ m \cdot s^{-1}$

Energy equations may also be used to calculate the strike speed at the ground.

DURING COLLISION

$\Delta E_k = E_{kf} - E_{ki}$ ✓
$\Delta E_k = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$
$= \frac{1}{2}(0,5)(11,92^2) - \frac{1}{2}(0,5)(20,379^2)$ ✓
$= 68,31\ J$ ✓

OPTION 2

DOWNWARDS AS POSITIVE: A-G

$v_f^2 = v_i^2 + 2a\Delta y$ ✓

$v_f^2 = (-10{,}744)^2 + 2(+9{,}8)(+15{,}3)$ ✓

$= 415{,}3135$

$v_f = 20{,}379\ m \cdot s^{-1}$

OR

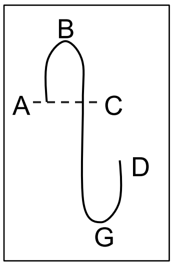
DOWNWARDS AS POSITIVE: B-G

$v_f^2 = v_i^2 + 2a\Delta y$ ✓

$v_f^2 = 0^2 + 2(+9{,}8)(+21{,}19)$ ✓

$= 415{,}324$

$v_f = 20{,}379\ m \cdot s^{-1}$



OR

DOWNWARDS AS POSITIVE: A-G

$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓

$+15{,}3 = (-10{,}744)\Delta t + \frac{1}{2}(+9{,}8)\Delta t^2$ ✓

$\Delta t = 3{,}18\ s$

$v_f = v_i + a\Delta t$

$= -10{,}744 + (+9{,}8)(3{,}18)$

$= 20{,}42\ m \cdot s^{-1}$

OR

DOWNWARDS AS POSITIVE: C-G

$v_f^2 = v_i^2 + 2a\Delta y$ ✓

$v_f^2 = (+10{,}744)^2 + 2(+9{,}8)(+15{,}3)$ ✓

$= 415{,}3135$

$v_f = 20{,}379\ m \cdot s^{-1}$

Energy equations may also be used to calculate the strike speed at the ground.

DURING COLLISION

$\Delta E_k = E_{kf} - E_{ki}$ ✓

$\Delta E_k = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

$= \frac{1}{2}(0{,}5)(11{,}92^2) - \frac{1}{2}(0{,}5)(20{,}379^2)$ ✓

$= 68{,}31\ J$ ✓

(5)

22.3.2

UPWARDS AS POSITIVE: G-D

$v_f = v_i + a\Delta t$ ✓

$0 = 11{,}92 + (-9{,}8)\Delta t$ ✓

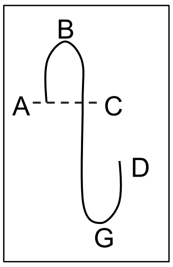
$\Delta t = 1{,}22\ s$ ✓

DOWNWARDS AS POSITIVE: G-D

$v_f = v_i + a\Delta t$ ✓

$0 = -11{,}92 + (+9{,}8)\Delta t$ ✓

$\Delta t = 1{,}22\ s$ ✓



(3)

22.4.1 11,92 ($m \cdot s^{-1}$) ✓ (1)

22.4.2 10,74 ($m \cdot s^{-1}$) ✓ (1)

22.4.3 1,22 (s) ✓ (1)

[16]

MOMENTUM AND IMPULSE

QUESTION 1

1.1

$p = mv$ ✓ $= 50(5)$ ✓ $= 250\ kg·m·s^{-1}$ ✓ (downward)	**OR**	$p = mv$ ✓ $= 50(-5)$ ✓ $= -250\ kg·m·s^{-1}$ ∴ $250\ kg·m·s^{-1}$ ✓ (downward)

(3)

1.2 The product of the net force and the time interval during which the force acts. ✓✓ (2)

1.3

$\Delta p = F_{net}\Delta t$ ✓ $0 - 250$ ✓ $= F_{net}(0,2)$ $F_{net} = -1\ 250\ N$ ∴ $F_{net} = 1\ 250\ N$ ✓	$\Delta p = F_{net}\Delta t$ ✓ $250 - 0$ ✓ $= F_{net}(0,2)$ $F_{net} = 1\ 250\ N$ ✓	$\Delta p = F_{net}\Delta t$ ✓ $50(0 – (-5))$ ✓ $= F_{net}(0,2)$ $F_{net} = 1\ 250\ N$ ✓

(3)

1.4 Greater than ✓ (1)

1.5 For the same momentum change, ✓
the stopping time (contact time) ✓ will be smaller (less), ✓
∴ the (upward) force exerted (on her) is greater. (3)

[12]

QUESTION 2

2.1 Momentum is the product of an object's mass and its velocity. ✓✓ (2)

2.2

Direction of motion positive:	**Direction of motion negative:**
$\Delta p = mv_f - mv_i$ ✓ $= (175)(0 - (+20))$ ✓ $= -3\ 500\ kg·m·s^{-1}$ ✓ ∴ $\Delta p = 3\ 500\ kg·m·s^{-1}$ opposite to direction of motion ✓	$\Delta p = mv_f - mv_i$ ✓ $= (175)(0 - (-20))$ ✓ $= 3\ 500\ kg·m·s^{-1}$ ✓ ∴ $\Delta p = 3\ 500\ kg·m·s^{-1}$ opposite to direction of motion ✓

(4)

2.3

Direction of motion positive:	**Direction of motion negative:**
$F_{net}\Delta t = \Delta p$ ✓ $f(8) = -3\ 500$ ✓ $f = -437,5\ N$ ✓ ∴ $f = 437,5\ N$ opposite to direction motion ✓	$F_{net}\Delta t = \Delta p$ ✓ $f(8) = 3\ 500$ ✓ $f = 437,5\ N$ ✓ ∴ $f = 437,5\ N$ opposite to direction of motion ✓

(4)
[10]

QUESTION 3

3.1 A collision in which both total momentum and total kinetic energy are conserved. ✓✓ (2)

3.2 **OPTION 1**

For ball A

$(E_{mech})_{top} = (E_{mech})_{bottom}$
$(E_K + E_P)_{top} = (E_K + E_P)_{bottom}$
$(½mv^2 + mgh)_{top} = (½mv^2 + mgh)_{bottom}$
} Any one ✓

$½ (0,2)(0)^2 + (0,2)(9,8)(0,2)_{top} = E_k + m(9,8)(0)_{bottom}$ ✓

$E_k = 0,39\ J$ ✓

OPTION 2

$W_{nc} = \Delta E_p + \Delta E_k$ ✓ ∴ $0 = mg(h_f – h_i) + ½m(v_f^2 – v_i^2)$

$0 = (0,2)(9,8)(0,2 – 0) + ½mv_f^2 – ½ (0,2)(0)^2$ ✓ ∴ $E_k = 0,39\ J$ ✓ (3)

3.3

$\Sigma E_{Kbefore} = \Sigma E_{Kafter}$
$E_{KiA} + E_{KiB} = E_{KfA} + E_{KfB}$
$E_{KiA} + E_{KiB} = ½ m_A v_{fA}^2 + E_{KfB}$
} ✓Any one

$0,39 + 0$ ✓ $= ½ (0.2)v_{fA}^2 + 0,12$ ✓ ∴ $v_{fA} = 1,64\ m·s^{-1}$ ✓ (4)

3.4 $E_{Kbefore} = ½ m_A v_{iA}^2$ ∴ $0,39 = ½ (0,2) v_{iA}^2$ ✓ ∴ $v_{iA} = 1,98\ m·s^{-1}$

Impulse $= m(v_f - v_i)$
Impulse $= m(v_{iA} - v_{fA})$
} ✓Any one

$= 0,2(-1,64)$ ✓ $- (0,2)(1,98)$ ✓ $= 0,72\ N·s$ ✓ (5)

[14]

QUESTION 4

4.1

OPTION 1	**OPTION 2**
Take motion to the right as positive. $\Sigma p_i = \Sigma p_f$ $(m_1 + m_2)v_i = m_1v_{f1} + m_2v_{f2}$ } ✓ Any one $(3 + 0,02)(0)$ ✓ $= (3)(-1,4) + (0,02) v_{f2}$ ✓ $v_{f2} = 210\ m·s^{-1}$ ✓	Take motion to the left as positive. $\Sigma p_i = \Sigma p_f$ $(m_1 + m_2)v_i = m_1v_{f1} + m_2v_{f2}$ } ✓ Any one $(3 + 0,02)(0)$ ✓ $= (3)(1,4) + (0,02) v_{f2}$ ✓ $v_{f2} = -210\ m·s^{-1}$ ∴ speed $= 210\ m·s^{-1}$ ✓

(4)

4.2

OPTION 1	OPTION 2
$v_f^2 = v_i^2 + 2a\Delta x$ ✓ $0 = 210^2 + 2a(0,4)$ ✓ $a = -55\ 125\ m\cdot s^{-2}$ $F_{net} = ma$ ✓ $= (0,02)(-55\ 125)$ ✓ $= -1\ 102,5\ N$ Magnitude of force = 1 102,5 N ✓	$\Delta x = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓ $\therefore\ 0,4 = \left(\frac{210+0}{2}\right)\Delta t$ ✓ $\therefore \Delta t = 0,004\ s\ (0,00381 s)$ $F_{net}\Delta t = \Delta p = m\Delta v$ ✓ $\therefore F_{net} = \frac{(0,02)(0-210)}{0,004}$ ✓ $= -1\ 050\ N$ Magnitude of force = 1 050 N ✓

(5)

4.3 The same as/equal ✓ (1)

[10]

QUESTION 5

5.1 The total (linear) momentum of an isolated/(closed system ✓ is constant/conserved. ✓ (2)

5.2.1 $\sum p_i = \sum p_f$ ✓

$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$

$(m_1 + m_2)v_i = m_1v_{1f} + m_2v_{2f}$

0 ✓ $= (0,4)v_{1f} + 0,6\ (4)$ ✓

$v_{1f} = -6\ m\cdot s^{-1}$

$= 6\ m\cdot s^{-1}$ to the left/*na links* ✓

(4)

5.2.2

OPTION 1	OPTION 2	OPTION 3
$\Delta p = F_{net}\Delta t$ ✓ $[(0,6)(4) - 0]$ ✓ $= F_{net}\ (0,3)$ ✓ $F_{net} = 8\ N$ ✓ ***OR/OF*** $m(v_f - v_i) = F_{net}\Delta t$ ✓ $0,6(4 - 0)$ ✓ $= F_{net}(0,3)$ ✓ $F_{net} = 8\ N$ ✓	$v_f = v_i + a\Delta t$ $4 = 0 + a(0,3)$ $a = 13,33\ m\cdot s^{-2}$ $F_{net} = ma$ $= 0,6(13,33)$ $F_{net} = 8\ N$ ✓	$\Delta p = F_{net}\Delta t$ ✓ $[(0,4)(6) - 0]$ ✓ $= F_{net}\ (0,3)$ ✓ $F_{net} = 8\ N$ ✓ ***OR/OF*** $m(v_f - v_i) = F_{net}\Delta t$ ✓ $0,4(6 - 0)$ ✓ $= F_{net}(0,3)$ ✓ $F_{net} = 8\ N$ ✓

(4)

5.3 No ✓ (1)

[11]

QUESTION 6

6.1 The total (linear) momentum of an isolated/closed system ✓ is constant/conserved. ✓ (2)

6.2.1

OPTION 1	OPTION 2
$\sum p_i = \sum p_f$ $m_1 v_{1i} + m_2v_{2i} = m_1 v_{1f} + m_2v_{2f}$ } ✓ any one $m_1 v_{1i} + m_2v_{2i} = (m_1 + m_2)v_f$ $(5)(4) + (3)(0)$ ✓ $= (5 + 3)v_f$ ✓ $\therefore v = 2,5\ m\cdot s^{-1}$ ✓	$\Delta p_{5kg} = -\Delta p_{3kg}$ ✓ $mv_f - mv_i = mv_f - mv_i$ $5v_f - (5)(4)$ ✓ $= 3v_f - (3)(0)$ ✓ $v_f = 2,5\ m\cdot s^{-1}$ ✓

(4)

6.2.2

OPTION 1 $F_{net}\Delta t = \Delta p = (p_f - p_i) = (mv_f - mv_i)$ ✓ $\therefore$ $F_{net}(0,3)$ ✓ $= 8\ [(0 - (2,5)]$ ✓
$\therefore$ $F_{net} = -66,67\ N$ $\therefore F_{net} = 66,67\ N$ ✓

OPTION 2	OPTION 3
$F_{net} = ma$ ✓ $= \frac{m(v_f - v_i)}{\Delta t} = \frac{8(0 - 2,5)}{0,3}$ ✓ $= -66,67\ N$ $\therefore F_{net} = 66,67\ N$ ✓	$v_f = v_i + a\Delta t \therefore 0 = 2,5 + a(0,3)$ ✓ $\therefore a = -8,333\ m\cdot s^{-2}$ $F_{net} = ma$ ✓ $= 8\ (-8,333)$ ✓ $= -66,67\ N$ $\therefore F_{net} = 66,67\ N$ ✓

(4)

[10]

QUESTION 7

7.1 A system on which the resultant/net external force is zero. ✓ (2)

7.2.1

OPTION 1	OPTION 2
$p = mv$✓ ∴ $\underline{30\ 000 = (1\ 500)v}$ ✓ ∴$v = 20\ m\cdot s^{-1}$✓	$\Delta p = mv_f - mv_i$ ✓ ∴ $\underline{0 = (1\ 500)v_f - 30\ 000}$ ✓ ∴ $v = 20\ m\cdot s^{-1}$✓

(3)

7.2.2

OPTION 1	OPTION 2
$\sum p_i = \sum p_f$ $m_1 v_{1i} + m_2v_{2i} = m_1 v_{1f} + m_2v_{2f}$ } ✓ for any $\underline{30\ 000 + (900)(-15)}$ ✓ = $\underline{14\ 000 + 900v_B}$✓ ∴ $v_B = 2,78\ m\cdot s^{-1}$ ✓east ✓	$\Delta p_A = -\Delta p_B$ $p_f - p_i = -(mv_f - mv_i)$ } ✓ for any $\underline{14\ 000 - 30\ 000}$ ✓= $\underline{900v_f - 900(-15)}$ ✓ $v_f = 2,78\ m\cdot s^{-1}$✓ east

7.2.3

OPTION 1	OPTION 2
Slope = $\frac{\Delta p}{\Delta t}$ = F_{net}✓ = $\frac{(14\ 000 - 30\ 000)}{20,2 - 20,1}$ ✓ ✓ = - 160 000 ∴ F_{net} = 160 000 N ✓	$F_{net}\Delta t = \Delta p$ ✓ $F_{net}(0,1)$ ✓ = $\underline{14\ 000 - 30\ 000}$ ✓ F_{net} = - 160 000 N F_{net} = 160 000 N ✓

OPTION 3
$F_{net}\Delta t = \Delta p$ ✓ ∴ $F_{net}(0,1)$ ✓ = $\underline{900[(2,78) - (-15)]}$ ✓ ∴ F_{net} = - 160 020 N (4)
$F_A = - F_B$ ∴ F_{net} = 160 020 N ✓ **[13]**

QUESTION 8

8.1

$v = \frac{\Delta x}{\Delta t} = \frac{0,2}{0,4} = 0,5\ m\cdot s^{-1}$	$v = \frac{\Delta x}{\Delta t} = \frac{0,4}{0,8} = 0,5\ m\cdot s^{-1}$	$v = \frac{\Delta x}{\Delta t} = \frac{0,6}{1,2} = 0,5\ m\cdot s^{-1}$
✓ Formula	✓ Correct substitution in all three equations.	✓ Arriving at correct answer.

(3)

8.2 The total linear momentum of a closed/isolated system is constant/is conserved. (2)

8.3 $\Sigma p_i = \Sigma p_f$
$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$ } ✓ Any one
$\underline{(3,5)(0,5)}$ ✓ = $\underline{(3,5 + 6)v_f}$ ✓
$v_f = v_{6kg} = 0,184\ m\cdot s^{-1}$

For trolley B:
$F_{net}\Delta t = \Delta p = m\Delta v$✓
$\underline{F_{net}(0,5) = 6(0,184 - 0)}$ ✓ ∴ F_{net} = 2,21 N✓
∴ Magnitude of the average net force experienced by trolley B = 2,21 N·✓

For trolley A:
$F_{net}\Delta t = \Delta p = m\Delta v$✓
$\underline{F_{net}(0,5) = 3,5(0,184 - 0,5)}$ ✓ ∴ F_{net} = - 2,21 N·
∴ Magnitude of the average net force experienced by trolley B = 2,21 N·✓ (6)
[11]

QUESTION 9

9.1 It is the <u>product of the resultant/net force acting on an object</u>✓ and <u>the time the resultant/net force acts on the object</u>. ✓ (2)

9.2.1 $p = mv$ ✓ = (0,03)(700) ✓ = 21 kg·m·s^{-1} ✓ (3)

9.2.2 **OPTION 1**

Δt for a bullet = $\frac{60}{220}$ ✓= 0,27 s

$F_{net}\Delta t = \Delta p = (p_f - p_i) = (mv_f - mv_i)$ **OR** $F_{ave\ gun\ on\ bullet} = \frac{\Delta p}{\Delta t} = \frac{21 - 0}{0,27}$ ✓ = 77,01 N ✓ (77,78 N)

∴average force of bullet on gun = 77,01 N / 77,8 N to the west ✓

OPTION 2
$F_{net}\Delta t = \Delta p = (p_f - p_i) = (mv_f - mv_i)$
$F_{av} = \frac{\Delta p}{\Delta t}$ } ✓ Any one
Δp_{tot} = (21)(220) ✓ = 4 620 kg·m·s^{-1}
$F_{ave\ gun\ on\ bullet} = \frac{4\ 620 - 0}{60}$ ✓ = 77,00 N ✓
∴ average force of bullet on gun = 77,01 N / 77,78 N to the west ✓ (5)

9.3 77 N / 77,78 N ✓ to the east ✓ (2)
[12]

QUESTION 10

10.1 The total linear momentum of a closed/isolated system is constant/conserved. ✓✓ (2)

10.2 $\Sigma p_i = \Sigma p_f$
$m_Bv_{Bi} + m_bv_{bi} = m_Bv_{Bf} + m_bv_{bf}$ } ✓ Any one
$\Delta p_{bullet} = -\Delta p_{block}$
$\underline{(0,015)(400)}$ ✓ + 0 = (0,015)v_{Bf} + $\underline{2(0,7)}$ ✓ ∴ V_{Bf} = 306,67 m·s^{-1}✓ (4)

10.3

OPTION 1

$F_{net}\Delta t = \Delta p$
$\Delta p = mv_f - mv_i$ } ✓ Any one

For bullet:
$\Delta p = (0,015)(306,666 - 400)$ ✓
$= -1,4\ kg\cdot m\cdot s^{-1}$
$F_{net}(0,002) = -1,4 \therefore F_{net} = -700\ N$

For block:
$\Delta p = (2)(0,7 - 0)$ ✓
$= 1,4\ kg\cdot m\cdot s^{-1}$
$F_{net}(0,002) = 1,4 \therefore F_{net} = 700\ N$

$W_{net} = \Delta E_k$
$F_{net}\Delta x\cos\theta = \frac{1}{2} m(v_f^2 - v_i^2)$
$(700)\Delta x\cos180° = \frac{1}{2}(0,015)(306,67^2 - 400^2)$ ✓
$\therefore \Delta x = 0,71\ m$ ✓

$F_{net} = ma$
$-700 = (0,015)a$ **OR** $700 = (0,015)a$
$a = -46\ 666,67$ **OR** $46\ 665\ m\cdot s^{-2}$

$\Delta x = v_i\Delta t + \frac{1}{2} a\Delta t^2$
$= (400)(0,002)$ ✓ $+ \frac{1}{2}(-46666,67)(0,002)^2$ ✓
$= 0,71\ m\ (0,70667)\ m$ ✓
OR
$v_f^2 = v_i^2 + 2a\Delta x$
$(306,67)^2$ ✓ $= (400)^2 + 2(-46\ 666,67)\Delta x$ ✓
$\Delta x = 0,71\ m\ (0,70667\ m)$ ✓

OPTION 2

$v_f = v_i + a\Delta t$ ✓ $\therefore 306,666 = 400 + a(0,002)$ ✓ $\therefore a = -46\ 667\ m\cdot s^{-2}$

$v_f^2 = v_i^2 + 2a\Delta x \therefore (306,666)^2$ ✓ $= 400^2 + 2(-4667)\Delta x$ ✓ $\therefore \Delta x = 0,71\ m\ (0,706\ m)$ ✓ (5) **[11]**

QUESTION 11

11.1 The total linear momentum of a closed/isolated system remains constant/is conserved.✓✓ (2)

11.2 $\Sigma p_i = \Sigma p_f$
$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$ } ✓ any one
For the system cat-skate board **A**
$(3,5)(0) + (2,6)(0)$ ✓ $= (3,5)v_{skateboard} + (2,6)(3)$ ✓ $\therefore v_{skateboard} = 2,23\ m\cdot s^{-1}$ ✓ to the left ✓ (5)

11.3

OPTION 1	**OPTION 2**
$F_{net}\Delta t = \Delta p = mv_f - mv_i$ ✓ $= (3,5)(1,28 - 0)$ ✓ $= 4,48\ N\cdot s$ ✓	$F_{net}\Delta t = \Delta p = mv_f - mv_i$ ✓ $= (2,6)(1,28 - 3)$ ✓ $= -4,48\ N\cdot s$ ✓

(3) **[10]**

QUESTION 12

12.1 $E_{(mech\ top)} = E_{(mech\ bottom)}$
$(E_p + E_k)_{top/bo} = (E_p + E_k)_{bottom}$
$(mgh + \frac{1}{2} mv^2)_{top} = (mgh + \frac{1}{2} mv^2)_{bottom}$ } ✓ for any
$(1,5)(9,8)(2) + 0$ ✓ $= 0 + \frac{1}{2}(1,5)v^2$ ✓ $\therefore v = 6,26\ m\cdot s^{-1}$ ✓ (4)

12.2 The total linear momentum of a closed/isolated system is constant/conserved. ✓✓ (2)

12.3 $\Sigma p_i = \Sigma p_f$
$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$ } ✓ for any
$m_1v_{1i} + m_2v_{2i} = (m_1 + m_2)v$
$(1,5)(6,26) + 0$ ✓ $= (1,5 + 2)v_f$ ✓ $\therefore v_f = 2,68\ m\cdot s^{-1}$ ✓ (4)

12.4

OPTION 1	**OPTION 2**
$\Delta x = v\Delta t$ ✓ $= (2,68)(3)$ ✓ $= 8,04\ m$ ✓	$\Delta x = v_i\Delta t + \frac{1}{2} a\Delta t^2$ ✓ $= (2,68)(3) + \frac{1}{2}(0)(3)^2$ ✓ $= 8,04\ m$ ✓ (Range 8,04 – 8,05)

(3) **[13]**

QUESTION 13

13.1 Momentum is the product of the mass of an object and its velocity. ✓✓ (2)

13.2 To the left ✓ Newton's third law ✓ (2)

NOTE: For QUESTIONS 13.3 and 13.4 motion to the right has been taken as positive.

13.3

OPTION 1
$\sum p_i = \sum p_f$
$m_1v_{1i} + m_2v_{2i} = m_1v_{2f} + m_2v_{2f}$ } ✓
mass of girl is m
$\{(m + 2)(0)\} + \{8(0)\}$ ✓ $= \{(m + 2)(-0,6)\}$ ✓ $+ (8)(4)$ ✓ $\therefore m = 51,33\ kg$ ✓

OPTION 2	**OPTION 3**
$\sum p_i = \sum p_f$ $m_1v_{1i} + m_2v_{2i} = m_1v_{2f} + m_2v_{2f}$ $0 = m_1v_{1f} + m_2v_{2f}$ } ✓ 0✓ $= (8)(4)$ ✓ $+ m_2(-0,6)$ ✓ $\therefore m_2 = 53,33\ kg \therefore m_{girl} = 53,33 - 2 = 51,33\ kg$ ✓	$\Delta p_{girl} = -\Delta p_{parcel}$ ✓ $m(v_f - v_i) = -m(v_f - v_i)$ $(m + 2)(-0,6 - 0)$ ✓ $= -8(4 - 0)$ ✓ $m = 51,33\ kg$ ✓

(5)

13.4 Impulse = $\Delta p = m(v_f - v_i)$ ✓ = $\underline{(51{,}33 + 2)(-0{,}6 - 0)}$ ✓ = $-32\ N{\cdot}s/kg{\cdot}m{\cdot}s^{-1}$
Magnitude of impulse is $32\ N{\cdot}s\ /32\ kg{\cdot}m{\cdot}s^{-1}$ ✓
OR
Impulse = $\Delta p_{parcel} = m(v_f - v_i)$ ✓ = $(8)(4 - 0)$ ✓ = $32\ kg\ m{\cdot}s^{-1}$ ∴ $\Delta p_{girl} = 32\ kg\ m{\cdot}s^{-1}$ ✓ (3)
13.5 $32\ kg{\cdot}m{\cdot}s^{-1}$ ✓ to the right/opposite direction ✓ (2)
[14]

QUESTION 14
14.1 The total (linear) momentum in a isolated/closed system remains constant/is conserved. ✓✓ (2)
14.2 **OPTION 1**
$\sum p_i = \sum p_f$
$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$ } ✓Any one
$m_1v_{1i} + m_2v_{2i} = (m_1 + m_2)v_f$
$\{0{,}45(9) + 0{,}20(0)\}$ ✓ = $(0{,}45 + 0{,}20)v$ ✓ ∴ $v = 6{,}23\ m{\cdot}s^{-1}$ ✓
OR
$\Delta p_{ball} = -\Delta p_{cont}$ ✓ ∴ $0{,}45(v - 9)$ ✓ = $-0{,}2(v - 0)$ ✓ ∴ $v = 6{,}23\ m{\cdot}s^{-1}$ ✓ (4)
14.3 $K = \frac{1}{2}mv^2$ ✓
Total kinetic energy before collision: $\underline{\frac{1}{2}(0{,}45)(9)^2 + 0}$ ✓= 18,225 J
Total kinetic energy after collision: $\underline{\frac{1}{2}(0{,}45 + 0{,}20)(6{,}23)^2}$ ✓ = 12,614 J
$\sum K_{before} \neq \sum K_{after}$ ∴ Collision is inelastic. ✓✓ (5)
[11]

QUESTION 15
15.1 Isolated system is a system on which the resultant/net external force is zero. ✓✓ (2)
15.2.1 $p = mv$ ✓
$24 = m(480)$ ✓
$m = 0{,}05\ kg$ ✓ (3)
15.2.2

OPTION 1	**OPTION 2**
$F_{net}\Delta t = \Delta p$ $F_{net}\Delta t = (p_{bullet})_f - (p_{bullet})_i$ } ✓Any one $F_{net}\Delta t = (mv_{bullet})_f - (mv_{bullet})_i$ $F_{net}(0{,}01)$ ✓ = $\underline{(0{,}05)(80) - 24}$ ✓ $F_{net} = -2\ 000\ N$ $F_{net} = 2\ 000\ N$ ✓ west ✓	$v_f = v_i + a\Delta t$ $\underline{80 = 480 + a(0{,}01)}$ ✓ $a = -40\ 000\ m{\cdot}s^{-2}$ $F_{net} = ma$ ✓ $= (0{,}05)(-40\ 000)$ ✓ $= -2\ 000\ N$ $F_{net} = 2\ 000\ N$ ✓ west ✓

(5)
[10]

QUESTION 16
16.1 (Linear) momentum (of an object) is the product of mass and velocity. ✓✓ (2)
16.2.1 **OPTION 1**
East as positive
$\sum p_i = \sum p_f$
$m_pv_{pi} + m_Qv_{Qi} = m_pv_{pf} + m_Qv_{Qf}$ } ✓Any one

$\underline{(0{,}16)(10) + (0{,}2)(-15)}$ ✓= $\underline{(0{,}16)(-5) + (0{,}2)v_{Qf}}$ ✓
$v_{Qf} = -3\ m{\cdot}s^{-1}$
$v_{Qf} = 3\ m{\cdot}s^{-1}$ ✓ west ✓

OPTION 2
West as positive
$\sum p_i = \sum p_f$
$m_pv_{pi} + m_Qv_{Qi} = m_pv_{pf} + m_Qv_{Qf}$ } ✓Any one

$\underline{(0{,}16)(-10) + (0{,}2)(15)}$ ✓= $\underline{(0{,}16)(5) + (0{,}2)Q_{Nf}}$ ✓
$v_{Qf} = 3\ m{\cdot}s^{-1}$ ✓ west ✓

OPTION 3
$\Delta p_p = -\Delta p_Q$ ✓
$\underline{(0{,}16)(-5 - 10)}$ ✓= $\underline{-(0{,}2)(v - (-15))}$ ✓
$v = -3\ m{\cdot}s^{-1}$
$= 3\ m{\cdot}s^{-1}$ ✓west ✓

IF: $\Delta p_p = \Delta p_Q$: $\frac{0}{5}$
(5)

16.2.2

For ball P
West as negative
Impulse = Δp
$F_{net}Δt = Δp$ } ✓Any one
$Δp = m(v_{Pf} – v_{Pi})$
= 0,16(-5 – 10) ✓
= - 2,4
∴ 2,4 N·s ✓ (2,4 kg·m·s^{-1})

OR
West as positive
Impulse = Δp
$F_{net}Δt = Δp$
= $m(v_{Pf} – v_{Pi})$ } ✓Any one
= 0,16(5 – (-10)) ✓
= 2,4 N·s ✓

For ball Q
West as negative
Impulse = Δp
$F_{net}Δt = Δp$
= $m(v_{Qf} – v_{Qi})$ } ✓Any one
= 0,2[-3 – (-15)] ✓
= 2,4 N·s ✓ (2,4 kg·m·s^{-1})

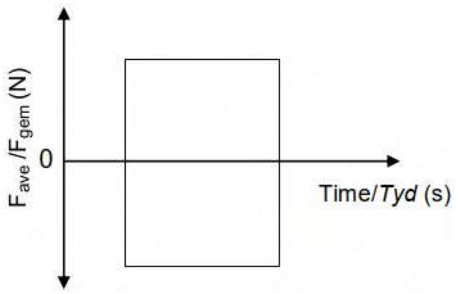
OR
West as positive
Impulse = Δp
$F_{net}Δt = Δp$
= $m(v_{Qf} – v_{Qi})$ } ✓Any one
= 0,16(3 – (15)) ✓
= - 2,4 N·s
∴ 2,4 N·s ✓ (2,4 kg·m·s^{-1}) (3)
[10]

QUESTION 17

17.1 The total (linear) momentum of an isolated system remains constant (is conserved).✓✓
OR
The total (linear) momentum before a collision is equal to the total linear momentum after collision in an isolated system. (2)

17.2
UPWARDS AS POSITIVE
$\sum p_i = \sum p_f$ ✓ OR/OF
$(m_1 + m_2)v_i = m_1v_{2f} + m_2v_{Bf}$
$(2m + 3m)v$ ✓= $(3m)(-\frac{1}{3}v) + 2mv_{Bf}$ ✓
$v_{Bf} = 3v$ ✓upwards ✓
(5)

17.3 Impulse (1)

17.4


(2)
[10]

QUESTION 18

18.1 A collision in which both the total momentum and total kinetic energy are conserved.✓✓ (2)

18.2
EAST +
$\Sigma E_{ki} = \Sigma E_{kf}$ ✓
$\frac{1}{2}(10)(2^2) + \frac{1}{2}(2)v_i^2$✓ $= 0 + 36$ ✓
$v_y = 4\ m \cdot s^{-1}$ ✓ *west* ✓
(5)

18.3
OPTION 1
EAST + for Y
$F_{net}Δt = Δp$ ✓
$F_{net}(0,1) = 2(6 - (-4))$ ✓
$F_{net} = 200\ N$
Magnitude of F_{net} = 200 N ✓

OPTION 2
EAST + for X
$F_{net}Δt = Δp$ ✓
$F_{net}(0,1) = 10(0 - 2)$ ✓
$F_{net} = -200\ N$
Magnitude of F_{net} = 200 N ✓
(3)
[10]

QUESTION 19

19.1 A system on which the resultant/net external force is zero. ✓✓ (2)

19.2.1 According to Newton 3" Law ✓ the rocket exerts a force on the toy cart to the left / opposite to direction of motion. ✓ **OR**
The toy cart exerts a force on the rocket to the right ✓ and the rocket exerts a force on the toy cart to the left / opposite to direction of motion. ✓ **OR**
The rocket experiences a change in momentum to the right ✓; the toy cart experiences a change in momentum to the left. ✓ **OR**
$\Delta p_{toy\ cart} = -\Delta p_{rocket}$ ✓✓ **OR**
Total momentum is conserved / remains constant. ✓ The momentum of the rocket increases. Therefore, the momentum of the toy cart must decrease. ✓ **OR**
The rocket experiences an impulse to the right. ✓ Therefore, the toy cart experiences an impulse to the left. ✓ **OR**
$\text{Impulse}_{rocket} = -\text{Impulse}_{toy\ cart}$ ✓✓ (2)

19.2.2

OPTION 1	OPTION 2
RIGHT AS POSITIVE	**RIGHT AS POSITIVE**
$\Sigma p_i = \Sigma p_f$ ✓	$\Delta p_{cart} = -\Delta p_{rocket}$ ✓
$(20 + m_{rocket})2{,}5$ ✓ $= (20)(0{,}6)$ ✓ $+ m_{rocket}(30)$ ✓	(20)✓$(0{,}6 - 2{,}5)$ ✓ $= -m_{rocket}(30 - 2{,}5)$ ✓
$m_{rocket} = 1{,}38\ kg$ ✓	$m_{rocket} = 1{,}38\ kg$ ✓

(5)
[9]

QUESTION 20

20.1 In an isolated/closed system the total (linear) momentum is conserved/remains constant. ✓✓ (2)

20.2.1

OPTION 1

EAST AS POSITIVE	WEST AS POSITIVE
$\Sigma p_i = \Sigma p_f$ ✓	$\Sigma p_i = \Sigma p_f$ ✓
$m_x v_{ix} + m_y v_{iy} = m_x v_{fx} + m_y v_{fy}$	$m_x v_{ix} + m_y v_{iy} = m_x v_{fx} + m_y v_{fy}$
$(1{,}2)(8)$✓ $+ (0{,}5)(0) = (1{,}2)(4) + (0{,}5)v_{fy}$ ✓	$(1{,}2)(-8)$✓ $+ (0{,}5)(0) = (1{,}2)(-4) + (0{,}5)v_{fy}$ ✓
$v_{fy} = 9{,}6\ m\cdot s^{-1}$ ✓	$v_{fy} = -9{,}6\ m\cdot s^{-1}$
	$\therefore v_{fy} = 9{,}6\ m\cdot s^{-1}$ ✓

OPTION 2

EAST AS POSITIVE	WEST AS POSITIVE
$\Delta p_x = -\Delta p_y$ ✓	$\Delta p_x = -\Delta p_y$ ✓
$m_x(v_{fx} - v_{ix}) = -m_y(v_{fy} - v_{iy})$	$m_x(v_{fx} - v_{ix}) = -m_y(v_{fy} - v_{iy})$
$(1{,}2)(4 - 8)$✓ $= -(0{,}5)(v_{fy} - 0)$ ✓	$(1{,}2)(-4 - (-8))$✓ $= -(0{,}5)(v_{fy} - 0)$ ✓
$v_{fy} = 9{,}6\ m\cdot s^{-1}$ ✓	$v_{fy} = -9{,}6\ m\cdot s^{-1}$
	$\therefore v_{fy} = -9{,}6\ m\cdot s^{-1}$ ✓

(4)

20.2.2

OPTION 1

FOR Y: EAST AS POSITIVE	FOR Y: WEST AS POSITIVE
$F_{net}\Delta t = \Delta p$ ✓	$F_{net}\Delta t = \Delta p$ ✓
$F_{net}\Delta t = m_x(v_f - v_i)$	$F_{net}\Delta t = m_x(v_f - v_i)$
$F_{net}(0{,}1) = (0{,}5)(9{,}6 - 0)$ ✓	$F_{net}(0{,}1) = (0{,}5)(-9{,}6 - 0)$ ✓
$F_{net\ on\ Y} = +48\ N$ ✓	$F_{net\ on\ Y} = -48\ N$
$\therefore$ Magnitude of $F_{net\ on\ Y} = 48\ N$ ✓	$\therefore$ Magnitude of $F_{net\ on\ Y} = 48\ N$ ✓

OPTION 2

FOR X: EAST AS POSITIVE	FOR X: WEST AS POSITIVE
$F_{net}\Delta t = \Delta p$ ✓	$F_{net}\Delta t = \Delta p$ ✓
$F_{net}\Delta t = m_x(v_f - v_i)$	$F_{net}\Delta t = m_x(v_f - v_i)$
$F_{net}(0{,}1) = (1{,}2)(4 - (+8))$ ✓	$F_{net}(0{,}1) = (1{,}2)(-4 - (-8))$ ✓
$F_{net\ on\ X} = -48\ N$	$F_{net\ on\ X} = +48\ N$
$F_{net\ on\ Y} = +48\ N$ ✓	$F_{net\ on\ Y} = -48\ N$
$\therefore$ Magnitude of $F_{net\ on\ Y} = 48\ N$ ✓	$\therefore$ Magnitude of $F_{net\ on\ Y} = 48\ N$ ✓

(3)

20.3

Inelastic ✓

Once for: $E_k = \frac{1}{2}mv^2$ ✓

$\Sigma E_{ki} = \frac{1}{2}m_x v_x^2 + \frac{1}{2}m_y v_y^2$
$= \frac{1}{2}(1,2)(8^2) + \frac{1}{2}(0,5)(0^2)$ ✓
$= 38,4\ J$

$\Sigma E_{kf} = \frac{1}{2}m_x v_x^2 + \frac{1}{2}m_y v_y^2$
$= \frac{1}{2}(1,2)(4^2) + \frac{1}{2}(0,5)(9,6^2)$ ✓
$= 32,64\ J$

$\therefore\ \Sigma E_{kf} \neq \Sigma E_{ki}$ ✓

(5)
[14]

QUESTION 21

21.1 In an isolated system the total (linear) momentum is conserved/remains constant. ✓✓ (2)

21.2.1

OPTION 1

RIGHT AS POSITIVE

$\Sigma p_i = \Sigma p_f$ ✓
$m_A v_{Ai} + m_B v_{Bi} = (m_{A+B})v_f$
$(7,2)(0,4) + (5,3)(0) = 12,5v_f$ ✓
$v_f = 0,2304\ m \cdot s^{-1}$
$\therefore Magnitude\ of\ v_f = 0,2304\ m \cdot s^{-1}$ ✓

LEFT AS POSITIVE

$\Sigma p_i = \Sigma p_f$ ✓
$m_A v_{Ai} + m_B v_{Bi} = (m_{A+B})v_f$
$(7,2)(-0,4) + (5,3)(0) = 12,5v_f$ ✓
$v_f = -0,2304\ m \cdot s^{-1}$
$\therefore Magnitude\ of\ v_f = 0,2304\ m \cdot s^{-1}$ ✓

OPTION 2

RIGHT AS POSITIVE

$\Delta p_A = -\Delta p_B$ ✓
$m_A(v_{Af} - v_{Ai}) = -m_B(v_{Bf} - v_{Bi})$
$(7,2)(v_f - 0,4) = -(5,3)(v_f - 0)$ ✓
$v_f = 0,2304\ m \cdot s^{-1}$
$\therefore Magnitude\ of\ v_f = 0,2304\ m \cdot s^{-1}$ ✓

LEFT AS POSITIVE

$\Delta p_A = -\Delta p_B$ ✓
$m_A(v_{Af} - v_{Ai}) = -m_B(v_{Bf} - v_{Bi})$
$(7,2)(v_f - (-0,4)) = -(5,3)(v_f - 0)$ ✓
$v_f = -0,2304\ m \cdot s^{-1}$
$\therefore Magnitude\ of\ v_f = 0,2304\ m \cdot s^{-1}$ ✓

(3)

21.2.2

Force of A on B

OPTION 1: RIGHT AS POSITIVE

$F_{net}\Delta t = m_B(v_f - v_i)$ ✓
$F_{net}(0,02) = 5,3(0,2304 - 0)$ ✓
$F_{net} = 61,06\ N$
$\therefore Magnitude\ of\ F_{net}\ on\ B = 61,06\ N$ ✓

LEFT AS POSITIVE

$F_{net}\Delta t = m_B(v_f - v_i)$ ✓
$F_{net}(0,02) = 5,3(-0,2304 - 0)$ ✓
$F_{net} = -61,06\ N$
$\therefore Magnitude\ of\ F_{net}\ on\ B = 61,06\ N$ ✓

Force of B on A

OPTION 2: RIGHT AS POSITIVE

$F_{net}\Delta t = m_A(v_f - v_i)$ ✓
$F_{net}(0,02) = 7,2(0,2304 - 0,4)$ ✓
$F_{net} = -61,06\ N$
$\therefore Magnitude\ of\ F_{net}\ on\ B = 61,06\ N$ ✓

LEFT AS POSITIVE

$F_{net}\Delta t = m_A(v_f - v_i)$ ✓
$F_{net}(0,02) = 7,2(-0,2304 - (-0,4))$ ✓
$F_{net} = 61,06\ N$
$\therefore Magnitude\ of\ F_{net}\ on\ B = 61,06\ N$ ✓

(3)
[8]

QUESTION 22

22.1 591 N to the right ✓ (1)

22.2

OPTION 1	
RIGHT AS POSITIVE	**LEFT AS POSITIVE**
$F_{net}\Delta t = m\Delta p$ ✓	$F_{net}\Delta t = m\Delta p$ ✓
$F_{net}\Delta t = mv_f - mv_i$	$F_{net}\Delta t = mv_f - mv_i$
$(-591)(0{,}02)$ ✓ $= (0{,}03)(0) - (0{,}03)v_i$ ✓	$(+591)(0{,}02)$ ✓ $= (0{,}03)(0) - (0{,}03)v_i$ ✓
$v_i = 394\ m \cdot s^{-1}$	$v_i = -394\ m \cdot s^{-1}$
$Magnitude\ of\ velocity = 394\ m \cdot s^{-1}$ ✓	$Magnitude\ of\ velocity = 394\ m \cdot s^{-1}$ ✓

OPTION 2	
RIGHT AS POSITIVE	**LEFT AS POSITIVE**
$F_{net} = ma$	$F_{net} = ma$
$-591 = (0{,}03)a$ ✓	$+591 = (0{,}03)a$ ✓
$a = -19\ 700\ m \cdot s^{-2}$	$a = +19\ 700\ m \cdot s^{-2}$
$v_f = v_i + a\Delta t$ ✓	$v_f = v_i + a\Delta t$ ✓
$0 = v_i + (-19\ 700)(0{,}02)$ ✓	$0 = v_i + (+19\ 700)(0{,}02)$ ✓
$v_i = 394\ m \cdot s^{-1}$	$v_i = -394\ m \cdot s^{-1}$
$Magnitude\ of\ velocity = 394\ m \cdot s^{-1}$ ✓	$Magnitude\ of\ velocity = 394\ m \cdot s^{-1}$ ✓

(4)

22.3 In an isolated/closed system the total (linear) momentum is conserved/remains constant. ✓✓ (2)

22.4

RIGHT AS POSITIVE	**LEFT AS POSITIVE**
$\Sigma p_i = \Sigma p_i$ ✓	$\Sigma p_i = \Sigma p_i$ ✓
$(0{,}03)(394) + (2{,}7)(-3)$ ✓ $= (0{,}03 + 2{,}7)v_f$ ✓	$(0{,}03)(-394) + (2{,}7)(+3)$ ✓ $= (0{,}03 + 2{,}7)v_f$ ✓
$v_f = 1{,}36\ m \cdot s^{-1}$	$v_f = -1{,}36\ m \cdot s^{-1}$
$Magnitude\ of\ velocity = 1{,}36\ m \cdot s^{-1}$ ✓	$Magnitude\ of\ velocity = 1{,}36\ m \cdot s^{-1}$ ✓

(4)
[11]

WORK, ENERGY AND POWER

QUESTION 1

1.1.1 In an isolated/closed system, ✓ the total mechanical energy is conserved/remains constant. ✓ (2)

1.1.2 No ✓ (1)

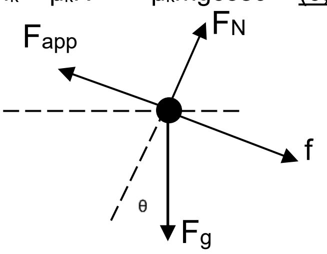
1.1.3

OPTION 1	**OPTION 2**
Along **AB** $E_{mech\ at\ A} = E_{mech\ at\ B}$ $(E_p + E_k)_A = (E_p + E_k)_B$ ✓Any one $(mgh + \frac{1}{2}mv^2)_A = (mgh + \frac{1}{2}mv^2)_B$ $(10)(9,8)(4) + 0 = 0 + \frac{1}{2}(10)v_f^2$ ✓ $v_f = 8,85\ m{\cdot}s^{-1}$	Along **AB** $W_{net} = \Delta E_k$ ✓ $F_g\Delta h\cos\theta = \frac{1}{2}m(v_f^2 - v_i^2)$ $(10)(9,8)(4)\cos 0° = \frac{1}{2}(10)(v_f^2 - 0)$ ✓ $v_f = 8,85\ m{\cdot}s^{-1}$
Substitute 8,85 m·s⁻¹ in one of the following options	
Along **BC** $W_{net} = \Delta K$ ✓ $\therefore f\Delta x\cos\theta = \Delta K$ $f(8)\cos 180°$ ✓ $= \frac{1}{2}(10)(0 - 8,85^2)$ ✓ $f = 48,95\ N$ ✓	Along **BC** $W_{nc} = \Delta K + \Delta U$ ✓ $\therefore f\Delta x\cos\theta = \Delta K + \Delta U$ $f(8)\cos 180$ ✓ $= \frac{1}{2}(10)(0 - 8,85^2) + 0$ ✓ $f = 48,95\ N$ ✓

(6)

1.2.1 $f_k = \mu_k N$ ✓ $= \mu_k mg\cos\theta = (0,19)(300)(9,8)\cos 25°$ ✓ $= 506,26\ N$ ✓ (3)

1.2.2



$F_{net} = 0$ OR $F_{app} + (-F_g\sin\theta) + (-f) = 0$ ✓

$F_{app} - (300)(9,8)\sin 25°$ ✓ $- 506,26$ ✓ $= 0$

$F_{app} = 1\ 748,76\ N$

$P_{ave} = Fv_{ave}$ ✓ $= 1748,76 \times 0,5$ ✓ $= 874,38\ W$ ✓

(6)
[18]

QUESTION 2

2.1 $\Delta U + \Delta K = 0$ ✓

$(5)(9,8)(5) + 0$ ✓ $+ (0 + \frac{1}{2}(5v_f^2))$ ✓ $= 0$

$v_f = \sqrt{2 \times 9,8 \times 5}$

$= 9,90\ m{\cdot}s^{-1}$ ✓ $(9,899\ m{\cdot}s^{-1})$ (4)

2.2 No friction/zero resultant force ✓ and thus no loss in energy. ✓
OR Only conservative forces are present. **OR** Mechanical energy is conserved. (2)

2.3 The force for which the work done is path dependent. ✓✓ (2)

2.4

OPTION 1

$W_{nc} = \Delta U + \Delta K$ ✓

$F\Delta x\cos\theta = \Delta U + \Delta K$

$(18\Delta x\cos 180$ ✓$) = (5)(9,8)(3 - 0)$ ✓ $+ \frac{1}{2}(5)(0 - 9,90^2)$ ✓

$\Delta x = 5,4458\ m$ ✓

$\theta = \sin^{-1}\frac{3}{5,4458}$ ✓

$\theta = 33,43°$ ✓

OPTION 2

$W_{net} = W_f + W_G$ ✓

$W_{net} = f\Delta x\cos\theta + mg\sin\theta\Delta x\cos\theta$

$= [(18)\Delta x\cos 180°) + 5(9,8)\frac{3}{\Delta x}(\Delta x)\cos 180°]$ ✓

$= -18\Delta x - 147$

$W_{net} = \Delta K$ ✓

$\Delta K = \frac{1}{2}(5)(0 - 9,90^2)$ ✓

$= -245,025$

$-18\Delta x - 147 = -245,025$

$\Delta x = 5,4458\ m$ ✓

$\theta = \sin^{-1}\frac{3}{5,4458}$ ✓

$\theta = 39,43°$ ✓

(7)
[15]

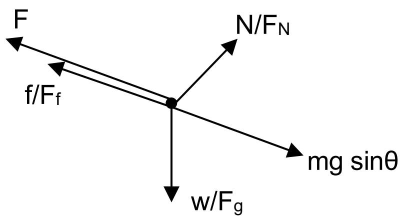
QUESTION 3

3.1 If the work done in moving an object between two points depends on the path taken (then the force applied is non-conservative). ✓✓ (2)

3.2.1 No ✓ (1)

3.2.2 Since there is no acceleration, the net force is zero ✓hence net work done ($F_{net}\Delta x\cos\theta$) must be zero. ✓ (2)

3.3 $F_{//} - (f + F) = 0$ ✓
OR $F = mg\sin\theta - f_k$
OR $F = mg\sin\theta - 266$
$F = [100(9,8)\sin 25°]$ ✓ $- 266$ ✓
$F = 148,17$ N ✓



(4)

3.4

OPTION 1
$W = F\Delta x\cos\theta$ **OR** $W_{net} = W_f + W_g + W_N$ **OR** $W_{net} = f_k\Delta x\cos 180°$ ✓ $+ mg\sin\theta\Delta x\cos 0° + 0$
$= (266)(3)(-1)$ ✓$+ [100(9,8)\sin 25°(3)(1)]$ ✓ $+ 0 = 444,5$ J
$W_{net} = \Delta E_K/\Delta K = ½m(v_f^2 - v_i^2)$ ✓
$444,5 = ½(100)(v_f^2 - 0)$ ✓ $\therefore v_f = 2,98$ m·s^{-1}✓

OPTION 2
$W_{nc} = \Delta E_p + \Delta E_k$ ✓
$f\Delta x\cos\theta$ ✓$= (mgh_f - mgh_i) + (½ mv_f^2 - ½ mv_i^2)$
$266\Delta x\cos 180°$ ✓ $= (0 - mg\sin 25°\ \Delta x\cos 0°) + (½ mv_f^2 - 0)$
$266(3)(-1) = [-100(9,8)\sin 25°(3)(1)]$ ✓ $-½(100)(v_f^2 - 0)$✓ $\therefore v_f = 2,98$ m·s^{-1}✓

OPTION 3
$W_{net} = \Delta E_k$ ✓
$F_{net}\Delta x\cos\theta$ ✓$= ½ m(v_f^2 - v_i^2)$
$(148,17)$ ✓ $(3)\cos 0°$✓ $= ½(100)(v_f^2 - 0^2)$ $\therefore 444,51 = 50v_f^2$ ✓ $\therefore v_f = 2,98$ m·s^{-1} ✓

OPTION 4
$F_{net} = ma$ ✓
$148,17$✓ $=100a$ ✓
$a = 1,48$ m·s^{-2}
$v_f^2 = v_i^2 + 2a\Delta x$ ✓
$= 2(1,48)(3)$ ✓ $\therefore v_f = 2,98$ m·s^{-1} ✓

(6)
[15]

QUESTION 4

4.1

OPTION 1
$v_{ave} = \frac{800}{75}$ ✓$= 10,67$m·s^{-1}
$P_{ave} = Fv_{ave}$✓
$P_{ave} = (240)(10,67)$
$=2\ 560,8$ W (2,56 kW) ✓

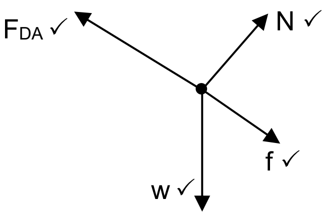
OPTION 2
$v_{ave} = \frac{800}{75}$ ✓ $= 10,67$m·s^{-1}
Distance covered in 1 s = 10,67m·
$\therefore$ W(Work done in 1 s) = $F\Delta x\cos\theta$ ✓
$= (240)(10,67)(1)$
$= 2\ 560,8$ J s^{-1}
$\therefore P_{ave} = 2\ 560,8$ W (2,56 kW) ✓

OPTION 3
$P = \frac{W}{\Delta t}$ ✓ $= \frac{F\Delta x\cos\theta}{\Delta t} = \frac{(240)(800)\cos 0°}{75}$ ✓
$= 2\ 560$ W ✓

OPTION 4
$P = \frac{W}{\Delta t}$ ✓ $= \frac{F\Delta x\cos\theta}{\Delta t} = \frac{(240)(800)\cos 0°}{75}$ ✓
$= 2\ 560$ W ✓

(3)

4.2



Accepted labels	
w	F_g/F_w/weight/mg/gravitational force/2 940 N
f	$F_{friction}$/F_f/friction/294 N/f_k
N	F_N/F_{normal}/normal force
F_D	$F_{Applied}$/350 N/Average driving force/$F_{driving\ force}$

(4)

4.3 The net/total work done on an object is equal ✓ to the change in the object's kinetic energy.✓ (2)

4.4 **OPTION 1**

$W_{nc} = \Delta U + \Delta K$ ✓ ∴ $W_f + W_D = \Delta U + \Delta K$

$(f\Delta x\cos\theta + F_D\Delta x\cos\theta = mg(h_f - h_i) + \frac{1}{2}m(v_f^2 - v_i^2)$

(294)(450)(cos180°) ✓ + (350)(450)cos0° ✓ = (300)(9,8)(5 - 0) ✓ + ½(300)(v_f^2 – 0) ✓ ∴ v_f = 8,37 m·s^{-1} ✓

OPTION 2

$W_{net} = \Delta K$ ✓ ∴ $W_{net} = W_D + W_g + W_f + W_N = (F_D\Delta x\cos\theta) + (mg\sin\alpha)\Delta x\cos\theta) + (f\Delta x\cos\theta) + 0$

W_{net} = [350(450)](cos0°)✓+ (300)(9,8)$\left(\frac{5}{450}\right.$ (450)(cos180°) ✓+ 294(450)(cos180°)✓

= 157 500 – 14 700 – 132 300 = 10 500 J

$W_{net} = \Delta K$ ∴ 10 500 = ½ (300)(v_f^2 – 0) ✓ ∴ v_f = 8,37 m·s^{-1} ✓ (6)

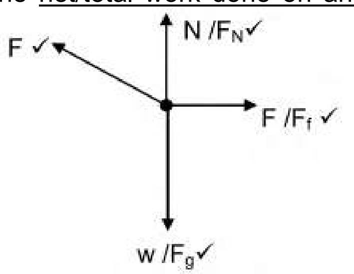
[15]

QUESTION 5

5.1 It is a ratio of two forces (hence units cancel). ✓ (1)

5.2 The net/total work done on an object is equal ✓ to the change in the object's kinetic energy.✓ (2)

5.3



(4)

5.4 $F\sin 20^\circ + N = mg$✓

$N = mg - F\sin 20^\circ$

$W_{fk} = f_k\Delta x\cos\theta = \mu_k N\Delta x\cos\theta$✓

$= \mu_k(mg - F\sin 20)(3)\cos\theta$

= (0,2)[200(9,8) - F sin 20](3)cos180°✓

= (-1176 + 0,205 F) J✓ (4)

5.5 $W_{tot} = [W_g] + W_f + W_F$ ✓

0 ✓ = [0] +[(-1176 + 0,205 F)] + [F (cos 20) (3) (cos 0)]✓ (4)

F = 388,88 N✓

[15]

QUESTION 6

6.1 The total mechanical energy in an isolated/closed system ✓remains constant/is conserved. ✓ (2)

6.2.1 $W = F\Delta x\cos\theta$ ✓ = (30)($\frac{5}{\sin 30^\circ}$)cosθ ✓ = (30)(10)cos180° = (30)(10)(-1) = - 300 J ✓ (3)

6.2.2 **OPTION 1**

$W_{nc} = \Delta E_P + \Delta E_K$

$W_{nc} = mg(h_f - h_i) + \frac{1}{2}m(v_f^2 - v_i^2)$ } ✓Any one

- 300 ✓= (20)(9,8)(0 - 5) ✓+ ½ (20)(v_f^2 –0) ✓ ∴ v = 8,25 m·s^{-1}✓

OPTION 2

$W_{net} = \Delta E_K$

$W_g + W_f = \frac{1}{2}m(v_f^2 - v_i^2)$ } ✓Any one

W_g + (-300) = ½(20)(v_f^2 - 0) ✓

[(20)(9,8)sin30° $\frac{5}{0,5}$ cos0°] ✓ + (- 300) ✓ = 10v_f^2 ∴ v_f = 8,25 m·s^{-1} ✓ (5)

6.3 $F = w_{//} + f$ = (100)(9,8)sin30° + 25 ✓ = 515 N

$P_{ave} = Fv_{ave}$ ✓ = (515)(2) ✓ = 1 030 W ✓ (4)

[14]

QUESTION 7

7.1 $E_k = \frac{1}{2}mv^2$ ✓ $= \frac{1}{2}(2)(4,95)^2$ ✓ $= 24,50$ J ✓ (3)

7.2 **OPTION 1**

$E_{mech\ before} = E_{mech\ after}$
$[(E_{mech})_{bob} + (E_{mech})_{block}]_{before} = [(E_{mech})_{Block} + (E_{mech})_{bob}]_{after}$
$(mgh + \frac{1}{2}mv^2)_{before} = (mgh + \frac{1}{2}mv^2)_{after}$
} Any one ✓

$\underline{(5)(9,8)h + 0 + 0}$ ✓ $= \underline{5(9,8)\frac{1}{4}h + 0 + 24,50}$ ✓ ∴ h = 0,67 m ✓

OPTION 2

$W_{nc} = \Delta E_p + \Delta E_k$
$0 = \Delta E_p + \Delta E_k$
$-\Delta E_p = \Delta E_k$
} Any one ✓

$-\underline{[(5)(9,8)(\frac{1}{4}h) - (5)(9,8)h]}$ ✓ = 24,50 ✓

∴ h = 0,67 m ✓

OPTION 3

Loss E_p bob = Gain in E_k of block ✓

$mg(\frac{3}{4}h) = 24,5$

$(5)(9,8)(\frac{3}{4}h)$ ✓ = 24,5 ✓

∴ h = 0,67 m ✓ (4)

7.3 The net/total work done on an object is equal ✓ to the change in the object's kinetic energy. ✓ (2

7.4 **OPTION 1**

$W_{net} = \Delta E_K$ ✓
$W_f + mg\Delta y\cos\theta = \frac{1}{2}m(v_f^2 - v_i^2)$
$W_f + \underline{(2)(9,8)(0,5)\cos 180°}$ ✓ $= \underline{\frac{1}{2}(2)(2^2 - 4,95^2)}$ ✓
$= -10,7$ J ✓

OPTION 2

$W_{nc} = \Delta E_K + \Delta U$
$W_{nc} = \Delta E_K + \Delta E_P$
} ✓

$W_f = \underline{\frac{1}{2}(2)(2^2 - 4,95^2)}$ ✓ + $\underline{(2)(9,8)(0,5-0)}$ ✓
∴ $W_f = -10,7$ J ✓ (4)

[13]

QUESTION 8

8.1 $W_{net} = \Delta K$
$W_{net} = \frac{1}{2}(M + m)(v_f^2 - v_i^2)$ ✓

$W_{fr} = f\Delta x\cos\theta$ ✓ $= \frac{1}{2}(M + m)(v_f^2 - v_i^2)$
$\underline{10 \times 2\cos 180}$ ✓ $= \underline{\frac{1}{2}(7,02)(0 - v_i^2)}$ ✓
$v_{bb} = 2,39$ m·s⁻¹ ✓ (2,387) m·s⁻¹ (5)

8.2 The total (linear) momentum of an isolated/closed system ✓ is constant/conserved. ✓ (2)

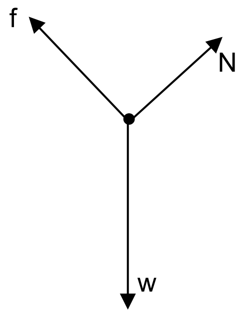
8.3 **POSITIVE MARKING FROM QUESTION 8.1.**

$\Sigma p_i = \Sigma p_f$ ✓
$m_1v_{1i} + m_2v_{2i} = (m_1 + m_2)v_f$
$0,02v_i + (7)(0) = (7,02)(2,39)$
$0,02v_i$ ✓ $= 7,02(2,39)$ ✓
$v_i = 838,89$ m·s⁻¹ ✓ (4)

[11]

QUESTION 9

9.1



Accepted labels		
w	F_g/F_w/weight/mg/gravitational force	✓
f	Friction/F_f/50 N	✓
N	Normal force/F_{NORMAL}/F_{NOR}	✓

(3)

9.2 The net/total work done on an object equals the change in the object's kinetic energy. ✓✓ (2)

9.3

OPTION 1

$W_{net} = \Delta E_K$
$f\Delta x\cos\theta + F_g\Delta x\cos\theta = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$
} ✓Any one

$(50)(25\cos 180°)$ ✓ $+ (60)(9,8)(25\cos 70°)$ ✓ $= \frac{1}{2}(60)(15^2 - v_i^2)$ ✓
$-1\,250 + 5\,027,696 = 6\,750 - 30v_i^2$ ∴ $v_i = 9,95(4)$ m.s⁻¹ ✓

OPTION 2

$W_{net} = \Delta E_K$
$f\Delta x\cos\theta + F_{g||}\Delta x\cos\theta = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$
} ✓Any one

$(50)(25\cos 180°)$ ✓ $+ (60)(9,8\sin 20°)(25\cos 0°)$ ✓ $= \frac{1}{2}(60)(15^2 - v_i^2)$ ✓
$-1\,250 + 5\,027,696 = 6\,750 - 30v_i^2$ ∴ $v_i = 9,95(4)$ m.s⁻¹ ✓

OPTION 3

$W_{nc} = \Delta E_K + \Delta E_P$
$f\Delta x\cos\theta = \frac{1}{2}(mv_f^2 - mv_i^2) + (mgh_Q - mgh_P)$ ✓Any one
$E_{mechP} + E_{mechQ} + W_{nc} = 0$

$(50)(25\cos180^\circ)$ ✓ $= \frac{1}{2}(60)(15^2 - v_i^2)$ ✓ $+ (60)(9,8)(-25\sin 20^\circ)$ ✓

$-1\,250 = 6\,750 - 30\,v_i^2 - 5\,027,696$ $\therefore v_i = 9,95(4)\ m.s^{-1}$ ✓ (5)

9.4 **OPTION 1**

$P_{ave} = Fv_{ave}$ ✓ $= 50$ ✓ $\frac{(9,95+15)}{2}$ ✓ $= 623,75\ W$ ✓

OPTION 2

$P = \frac{W}{\Delta t}$
$P = \frac{f\Delta x\cos\theta}{\Delta t}$ ✓Any one

$\Delta x = \frac{(v_i + v_f)}{2}\Delta t$

$25 = \frac{(9,954+15)}{2}\Delta t$ ✓

$\Delta t = 2,004\ s$

$= \frac{[50(25\cos180^\circ)]}{2,004}$ ✓ ✓ $= -623,75\ W$ ✓ (4)

[14]

QUESTION 10

10.1 The rate at which work is done. / Rate at which energy is expended. ✓✓ (2)

10.2.1 **OPTION 1**

$W = F\Delta x\cos\theta$ ✓

$W_{gravity} = mg\Delta y\cos\theta = (1\,200)(9,8)(55)\cos180^\circ$ ✓ $= -646\,800\ J\ (6,47 \times 10^5\ J)$ ✓

OPTION 2

$W = -\Delta E_p$ ✓ $= -(1200)(9,8)(55 - 0)$ ✓ $= -646800\ J$ ✓ (3)

10.2.2 $W_{counterweight} = mg\Delta y\cos\theta = (950)(9,8)(55)\cos0^\circ$ ✓ $= 512\,050\ J$ ✓ $(5,12 \times 10^5\ J)$ (2)

10.3 **OPTION 1**

$W_{net} = \Delta E_K$
$W_{gravity} + W_{countweight} + W_{motor} = 0$
$W_{motor} = -(W_{gravity} + W_{countweight})$ ✓Any one
$W_{nc} = \Delta E_K + \Delta E_p$

Substituting into any of the above equations will lead to:

-646800 ✓ $+ 512050$ ✓ $+ W_{motor} = 0$

$\therefore W_{motor} = 134\,750\ J$ $\therefore P_{av\ motor} = \frac{W}{\Delta t}$ ✓ $= \frac{34750}{180}$ ✓ $= 748,61\ W$ ✓

OPTION 2

$F_{net} = 0$ $\therefore$ $F_{gcage} + F_{gcount} + F_{motor} = F_{net}$ ✓

-117600 ✓ $+ 9310$ ✓ $+ F_{motor} = 0$ $\therefore$ $F_{motor} = 2450\ N$

$P_{ave} = Fv_{ave}$ ✓ $= 2450\ \frac{55}{180}$ ✓ $= 748,61\ W$

OPTION 3

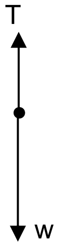
$P_{ave} = Fv_{ave}$ ✓✓ $= [1200(9,8) - 950(9,8)]\frac{55}{180}$ ✓ ✓ ✓ $= 748,61\ W$ ✓ (6)

[13]

QUESTION 11

11.1 The net/total work done (on an object) is equal to the change in the object's kinetic energy.✓✓ (2)

11.2



Accepted labels	
w✓	F_g / F_w / weight / mg/ 58,8N / gravitational force / $F_{earth\ on\ block}$
T✓	F_T/ Tension

(2)

11.3

$W_w = w\Delta x\cos\theta$ ✓ $= mg\Delta x\cos\theta$ $= (6)(9,8)(1,6)\cos0^\circ$ ✓ $\therefore W = 94,08\ J$ ✓	$W_w = -\Delta E_P$ ✓ $= -mg(h_f - h_i)$ $= -(6)(9,8)(0 - 1,6)$ ✓ $= 94,08\ J$ ✓

(3)

11.4

OPTION 1

$W_{net} = \Delta E_K$ / $\Delta K = ½m(v_f^2 - v_i^2)$
$W_{net} = F_{net}\Delta x\cos\theta$
$W_{net} = W_f + W_g + W_N$
$= \mu_k N\Delta x\cos\theta + W_g + W_N$ } ✓Any one

W_{net} = (0,4)(4)(9,8)(1,6)cos180° ✓ + 94,08 + 0 = 68,992 J

$W_{net} = ½m(v_f^2 - v_i^2)$ ∴ 68,992✓= ½(4)(v_f^2 – 0) + ½(6)(v_f^2 – 0)✓ ∴v = 3,71 m·s⁻¹ ✓

OPTION 2

$W_{nc} = \Delta E_p + \Delta E_k$
$f\Delta x\cos\theta = (m_1gh_f - m_1gh_i) + (½m_1v_f^2 - ½m_1v_i^2) + (½m_2v_f^2 - ½m_2v_i^2)$ } ✓Any one

(0,4)(4)(9,8) (1,6) cos 180° ✓= [0 - (6)(9,8)(1,6)]✓+ (½(6)v_f^2 + ½(4)v_f^2 - 0)✓ ∴v = 3,71 m·s⁻¹ ✓

OPTION 3

$W_{net} = \Delta E_K$ ✓

For the 4 kg mass: T(1,6)cos0° + [(0,4)(9,8)(4)](1,6)cos180°✓ = ½(4)v^2 – 0)

For the 6 kg mass: (6)(9,8)(1,6)]cos0°+ T(1,6)cos180°✓ = ½(6)(v^2 – 0)

Adding the two equations : 68,992 = ½ (4)v^2 + ½ (6)v^2 ✓ ∴v = 3,71 m·s⁻¹ ✓ (5)

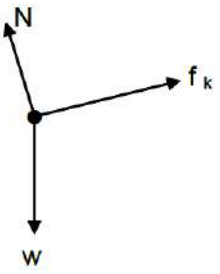
[12]

QUESTION 12

12.1 The total mechanical energy in a closed/isolated system is constant/conserved. ✓✓ (2)

12.2 $E_{mech\ P} = E_{mech\ Q}$ **OR** $(E_p + E_k)_{Pe} = (E_p + E_k)_Q$ **OR** $W_{net} = \Delta E_K$ OR $W_{con} = \Delta E_K$ **OR**
(mgh + ½ mv²)$_P$ = (mgh + ½ mv²)$_Q$ ✓
(50)(9,8)3 + 0 ✓= 0 + ½(50)v^2✓ ∴ v = 7,67 m·s ✓ (4)

12.3



Accepted labels		
w	F_g/F_w/weight/mg/gravitational force	✓
f	Friction/F_f	✓
N	Normal force/F_{NORMAL}/F_N	✓

(3)

12.4 $f_k = \mu_k N$ **OR** $f_k = \mu_k mg\cos\theta$ ✓
f_k = (0,08)(50)(9,8)cos30° ✓= 33,95 N ✓ (3)

12.5 **POSITIVE MARKING FROM QUESTION 5.4/*POSITIEWE NASIEN VANAF VRAAG 5.4***

$W = F_{net}\Delta x\cos\theta$
$W_{net} = W_f + W_w + W_N$
$W_{net} = W_f + (-\Delta E_P) + W_N$
$W_{net} = f_k\Delta x\cos180° + mg\sin\theta\,\Delta x\cos0 + 0$
$W_{net} = \Delta E_K/\Delta K$

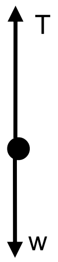
✓1 mark for any one/
1 punt vir enige van die drie

W_{net} = [33,948)(5)(-1)] ✓+ [(50)(9,8) (5)sin 30° + 0]✓
= 1055, 26 (1055,259)
1055,259 = ½ (50) (v_f^2 – 7,668²) ✓
v_f = 10,05 m·s⁻¹✓ (5)

[17]

QUESTION 13

13.1



Accepted labels	
w	F_g/F_w/weight/mg/gravitational force/N/19,6 N
T	Tension/F_T/ F_A/

(2)

13.2 Tension ✓ **OR** $F_{applied}$ (1)

13.3 $W = F\Delta x\cos\theta$ } ✓any one
$W_w = mg\Delta x\cos\theta$
$= \underline{75(9,8)(12)\cos 180°}$ ✓ $= -8\,820$ J ✓
OR $W_w = -\Delta E_p$ ✓ $= -(mgh - 0) = -(75)(9,8)(12)$ ✓ $= -8\,820$ J ✓ (3)

13.4 The net work done on an object is equal to the change in the object's kinetic energy. ✓✓ (2)

13.5 **OPTION 1**
$W_{net} = \Delta K$ } ✓any one
$F_{net}\Delta x\cos\theta = (\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2)$
$\underline{(75)(0,65)(12)}$ ✓$\cos 0°$ ✓ $= \frac{1}{2}(75)(v_f^2 - 0)$ ✓
$\therefore v_f = 3,95\ m\cdot s^{-1}$ ✓

OPTION 2
$W_{net} = \Delta K$ } ✓any one
$W_{nc} = \Delta K + \Delta U$
$W_T + W_g = \Delta K$
$T - mg = ma$
$T - 75(9,8) = 75(0,65)$ ✓ $\therefore T = 783,75$ N
$W_T = 783,75(12)\cos 0°$ ✓ $= 9405$ J
$9405 - (8820) = \frac{1}{2}(75)(v_f^2 - 0)$ ✓ $\therefore v_f = 3,95\ m\cdot s^{-1}$ ✓

$W_{nc} = (\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2) + (mgh_f - mgh_i)$
9405 ✓$= (\frac{1}{2}(75)v_f^2 - 0)$ ✓$+ (75)(9,8)(12 - 0)$ ✓
$v_f = 3,95\ m\cdot s^{-1}$ ✓ (5)
[13]

QUESTION 14

14.1 A force for which the work done in moving an object between two points depends on the path taken. ✓✓ (2)

14.2 No ✓ (1)

14.3 **OPTION 1**
$P = \frac{W}{\Delta t}$ ✓
$= \frac{4,8\times10^6}{(90)}$ ✓
$= 53\,333,33$ W
$= 5,33 \times 10^4$ W (53,33 kW) ✓

OPTION 2
$\Delta x = \left(\frac{v_f + v_i}{2}\right)\Delta t$
$= \left(\frac{0 + 25}{2}\right)(90) = 1\,125$ m
$W_F = F\Delta x\cos\theta$
$4,80 \times 10^6 = F(1\,125)\cos 0°$ $\therefore F = 4\,266,667$ N
$P_{ave} = Fv_{ave}$ ✓ $= (4\,266,667)(12,5)$ ✓
$= 53\,333,33$ W ✓ (3)

14.4 The net/total work done on an object is equal to the change in the object's kinetic energy ✓✓ (2)

14.5 **OPTION 1**
$W_{net} = \Delta K$ ✓ **OR** $W_w + W_f + W_F = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$ **OR**
$mg\Delta x\cos\theta + W_f + W_F = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$
$\therefore \underline{(1\,500)(9,8)200\cos180°}$ ✓ $+ \underline{W_f + 4,8 \times 10^6}$ ✓$= \underline{\frac{1}{2}(1\,500)(25^2 - 0)}$ ✓
$-2\,940\,000 + W_f + 4,8 \times 10^6 = 468\,750$ $\therefore W_f = -1\,391\,250$ J $= -1,39 \times 10^6$ J ✓
OR
$W_{net} = \Delta K$ ✓ OR $W_w + W_f + W_F = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$ OR $-\Delta E_p + W_f + W_F = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$
$\therefore \underline{-(1\,500)(9,8)(200 - 0)}$ ✓ $+ \underline{W_f + 4,8 \times 10^6}$ ✓$= \underline{\frac{1}{2}(1\,500)(25^2 - 0)}$ ✓
$-2\,940\,000 + W_f + 4,8 \times 10^6 = 468\,750$ $\therefore W_f = -1\,391\,250$ J $= -1,39 \times 10^6$ J ✓ (5)

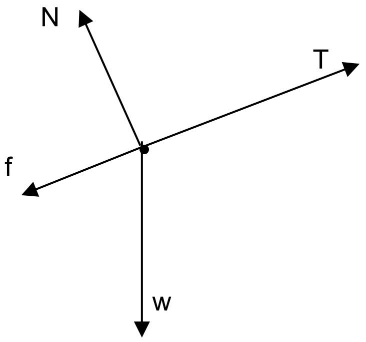
OPTION 2
$W_{nc} = \Delta K + \Delta U$ ✓ **OR** $W_{nc} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 + mgh_f - mgh_i = \frac{1}{2}m(v_f^2 - v_i^2) + mg(h_f - h_i)$ **OR**
$W_{nc} = \frac{1}{2}mv_f^2 + mgh_f - \frac{1}{2}mv_i^2 - mgh_i$ **OR** $W_f + W_F = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 + mgh_f - mgh_i$ ✓
$\therefore \underline{W_f + 4,8 \times 10^6}$ ✓$= \underline{[\frac{1}{2}(1\,500)(25)^2 + -0]}$ ✓$+ \underline{[(1\,500)(9,8)(200) - 0]}$ ✓
$\therefore W_f = -1,39 \times 10^6$ J ($-1,40 \times 10^6$ J) ✓
OR
$W_{nc} = \Delta K + \Delta U$ ✓ **OR** $W_{nc} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 + mgh_f - mgh_i = \frac{1}{2}m(v_f^2 - v_i^2) + mg(h_f - h_i)$ **OR**
$W_{nc} = \frac{1}{2}mv_f^2 + mgh_f - \frac{1}{2}mv_i^2 - mgh_i$
$\therefore \underline{W_f + 4,8 \times 10^6}$ ✓$= [\underline{\frac{1}{2}(1500)(25)^2}$ ✓$+ \underline{(1500)(9,8)(200)}$ ✓$] - [0 + 0]$ (5)
$\therefore W_f = -4,8 \times 10^6 + 3,4 \times 10^6 = -1,39 \times 10^6$ J ($-1,40 \times 10^6$ J) ✓
[13]

QUESTION 15

15.1 Tension ✓

15.2 There is friction/tension in the system. ✓
OR Friction/tension is a non-conservative force/ The system is not isolated because there is friction/tension. (1)

15.3



Accepted labels		
w	F_g/F_w/weight/mg/gravitational force	✓
f	Friction/F_f/f_k/178,22 N	✓
N	Normal (force)/F_{normal}/F_N/$F_{reaction}$	✓
T	F_T/F_A/$F_{applied}$/700 N/Tension	✓

(4)

15.4 $W = F\Delta x\cos\theta$ ✓
$W_f = [178{,}22(4)\cos 180^\circ]$ ✓
$= -712{,}88$ J ✓ (3)

15.5

OPTION 1
$W_{net} = \Delta E_K$
$W_f + W_g + W_T = \Delta K$
$W_f + mg\sin\theta\Delta x\cos\theta + W_T = \Delta K$
$-712{,}88 + \underline{(70)(9{,}8)(\sin 30^\circ)(4)\cos 180^\circ}$ ✓ $+ \underline{(700 \times 4 \times \cos 0^\circ)}$✓ $= \underline{\tfrac{1}{2}70(v_f^2 - 0)}$✓
$v_f = 4{,}52$ m·s^{-1}✓

OPTION 2
$W_{nc} = \Delta E_K + \Delta E_p$ ✓
$W_T + W_f = \Delta E_K + \Delta E_p$
$(700)(4)\cos 0^\circ)$ ✓ $+ (-712{,}88) = [(70)(9{,}8)\,4(\sin 30^\circ).\ -0\,]$ ✓$+ \underline{\tfrac{1}{2}70(v_f^2 - 0)}$ ✓
$v_f = 4{,}52$ m·s^{-1} ✓

OPTION 3
$F_{net} = F_T - [mg\sin\theta + f_k]$
$= \underline{700 - [(70)(9{,}8\sin 30^\circ) + 178{,}22]}$ ✓
$= 178{,}78$ N
$W_{net} = \Delta E_K$ ✓
$F_{net}\,.\,\Delta x\cos\theta = \Delta E_K$
$\underline{(178{,}78)(4)\cos 0^\circ}$ ✓ $= \underline{\tfrac{1}{2}70(v_f^2 - 0)}$✓ ∴ $v_f = 4{,}52$ m·s^{-1} ✓ (5)

15.6 $2(-712{,}88) = -1425{,}76$ J ✓ (1)
[15]

QUESTION 16

16.1 A *conservative force* is a force for which the work done in moving an object between two points is independent of the path taken. ✓✓ (2)

16.2 Gravitational (force) ✓ (1)

16.3 No ✓ There is friction ✓ (between the object and the track). (2)

16.4 $E_P = mgh$ ✓ $= \underline{(1{,}8)(9{,}8)(1{,}5)}$ ✓ $= 26{,}46$ J ✓ (3)

16.5

OPTION 1	OPTION 2
$W_{nc} = \Delta K + \Delta U$ } ✓Any one $W_f = \tfrac{1}{2}m(v_f^2 - v_i^2) + mg(h_f - h_i)$ $= \underline{\tfrac{1}{2}(1{,}8)(4^2 - 0{,}95^2)}$ ✓$+ \underline{(0 - 26{,}46)}$ ✓ $= -12{,}87$ J ✓	$W_{net} = \Delta K$ $W_f + W_g = \tfrac{1}{2}mv_f^2 - \tfrac{1}{2}mv_i^2$ $W_f + mgh = \tfrac{1}{2}m(v_f^2 - v_i^2)$ $W_f + mgh = \tfrac{1}{2}mv_f^2 - \tfrac{1}{2}mv_i^2$ } ✓Any one $W_f + 26{,}46$ ✓$= \underline{\tfrac{1}{2}(1{,}8)[(4)^2 - (0{,}95)^2]}$ ✓ $W_f = -12{,}87$ J (- 12,872 J) ✓

(4)

16.6 (W_{net} =) 0 J / zero ✓ (1)
[13]

QUESTION 17

17.1 A force is non-conservative if the work it does on an object (which is moving between two points) depends on the path taken. ✓✓ **OR** A force is non-conservative if the work it does on an object depends on the path taken. **OR** A force is non-conservative if the work it does in moving an object around a closed path is non-zero. (2)

17.2

$K = \frac{1}{2}mv^2$ / $E_k = \frac{1}{2}mv^2$
$\Delta K = K_f - K_i$
$\Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$
$= \frac{1}{2}m(v_f^2 - v_i^2)$ } ✓Any one
$= \frac{1}{2}(200)(2^2 - 4^2)$ ✓
$\Delta K = -1\,200$ J ✓

(3)

17.3

OPTION 1

$W_{nc} = \Delta K + \Delta U$
$W_{nc} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 + mgh_f - mgh_i$
$= \frac{1}{2}m(v_f^2 - v_i^2) + mg(h_f - h_i)$ } ✓Any one
$-3{,}40 \times 10^3$ ✓ = $-1\,200 + 200(9{,}8)(h_f - 10)$ ✓
h = 8,88 m ✓ (8,87765 m)

OPTION 2

$E_{(mech/meg)A} + W_f = E_{(mech)B}$
$(E_p + E_k)_A + W_f = (E_p + E_k)_B$
$(mgh + \frac{1}{2}mv^2)_A + W_f = (mgh + \frac{1}{2}mv^2)_B$ } ✓Any one
$200(9{,}8)(10) + \frac{1}{2}(200)(4^2) - 3{,}40 \times 10^3$ ✓ = $200(9{,}8)(h) + \frac{1}{2}(200)(2)^2$ ✓
h = 8,88 m ✓ (8,87755)

OPTION 3

$W_{net} = \Delta K$
$W_f + W_w = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$
$W_f - \Delta E_p = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$
$W_f - mg(h_f - h_i) = \frac{1}{2}m(v_f^2 - v_i^2)$ } ✓Any one
$-3{,}40 \times 10^3 - 200(9{,}8)(h-10)$ ✓ = $-1\,200$ ✓
h = 8,88 m ✓ (8,87755 m)

(4)

17.4

OPTION 1

$W_{nc} = \Delta K + \Delta U$
$W_{engine} + W_f = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 + mgh_f - mgh_i$
$= \frac{1}{2}m(v_f^2 - v_i^2) + mg(h_f - h_i)$ } ✓Any one
$W_{engine} + (50)(2)(15)\cos 180°$ ✓ = $0 + 200(9{,}8)(22 - 8{,}88)$ ✓
$W_{engine} = 27\,215{,}20$ J

$$P_{engine} = \frac{W_{engine}}{\Delta t} \checkmark$$
$$= \frac{27\,215{,}20}{15}$$
$$= 1\,814{,}35\ W \checkmark$$

OPTION 2

$W_{net} = \Delta K$
$W_N + W_{engine} + W_w + W_f = 0$
$W_N + W_{engine} - \Delta E_p + W_f = 0$ } ✓ Any one
$0 + W_{engine} - (200)(9{,}8)(13{,}12)$ ✓ + $(50)(2)(15)\cos 180° = 0$ ✓
$W_{engine} = 27\,215{,}20$ J

OR

$W_{net} = \Delta K$
$W_N + W_{engine} + W_{w||} + W_f = 0$
$W_N + W_{engine} + mg\sin\theta\Delta x\cos 180° + W_f = 0$ } ✓ Any one
$0 + W_{engine} - (200)(9{,}8)\left(\frac{13{,}12}{\Delta x}\right)(\Delta x)(-1)$ ✓ + $(50)(2)(15)\cos 180° = 0$ ✓
$W_{engine} = 27\,215{,}20$ J

$$P_{engine} = \frac{W_{engine}}{\Delta t} \checkmark$$
$$= \frac{27\,215{,}20}{15}$$
$$= 1\,814{,}35\ W \checkmark$$

OPTION 3

$F_{net} = ma$ } ✓ Enige een

$F_{engine} + F_{friction} + F_{g//} = 0$

$F_{engine} + (-50)$ ✓ $- \frac{(200)(9,8)(13,12)}{30}$ ✓ $= 0$

$F_{engine} = 907,17$ N

$P_{ave} = Fv_{ave}$ ✓

$P_{ave} = (907,17)(2)$

$= 1\ 814,35$ W ✓

OR

$W_{engine} = F_{engine}\Delta x\cos\theta$

$= (907,17)(30)\cos 0°$

$= 27\ 215,10$ J

$P_{engine} = \frac{W_{engine}}{\Delta t}$ ✓

$= \frac{27\ 215,10}{15}$

$= 1\ 814,34\ W$ ✓

(5)

[14]

QUESTION 18

18.1 The rate at which work is done/energy is expended. ✓✓ (2)

18.2

$P = \frac{W}{\Delta t}$ ✓

$= \frac{\Delta mgh}{\Delta t}$

$= \frac{(1\ 250)(9,8)(5,8)}{60}$ ✓

$= 1\ 184,17\ W$ ✓

OR

$P = \frac{W}{\Delta t}$ ✓

$= \frac{F\Delta y\cos\theta}{\Delta t}$

$= \frac{(1\ 250)(9,8)(\cos 0°)}{60}$ ✓

$= 1\ 184,17\ W$ ✓

OR

$P_{ave} = Fv_{ave}$ ✓

$= \frac{(1\ 250)(9,8)(5,8)}{60}$ ✓

$= 1\ 184,17\ W$ ✓

(3)

18.3 A conservative force is a force for which the work done (in moving an object between two points) is independent of the path taken. ✓✓ OR
A conservative force is a force for which the work done in moving an object in a closed path is zero. (2)

18.4 Non-conservate (1)

18.5 (Gravitational) potential energy to kinetic energy (1)

18.6

From R to the wall:

$(E_p + E_k)_R = (E_p + E_k)_{Bottom/Onder}$

$(mgh + ½ mv^2)_R = (mgh + ½ mv^2)_{Bottom/Onder}$

$(1\ 250)(9,8)(5,8) + 0 = 0 + E_k$ ✓

$E_k = 71\ 050$ J

Into the wall

$W_{net} = \Delta K$ ✓

$F_{wall/muur}\ \Delta x\cos\theta = K_f - K_i$

$F_{wall/muur}\ (0,25)(\cos 180°)$ ✓ $= 0 - 71\ 050$ ✓

$F_{wall/muur} = 284\ 200$ N ✓

(5)

[14]

QUESTION 19

19.1 The total mechanical energy in an isolated system remains constant / the same. ✓✓ OR The sum of the kinetic and gravitational potential energies in an isolated system remains constant/the same. (2)

19.2

$(E_p + E_k)_P = (E_p + E_k)_P$ ✓

$(2)(9,8)(5) + 0 = 0 + \frac{1}{2}(2)v_f^2$ ✓

$v_f = 9,90\ m \cdot s^{-1}$ ✓

(3)

19.3

OPTION 1

$W_{net} = \Delta K$ ✓

$f\Delta x\cos\Theta = \frac{1}{2}m(v_f^2 - v_i^2)$

$f(10)\cos 180°$ ✓ $= \frac{1}{2}(2)(4^2 - 9,90^2)$ ✓

$f = 8,2\ N$ ✓

OPTION 2

$W_{nc} = \Delta K + \Delta P$ ✓

$f\Delta x\cos\Theta = \frac{1}{2}m(v_f^2 - v_i^2) + mg(h_f - h_i)$

$f(10)\cos 180°$ ✓ $= \frac{1}{2}(2)(4^2 - 9,90^2) + 0$ ✓

$f = 8,2\ N$ ✓

(4)

19.4

RIGHT +	LEFT +
$F_{net}\Delta t = m(v_f - v_i)$ ✓ $-14 = 2(v_f - 4)$ ✓ $v_f = -3\ m \cdot s^{-1}$ $\Delta E_k = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$ ✓ $= \frac{1}{2}(2)[(-3)^2 - 4^2]$ ✓ $= -7\ J$ ✓	$F_{net}\Delta t = m(v_f - v_i)$ ✓ $14 = 2(v_f - (-4))$ ✓ $v_f = 3\ m \cdot s^{-1}$ $\Delta E_k = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$ ✓ $= \frac{1}{2}(2)[3^2 - (-4)^2]$ ✓ $= -7\ J$ ✓

(5)
[14]

QUESTION 20

20.1 The net/total work done on an object is equal to the change in the object's kinetic energy. ✓✓ (2)

20.2 F_{net} is opposite to the direction of the displacement Δx. ✓ **OR**
ΔK is negative. **OR**
The final K is zero. **OR**
Kinetic energy decreases. **OR**
$W_{net} = F_{net}\,\Delta x\cos\theta$ and θ = 180°. (1)

20.3

<u>OPTION 1</u>

$W_{net} = \Delta K$ ✓

$W_w + W_f = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

$mg\sin\Theta\Delta x\cos\Theta + W_f = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

$(30\ 000)(9{,}8)(\sin 28°)(\Delta x)(\cos 180°)$ ✓ $+ (31\ 000)(\Delta x)(\cos 180°)$ ✓ $= \frac{1}{2}(30\ 000)(0^2 - 33^2)$ ✓

$\Delta x = 96{,}64\ m$ ✓

<u>OPTION 2</u>

$W_{nc} = \Delta K + \Delta U$ ✓

$W_f = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 + mgh_f - mgh_i$

$(31\ 000)(\Delta x)(\cos 180°)$ ✓ $= \frac{1}{2}(30\ 000)(0^2 - 33^2)$ ✓ $+ (30\ 000)(9{,}8)(\Delta x\sin 28° - 0)$ ✓

$\Delta x = 96{,}64\ m$ ✓

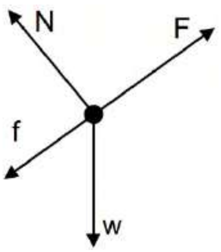
(5)

20.4 Ascending ✓
For ascending: $F_{w//}$ and *f* are both in the opposite direction as the direction of displacement.
For descending: Only *f* is in the opposite direction as the direction of displacement. ✓
The net force on the truck for ascending is greater than net force for descending. ✓ (3)
[11]

QUESTION 21

21.1 A force is non-conservative if the work done by the force on an object (which is moving between two points) depends on the path taken. ✓✓ **OR**
A force is non-conservative if the work it does in moving an object around a closed path is non-zero. (2)

21.2



Acceptable labels		
w	F_g/mg/weight/F_w/$F_{Earth\ on\ block}$/gravitational force/117,6 N	✓
F	F_A/Applied force/T/F_T	✓
f	F_f/f_k/(kinetic) friction/frictional force/kinetic frictional force	✓
N	F_N/Normal/F_{normal}/normal force	✓

(4)

21.3

<u>OPTION 1</u>

$W_{nc} = \Delta K + \Delta U$ ✓

$= \frac{1}{2}m(v_f^2 - v_i^2) + mg(h_f - h_i)$

$= \frac{1}{2}(12)(2{,}25^2 - 0^2)$ ✓ $+ (12)(9{,}8)(4{,}5 - 0)$ ✓

$= 559{,}58\ J$ ✓

OPTION 2

$W_{net} = \Delta K$
$= \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$
$= \frac{1}{2}(12)(2{,}25^2) - 0^2$ ✓
$= 30{,}375\ J$

$W_{weight} = mg\Delta y cos180°$
$= (12)(9{,}8)(4{,}5)(cos180°)$
$= -529{,}20\ J$

OR

$W_{weight} = -\Delta U$
$= -mg(h_f - h_i)$
$= -(12)(9{,}8)(4{,}5 - 0)$
$= -529{,}20\ J$

OR

$W_{weight_{par-component}} = mgsin\alpha\Delta x cos180°$
$= (12)(9{,}8)\left(\frac{4{,}5}{\Delta x}\right)\Delta x cos180°$
$= -529{,}20\ J$

$W_{net} = W_{nc} + W_{weight}$ ✓
$30{,}375 = W_{nc} + (-529{,}20)$ ✓
$W_{nc} = 559{,}58\ J$ ✓

(4)

21.4 **OPTION 1**

Along the incline A to B

$W_{nc} = W_F + W_{f1}$ ✓
$W_{nc} = F\Delta x cos0° + f_1\Delta x cos180°$
$559{,}58 = (F - f_1)\Delta x$ ✓..........(1)

(2) in (1):
$559{,}58 = 42\Delta x$
$\Delta x = 13{,}32\ m$ ✓

Along the horizontal B to C

$F - f_2 = ma\ (*)$
$F - f_2 = 0$ ✓
$F - (f_1 + 42)$✓ $= 0$
$F - f_1 = 42$ ....(2)

Directions are already applied in (*).

OPTION 2

Along the incline A to B

$W_{nc} = \Delta K + \Delta U$ ✓
$(F - f_1)\Delta x cos0° = [\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2] + [mgh_f - mgh_i]$

Along the horizontal B to C

$F - f_2 = ma\ (*)$
$F - f_2 = 0$ ✓
$F - (f_1 + 42)$✓ $= 0$
$F = f_1 + 42$

Directions are already applied in (*).

$(f_1 + 42 - f_1)(\Delta x)(1) = \left[\frac{1}{2}(12)(2{,}25^2 - 0^2)\right] + [(12)(9{,}8)(4{,}5) - 0]$ ✓
$42\Delta x = 559{,}58$
$\Delta x = 13{,}32\ m$ ✓

OPTION 3

Directions are already applied in the formulae marked with a (*).

Along the incline A to B (Positive)

$v_f^2 = v_i^2 + 2a\Delta x$
$2{,}25^2 = 0^2 + 2a\Delta x$ ✓
$a = \frac{2{,}531}{\Delta x}$

Along the horizontal B to C (Positive)

$F - f_2 = ma\ (*)$
$F - f_2 = 0$ ✓
$F - (f_1 + 42)$✓ $= 0$
$F = f_1 + 42$ ....(1)

$F_{net} = ma$
$F - w_{par-component} - f_1 = ma\ (*)$
$F - mgsin\alpha - f_1 = ma$
$F - (12)(9{,}8)\left(\frac{4{,}5}{\Delta x}\right) - f_1 = (12)\left(\frac{2{,}531}{\Delta x}\right)$ ✓ ....(2)

(1) into (2)
$f_1 + 42 - (12)(9{,}8)\left(\frac{4{,}5}{\Delta x}\right) - f_1 = (12)\left(\frac{2{,}531}{\Delta x}\right)$
$\Delta x = 13{,}32\ m$ ✓

(5)
[15]

QUESTION 22

22.1 A force is non-conservative if the work it does on an object which is moving between two points depends on the path taken. ✓✓ **OR**
A force is non-conservative if the work it does in moving an object around a closed path is non-zero. (2)

22.2

OPTION 1

$W_{net} = \Delta K$ ✓

$W_{w(par)} + W_f + W_F = \frac{1}{2}mv_f^2 + \frac{1}{2}mv_i^2$

$(20)(9,8)(sin18°)(15,6)(cos180°)$✓ $+ (13,5)(15,6)(cos180°) + (96,8)(15,6)(cos0°)$✓ $= \frac{1}{2}(20)(v_C^2 - 0^2)$✓

$v_C = 5,96\ m \cdot s^{-1}$ ✓

OPTION 2

$W_{nc} = \Delta K + \Delta U$ ✓

$W_f + W_F = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 + mgh_f - mgh_i$

$(13,5)(15,6)(cos180°) + (96,8)(15,6)(cos0°)$✓ $= \frac{1}{2}(20)(v_C^2 - 0^2)$✓ $+ (20)(9,8)(15,6)(sin18°) - 0$✓

$v_C = 5,96\ m \cdot s^{-1}$ ✓

OPTION 3: UP THE INCLINE AS POSITIVE

$F_{net} = w_{par} + f + F$
$= -(20)(9,8)(sin18°) - 13,5 + 96,8$ ✓
$= 22,733\ N$

$W_{net} = \Delta K$ ✓

$F_{net}\Delta x \cos\Theta = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

$(22,733)(15,6)(cos0°)$✓ $= \frac{1}{2}(20)(v_C^2 - 0^2)$✓

$v_C = 5,96\ m \cdot s^{-1}$ ✓

(5)

22.3

OPTION 1: UP THE INCLINE AS POSITIVE

$\Delta x = \left(\frac{v_i + v_f}{2}\right)\Delta t$

$15,6 = \left(\frac{0 + 5,96}{2}\right)\Delta t$

$\Delta t = 5,24\ s$

$P_{ave} = F_{ave}\left(\frac{\Delta x}{\Delta t}\right)$ ✓
$= \frac{(96,8)(15,6)}{5,24}$ ✓
$= 288,18\ W$ ✓

OR

$P = \frac{W}{\Delta t}$ ✓
$= \frac{(96,8)(15,6)(cos0°)}{5,24}$ ✓
$= 288,18\ W$ ✓

OPTION 2: UP THE INCLINE AS POSITIVE

$v_f^2 = v_i^2 + 2a\Delta x$
$5,96^2 = 0^2 + 2a(15,6)$
$a = 1,14\ m \cdot s^{-2}$

OR

$F_{net} = ma$
$-(20)(9,8)(sin18°) - 13,5 + 96,8 = 20a$
$a = 1,14\ m \cdot s^{-2}$

$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$
$15,6 = 0 + \frac{1}{2}(1,14)\Delta t^2$
$\Delta t = 5,23\ s$

OR

$v_f = v_i + a\Delta t$
$5,96 = 0 + 1,14\Delta t$
$\Delta t = 5,23\ s$

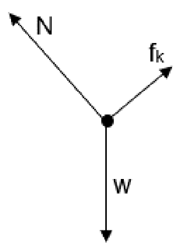
$P_{ave} = F_{ave}\left(\frac{\Delta x}{\Delta t}\right)$ ✓
$= \frac{(96,8)(15,6)}{5,23}$ ✓
$= 288,73\ W$ ✓

OR

$P = \frac{W}{\Delta t}$ ✓
$= \frac{(96,8)(15,6)(cos0°)}{5,23}$ ✓
$= 288,73\ W$ ✓

(3)

22.4



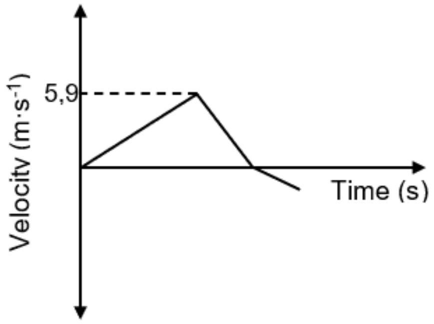
Accepted symbols

N✓	F_N/196N/Normal/F_{normal}
f_k✓	f/(kinetic) friction/F_f
w✓	F_g/F_w/weight/mg/gravitational force/$F_{Earth\ on\ block}$

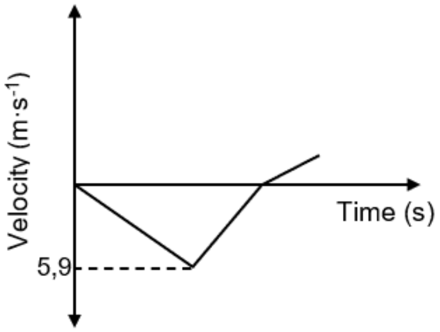
(3)

22.5

UPWARDS AS POSITIVE



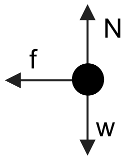
DOWNWARDS AS POSITIVE



(4)
[17]

QUESTION 23

23.1



Accepted labels	
w	F_w/F_g/mg/gravitational force/weight
f	F_f/f_k/(kinetic) friction
N	F_N/Normal

(3)

23.2 Initial kinetic energy ✓ (1)

23.3 The net/total work done (on an object) is equal to the change in the object's kinetic energy. ✓✓ **OR**
The work done on an object by a resultant/net force is equal to the change in the object's kinetic energy. (2)

23.4

OPTION 1

$W_{net} = \Delta K$ ✓
$f\Delta x\cos 180° = K_f - K_i$
$-f(4,5)$✓ $= 0 - 18$ ✓
$\boldsymbol{OR}\ -f(3) = 0 - 12$
$\boldsymbol{OR}\ -f(1,5) = 0 - 6$
$f = 4\ N$

$f_k = \mu_k N$ ✓
$4 = (0,18)(m)(9,8)$ ✓
$m = 2,27\ kg$ ✓

OPTION 2

$Gradient = \frac{\Delta x}{\Delta E_{ki}} = \frac{1}{f}$ ✓

$\therefore \frac{1}{f} = \frac{4,5 ✓}{18 ✓}$ $\boldsymbol{OR}\ \frac{3}{12}\ \boldsymbol{OR}\ \frac{1,5}{6}$
$f = 4\ N$

$f_k = \mu_k N$ ✓
$4 = (0,18)(m)(9,8)$ ✓
$m = 2,27\ kg$ ✓

(6)
[12]

DOPPLER EFFECT

QUESTION 1

1.1.1 An apparent change in observed/detected frequency/pitch/wavelength ✓ as a result of the relative motion between a source and an observer/listener. ✓ (2)

1.1.2 Towards ✓
Observed/detected frequency is greater than the actual frequency. ✓ (2)

1.1.3 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ **OR** $f_L = \frac{v}{v - v_s} f_s$ ✓

$\therefore 1\,200$ ✓ $=$✓ $\frac{343}{343 - v_s}(1130)$ ✓ $\therefore v_s = 20{,}01\ m{\cdot}s^{-1}$ ✓ (5)

1.2 The star is approaching the earth./The earth and the star are approaching (moving towards) each other ✓
The spectral lines in diagram 2 are shifted towards the blue end/are blue shifted. ✓ (2)
[11]

QUESTION 2

2.1.1 $v = f\lambda$ ✓

$\lambda = \frac{340}{520}$

$= 0{,}65\ m$ ✓ v = f (2)

2.1.2 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓

$f_L = \frac{340}{(340 - 15)}(520)$ ✓✓✓

$f_L = 544\ Hz$

$v = f\lambda$

$\lambda = \frac{340}{544}$ ✓

$= 0{,}63m$ ✓ (6)

2.2 The wavelength in QUESTION 2.1.2 is shorter because the waves are compressed as they approach the observer. ✓✓ (2)

2.3 The red shift occurs when the spectrum of a distant star moving away from the earth is shifted toward the red end of the spectrum. ✓✓ (2)
[12]

QUESTION 3

3.1 An apparent change in observed/detected frequency/pitch/wavelength ✓ as a result of the relative motion between a source and an observer/listener. ✓ (2)

3.2 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ **OR** $f_L = \frac{v}{v - v_s} f_s$ ✓ The following values are obtained using other points:

825 ✓ $= \frac{v}{v - v_s}(800)$ ✓

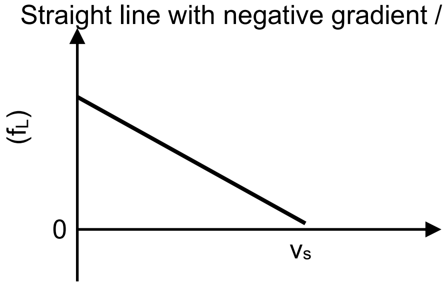
$(1{,}03125)(v - 10)$ ✓ $= v$

$v = 330\ m{\cdot}s^{-1}$ ✓

v_s (m·s⁻¹)	Frequencies	v (m·s⁻¹)
$v_s = 20$	850	310
$v_s = 20$	845	375,56
vs =30	880	330
40	910	331

(5)

3.3 Straight line with negative gradient / frequency decreases (linearly). ✓✓



(2)
[9]

QUESTION 4

4.1.1 Frequency (of sound detected by the listener (observer). ✓ (1)

4.1.2 An apparent change in observed/detected frequency/pitch/wavelength ✓ as a result of the relative motion between a source and an observer/listener. ✓

4.1.3 Away ✓ Detected frequency of source decreases. ✓ (2)

4.1.4

EXPERIMENT 2	**EXPERIMENT 3**
$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ **OR** $f_L = \frac{v}{v + v_s} f_s$ ✓ 874 ✓ $= \frac{v✓}{v + 10}(900)$ ✓ $\therefore$ v = 336,15 m·s^{-1} ✓	$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ **OR** $f_L = \frac{v}{v + v_s} f_s$ ✓ 850 ✓ $= \frac{v✓}{v + 20}(900)$ ✓ $\therefore$ v = 340 m·s^{-1} ✓
EXPERIMENT 4 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ **OR** $f_L = \frac{v}{v + v_s} f_s$ ✓ 827 ✓ $= \frac{v✓}{v + 30}(900)$ ✓ $\therefore$ v = 339,86 m·s^{-1} ✓	

(5)

4.2 Away from the earth. ✓ (1)

[11]

QUESTION 5

5.1 $v = f\lambda$ ✓

$= (222 \times 10^3)(1,5 \times 10^{-3})$ ✓

$= 333$ m.s^{-1} ✓ (3)

5.2.1 Towards the bat. ✓ (1)

5.2.2 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ **OR/*OF*** $f_L = \frac{v}{v - v_s} f_s$ ✓

$230,3$ ✓ $= \frac{333}{333 - v_s}$ ✓ (222) ✓ ✓

$76689,9 - 230,3\, v_s = 73\,926$

v = 12 m.s^{-1} ✓ (towards bat/*na die vlermuis toe*) (6)

[10]

QUESTION 6

6.1 **X** ✓ (1)

6.2 As ambulance approaches the hospital the waves are compressed ✓or wavelengths are shorter. Since the speed of sound is constant ✓ the observed frequency must increase. ✓ Therefore the hospital must be located on the side of X (from $v = f\lambda$)

OR: The number of wave fronts per second reaching the observer are more at X.✓✓.
For the same constant speed, this means that the observed frequency increases ✓ therefore the hospital must be located on the side of X. (from $v = f\lambda$) (3)

6.3 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ **OR** $f_L = \frac{v}{v - v_s} f_s$ ✓ $\therefore$ $f_L = \frac{340}{340 - 30}$ ✓ ✓ (400) ✓ $\therefore f_L = 438,71$ Hz ✓ (5)

6.4 $v = f\lambda$ ✓ $\therefore$ $340 = 400\lambda$ ✓ $\therefore$ $\lambda = 0,85$ m ✓ (3)

[12]

QUESTION 7

7.1.1 An apparent change in observed/detected frequency/pitch/wavelength ✓ as a result of the relative motion between a source and an observer/listener. ✓ (2)

7.1.2 $v = f\lambda$ ✓ $\therefore$ $340 = f(0,28)$ ✓ $\therefore$ $f_s = 1\,214,29$ Hz ✓ (3)

7.1.3 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ **OR** $f_L = \frac{v \pm v_L}{v \pm v_s} \times \frac{v}{\lambda_s}$ **OR** $f_L = \frac{v}{v - v_s} f_s$ ✓

$f_L = \left(\frac{340}{340 - 30}\right)$ ✓ ✓ $1214,29$ ✓ **OR** $f_L = \left(\frac{340}{340 - 30}\right) \times \frac{340}{0,28}$ $\therefore f_L = 1\,331,80$ Hz ✓ (5)

7.1.4 Decreases ✓ (1)

7.2 The spectral lines of the star are/should be shifted towards the lower frequency end, ✓ which is the red end (red shift) of the spectrum. ✓ (2)

[13]

QUESTION 8

8.1 Speed ✓ (1)

8.2 3 m·s⁻¹ ✓ (1)

8.3.1 An apparent change in observed/detected frequency/pitch/wavelength ✓ as a result of the relative motion between a source and an observer/listener. ✓ (2)

8.3.2 345 m·s⁻¹ ✓ (1)

8.3.3 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓ $= \left(\frac{345+0}{345 - 57,5}\right)$ ✓✓ $\left(\frac{1000}{1}\right) = 1\,200$ Hz ✓ (4)

8.3.4 295 ✓ (K) (1)

8.4.1 Diagram 3 ✓ (1)

8.4.2 1 ✓ The source is stationary. ✓ (2)

[13]

QUESTION 9

9.1.1 An apparent change in observed/detected frequency/pitch/wavelength ✓ as a result of the relative motion between a source and an observer/listener. ✓ (2)

9.1.2 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ **OR** $f_L = \frac{v}{v - v_s} f_s$ ✓

$365 = \frac{(340+0)}{(340 - v_s)} \times 330$ ✓✓✓ ∴ v_s = 32,60 m·s⁻¹ ✓ (5)

9.2 According to the Doppler Effect if the star moves away ✓ from the observer a lower frequency/longer wavelength ✓ is detected. This lower frequency/ longer wavelength corresponds to the the red end ✓ of the spectrum. (3)

[10]

QUESTION 10

10.1.1 Doppler effect ✓ (1)

10.1.2 Measuring the rate of blood flow. ✓ **OR:** Ultrasound (scanning) (1)

10.1.3 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ **OR** $f_L = \frac{v}{v - v_s} f_s$ **OR** $f_L = \frac{v}{v + v_s} f_s$ ✓

$2600 = \frac{340}{(340 - v_s)} f_s$ ✓✓

$1750 = \frac{340}{(340 + v_s)} f_s$ ✓ ∴ 2600(340-v_s) = 1750(340 + v_s) ✓ ∴ v_s = 66,44 m·s⁻¹ ✓ (6)

10.1.4 (a) Increase ✓ (1)

(b) Decrease ✓ (1)

10.2.1 The spectral lines (light) from the star are shifted towards longer wavelengths. ✓✓ (2)

10.2.2 Decrease ✓ (1)

[13]

QUESTION 11

11.1 An apparent change in observed/detected frequency/pitch/wavelength ✓ as a result of the relative motion between a source and an observer/listener. ✓ (2)

11.2.1 170 Hz ✓ (1)

11.2.2 130 Hz ✓ (1)

11.3 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓

$170 = \frac{(340+0)}{(340 - v_s)} \times f_s$ ✓✓ ------------ (1)

$130 = \frac{(340-0)}{340 + v_s} \times f_s$ ✓✓ ------------ (2)

v_s = 45,33 m·s⁻¹ ✓ (45,33 – 45,45 m·s⁻¹) (6)

[10]

QUESTION 12

12.1 An apparent change in observed/detected frequency/pitch/wavelength ✓ as a result of the relative motion between a source and an observer/listener. ✓ (2)

12.2 Towards A ✓ Recorded frequency higher. ✓ (2)

12.3
$$f_L = \frac{v \pm v_L}{v \pm v_s} f_s \ ✓$$

FOR A:
$$690 ✓ = \frac{340}{340 - v_s} f_s \ ✓ \quad (1)$$

FOR B:
$$610 ✓ = \frac{340}{340 + v_s} f_s \ ✓ \quad (2)$$

$$\frac{690}{610} = \frac{340 + v_s}{340 - v_s}$$

$1,131\ (340 - v_s) = 340 + v_s$

$v_s = 20,90\ m.s^{-1}$ ✓ (20.90 to $20.92\ m.s^{-1}$) (6)

12.4 Doppler flow meter/Measuring foetal heartbeat/Ultra sound/Sonar/Radar (for speeding) ✓ (1)

[11]

QUESTION 13

13.1 An apparent change in observed/detected frequency/pitch/wavelength ✓ as a result of the relative motion between a source and an observer/listener. ✓ (2)

13.2 **OPTION 1**

$$f_L = \frac{v \pm v_L}{v \pm v_s} f_s \ ✓ \ \textbf{OR} \ f_L = \frac{v}{v - v_s} f_s$$

$$(5100) ✓ = \frac{340}{340 - 240} f_s \ ✓$$

$f_s = 1\ 500\ Hz$

$v = f\lambda$ ✓ ∴ $340 = (1\ 500)\lambda$ ✓ ∴ $\lambda = 0,23\ m$ ✓

OPTION 2

$$f_L = \frac{v \pm v_L}{v \pm v_s} f_s \ ✓ \ \textbf{OR} \ f_L = \frac{v}{v - v_s}\left(\frac{v}{\lambda_s}\right)$$

$$(5100) ✓ = \left(\frac{340}{340 - 240}\right) ✓ \left(\frac{340}{\lambda_s}\right) ✓✓$$

$\lambda = 0,23\ m$ ✓ (7)

13.3 Greater than ✓ (1)

[10]

QUESTION 14

14.1 An apparent change in observed/detected frequency/pitch/wavelength ✓ as a result of the relative motion between a source and an observer/listener. ✓ (2)

14.2 Away from ✓ Observed frequency lower ✓ (2)

14.3 $v = f\lambda$ ✓ ∴ $340 = f\ (0,34)$ ✓ ∴ $f = 1\ 000\ Hz$ ✓ (3)

14.4 **OPTION 1**

$$f_L = \frac{v \pm v_L}{v \pm v_s} f_s \ ✓ \ \textbf{OR} \ f_L = \frac{v}{v - v_s} f_s$$

$$950 ✓ = \frac{340 - v_L}{340 + 0} ✓ \ 1\ 000 ✓ \quad ∴ v_L = 17\ m{\cdot}s^{-1}$$

Distance $x = v\Delta t = (17)(10)$ ✓ $= 170\ m$ ✓

OPTION 2

$$f_L = \frac{v \pm v_L}{v \pm v_s} f_s \ ✓ \ \textbf{OR} \ f_L = \frac{v}{v - v_s}\left(\frac{v}{\lambda_s}\right)$$

$$950 ✓ = \frac{340 - \frac{x}{10}}{340 + 0} ✓ \ (1000) ✓$$

Distance $x = 170\ m$ ✓ (6)

[13]

QUESTION 15

15.1.1 $\Delta x = v_i\Delta t + ½\ a\Delta t^2$ **OR** $v = \frac{d}{t} = \frac{300}{10}$ ✓ $= 30 m{\cdot}s^{-1}$ ✓

$300 = v_i\ (10)$ ✓

$v_i = 30\ m{\cdot}s^{-1}$ ✓ (2)

15.1.2 The change in frequency (or pitch) (of the sound) detected by a listener because the source and the listener have different velocities relative to the medium of sound propagation. ✓✓ (2)

15.1.3 Car/source (just) passes observer. ✓✓ (2)

15.1.4
$$f_L = \frac{v \pm v_L}{v \pm v_s} f_s \ ✓ \ \textbf{OR} \ f_L = \frac{v}{v - v_s} f_s$$

$$932 ✓ = \frac{340}{340 - 30} ✓ f_s \quad ∴ f_s = 849,76\ Hz ✓$$ (4)

15.2 **ANY TWO:**

Doppler / Blood flow meter/Measuring the heartbeat of a foetus/Radar/Sonar/Used to determine whether stars are receding or approaching earth. (2)

[12]

QUESTION 16

16.1 Doppler effect ✓ (1)

16.2 P registers a shorter period/higher frequency./Q registers a longer period/lower frequency. ✓ (1)

16.3 $f = \frac{1}{T}$ ✓ $= \frac{1}{17 \times 10^{-4}}$ ✓ $= 5{,}88 \times 10^{2} = 588{,}24$ Hz ✓ (3)

16.4 $f = \frac{1}{18 \times 10^{-4}}$ ✓ $= 5{,}56 \times 10^{2} = 555{,}56$ Hz

$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓ **OR** $f_L = \frac{v}{v + v_s} f_s$

$555{,}56$ ✓ $= \left(\frac{340}{340 + v}\right)$ ✓ $588{,}24$ ✓ ∴ $v = 20\ m \cdot s^{-1}$ ✓ (6)

[11]

QUESTION 17

17.1 The change in frequency✓ (or pitch) (of the sound) detected by a listener because the source and the listener have different velocities relative to the medium of propagation. ✓ **OR**
An (apparent) change in (observed/detected) frequency (pitch), as a result of the relative motion between a source and an observer (listener). (2)

17.2 Towards (1)

17.3

$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓

$3\,148$ ✓ $= \frac{340 + 0}{340 - v_s} f_s$ ✓

$2\,073$ ✓ $= \frac{340 - 0}{340 + v_s} f_s$ ✓

Solve for v_s: ∴ $v_s = 70\ m \cdot s^{-1}$ ✓

(6)

17.4

OPTION 1	OPTION 2	OPTION 3
$\Delta t = \frac{\Delta x}{v}$ $\Delta t = \frac{350}{70}$ ✓ $\Delta t = 5\ s$ ✓	$\Delta x = v_i \Delta t + ½ a \Delta t^2$ $350 = 70\Delta t + 0$ ✓ $\Delta t = 5$ s ✓	$\Delta x = \left(\frac{v_i + v_f}{2}\right)\Delta t$ $350 = \left(\frac{70 + 70}{2}\right)\Delta t$ ✓ $\Delta t = 5\ s$ ✓

(2)
[11]

QUESTION 18

18.1 The change in frequency (or pitch) of the sound detected by a listener because the sound source and the listener have different velocities relative to the medium of sound propagation. ✓✓ OR
An (apparent) change in observed/detected frequency (pitch), as a result of the relative motion between a source and an observer (listener). (2)

18.2.1 700 Hz ✓
Learner's speed is zero. / No relative motion between source and listener. / Listener and source are stationary. ✓ (2)

18.2.2 Away ✓ The observed frequency is smaller than the source frequency. ✓ (2)

18.2.3

$f_L = \frac{v \pm v_L}{v \pm v_S} f_S$ ✓

$679{,}1$ ✓ $= \frac{v - 10}{v}$ ✓(700) ✓

$v = 334{,}93\ m \cdot s^{-1}$ ✓

OR

$f_L = \frac{v \pm v_L}{v \pm v_S} f_S$ ✓

$658{,}2$ ✓ $= \frac{v - 20}{v}$ ✓(700) ✓

$v = 334{,}93\ m \cdot s^{-1}$ ✓

(5
[11]

QUESTION 19

19.1
$v = \lambda f$ ✓
$340 = 680\lambda$ ✓
$\lambda = 0,5\ m$ ✓
(3)

19.2 The change in frequency/pitch/wavelength of the sound detected by a listener because the sound source and the listener have different velocities relative to the medium of sound propagation. ✓✓
OR
An (apparent) change in observed/detected frequency/pitch/wavelength, as a result of the relative motion between a source and an observer (listener). (2)

19.3.1 Decreased ✓ (1)

19.3.2 Increased ✓ (1)

19.4

$f_L = \frac{v}{\lambda_L}$

$= \frac{340}{0,5 - 0,05}$ ✓

$= 755,56\ Hz$

$f_L = \frac{v \pm v_L}{v \pm v_S} f_S$ ✓

$755,56 = \left[\frac{340 + 0}{340 - v_S}\right](680)$ ✓✓

$v_S = 34\ m \cdot s^{-1}$ ✓
(5)
[12]

QUESTION 20

20.1 The (apparent) change in frequency (or pitch) (of the sound) detected by a listener because the source and the listener have different velocities relative to the medium of propagation. ✓✓ **OR**
An (apparent) change in observed/detected frequency/pitch as a result of the relative motion between a source and an observer/listener. (2)

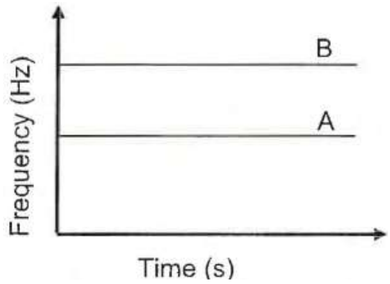
20.2
$v = \lambda f$ ✓
$340 = \lambda(880)$ ✓
$\lambda = 0,386\ m$ ✓
(3)

20.3

$f_L = \left(\frac{v \pm v_L}{v \pm v_S}\right) f_S$ ✓

$= \left(\frac{340 + 10}{340}\right)$ ✓(880) ✓

$= 905,882\ Hz$ ✓
(4)

20.4


(2)
[11]

QUESTION 21

21.1 Doppler effect ✓ (1)

21.2 Measurement of foetal heartbeat. **OR** Measurement of blood flow. **OR** Doppler flow meter ✓ (1)

21.3 Directly proportional **OR** $f_L \alpha f_S$ ✓ (1)

21.4

OPTION 1

$f_L = \left(\frac{v \pm v_L}{v \pm v_S}\right) f_S$ ✓

$\frac{f_L}{f_S} = \left(\frac{v \pm v_L}{v \pm v_S}\right)$

$1,06$ ✓✓ $= \left(\frac{340 + v_L}{340}\right)$ ✓

$v_L = 20,4\ m \cdot s^{-1}$ ✓

OPTION 2

$Gradient = \frac{\Delta f_L}{\Delta f_S}$

$1,06$ ✓✓ $= \frac{f_L - 0}{f_S - 0}$

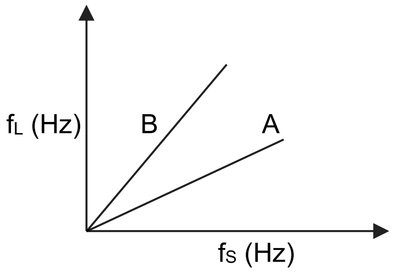
$f_L = 1,06 f_S$

$f_L = \left(\frac{v \pm v_L}{v \pm v_S}\right) f_S$ ✓

$1,06 f_S$ ✓✓ $= \left(\frac{340 + v_L}{340}\right) f_S$ ✓

$v_L = 20,4\ m \cdot s^{-1}$ ✓
(5)

21.5



Straight line starting at the origin. ✓
Gradient of **B** is greater than gradient of **A**. ✓ (2)

[10]

QUESTION 22

22.1.1 The (apparent) change in frequency (or pitch) (of the sound) detected by a listener because the source and the listener have different velocities relative to the medium of propagation. ✓✓ **OR**
An (apparent) change in observed/detected frequency/pitch as a result of the relative motion between a source and an observer/listener. (2)

22.1.2

$$f_L = \left(\frac{v \pm v_L}{v \pm v_S}\right) f_S \checkmark$$
$$= \left(\frac{340 + 22}{340}\right) \checkmark (24\,000) \checkmark$$
$$= 25\,552{,}941\ Hz$$

$$f_L = \left(\frac{v \pm v_L}{v \pm v_S}\right) f_S$$
$$= \left(\frac{340}{340 - 22}\right) \checkmark (25\,552{,}941) \checkmark$$
$$= 27\,320{,}75\ Hz \checkmark$$

(6)

22.2 The frequencies of the spectral lines have decreased. ✓✓ (2)

[10]

QUESTION 23

23.1.1 The change in frequency (or pitch) of the sound detected by a listener because the sound source and the listener have different velocities relative to the medium of sound propagation. ✓✓ **OR**
An apparent change in observed/detected frequency (pitch), as a result of the relative motion between a source and an observer (listener). (2)

23.1.2

$$f_L = \left[\frac{v \pm v_L}{v \pm v_S}\right] f_S \checkmark$$
$$512{,}64 \checkmark = \left[\frac{v}{v + 25}\right] \checkmark (550) \checkmark$$
$$v = 343{,}04\ m \cdot s^{-1}\ to\ 332{,}14\ m \cdot s^{-1} \checkmark$$

(5)

23.1.3 (a) Remains the same. (1)
(b) Remains the same. (1)
(c) Increases. (1)

23.2.1 Away from (1)

23.2.2 A lower frequency / longer wavelength ✓ is detected.
This lower frequency / longer wavelength corresponds to the red end of the spectrum ✓. (2)

[13]

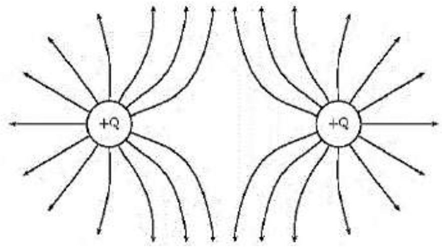
ELECTROSTATICS

QUESTION 1

1.1 To ensure that charge does not leak to the ground/is insulated. ✓ (1)

1.2 Net charge = $\frac{Q_R + Q_S}{2} = \frac{+8 + (-4)}{2}$ ✓= 2 μC ✓ (2)

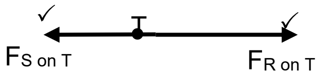
1.3



Criteria for sketch:	
Correct direction of field lines	✓
Shape of the electric field	✓
No field line crossing each other / No field lines inside the spheres.	✓

(3)

1.4



(2)

1.5

$F = k\frac{Q_1Q_2}{r^2}$ ✓

$F_{ST} = \frac{(9\times10^9)(1\times10^{-6})(2\times10^{-6})}{(0{,}2)^2}$ ✓✓ = 0,45 N left **OR** $F_{TS} = \frac{1}{4}F_{RT} = \frac{1}{4}(1{,}8)$ = 0,45 N left

$F_{RT} = \frac{(9\times10^9)(1\times10^{-6})(2\times10^{-6})}{(0{,}1)^2}$ ✓ = 1,8 N right **OR** $F_{RT} = 4F_{ST} = 4(0{,}45)$ = 1,8 N right *regs*

$F_{net} = F_{ST} + F_{RT}$ = 1,8 + (-0,45) ✓ = 1,35 N or towards sphere S or right *S* ✓ (6)

1.6 Force experienced ✓per unit positive charge ✓placed at that point. (2)

1.7

OPTION 1

$E = \frac{F}{q}$ ✓ $= \frac{1{,}35}{1\times10^{-6}}$ = 1,35 x 10^6 N·C^{-1} ✓

OPTION 2

$E_R = \frac{kQ}{r^2}$ ✓ $= \frac{(9\times10^9)(2\times10^{-6})}{(0{,}1)^2}$ ✓= 1,8 x 10^6 N·C^{-1} right

$E_S = \frac{kQ}{r^2} = \frac{(9\times10^9)(2\times10^{-6})}{(0{,}2)^2}$ = 4,5 x 10^5 N·C^{-1} left

E_{net} = 1,8 x 10^6 - 4,5 x 10^5 = 1,35 x 10^6 N·C^{-1} ✓ (3)

[19]

QUESTION 2

2.1 The (magnitude of the) electrostatic force exerted by one point charge on another point charge is directly proportional to the product of the (magnitudes of the) charges✓ and inversely proportional to the square of the distance between them.✓ (2)

2.2.1

$F = \frac{KQ_1Q_2}{r^2}$

$1{,}44\times10^{-1}$ ✓ $= \frac{(9\times10^9)Q^2}{(0{,}5)^2}$ ✓

Q = 2 x10^{-6} C✓ (4)

2.2.2

Q = ne✓

2 x10^{-6} = n(1,6x10^{-19}) ✓

n = 1,25 x10^{13} electrons/*elektrone*✓ (3)

2.3.1 Left / West ✓ (1)

2.3.2 Take right as positive/*Neem regs as positief*

$E_{net} = E_A + E_B$ ✓

$$(3\times10^4) = -\frac{(9\times10^9)(2\times10^{-6})}{(1,5)^2} ✓ + \frac{(9\times10^9)Q_{final}}{(1)^2} ✓$$

$Q_{final} = 4,22 \times 10^{-6}$ C ✓

Q = ne

$4,22 \times 10^{-6} = n(1,6\times10^{-19})$ ✓

$n_f = 2,64 \times 10^{13}$ electrons/*elektrone* ✓

electrons removed/*elektrone verwyder*

$= (2,64 \times 10^{13} + 1,25 \times 10^{13})$ ✓

$= 3,89 \times 10^{13}$ electrons/*elektrone* ✓ (8)

[18]

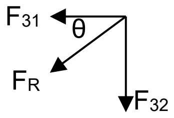
QUESTION 3

3.1 The (magnitude of the) electrostatic force exerted by one point charge on another point charge is directly proportional to the product of the (magnitudes of the) charges ✓ and inversely proportional to the square of the distance between them. ✓ (2)

3.2 $F = k\frac{Q_1Q_2}{r^2}$ ✓

$$F_{31} = \frac{(9\times10^9)(5\times10^{-6})(6\times10^{-6})}{✓(0,3)^2} = 3 \text{ N to the left}$$

$$F_{32} = \frac{(9\times10^9)(5\times10^{-6})(3\times10^{-6})}{(0,1)^2} ✓ = 13,5 \text{ N downwards}$$



F$_R$ = **F**$_{31}$ + **F**$_{32}$ ∴ $F_R = \sqrt{(3)^2 + (13,5)^2}$ ✓ = 13,83 N

Can use any trigonometric ratio

$\theta = \tan^{-1}\frac{13,5}{3}$ ✓ = 77,47°

OR $\theta = \tan^{-1}\frac{3}{13,5}$ ✓ = 12,53° ∴ Net force = 13,83 N in direction192,53° / 77,47° ✓ (7)

[9]

QUESTION 4

4.1 For object N: $n = \frac{Q}{q_e}$ ✓ ∴ $Q = (5 \times 10^6)(-1,6 \times 10^{-19})$ ✓ = -8×10^{-13} C ✓ (3)

4.2 Charge on M (Q_M) is $+8 \times 10^{-13}$ C ✓✓ (2)

4.3 The electrostatic force experienced per unit positive charge placed at that point. ✓✓ (2)

4.4 $E = \frac{kQ}{r^2}$ ✓

$E_{PM} = \frac{(9\times10^9)(8\times10^{-13})}{(0{,}25)^2}$ ✓ ✓ = 0,12 N·C^{-1} to the right

$E_{PN} = \frac{(9\times10^9)(8\times10^{-13})}{(0{,}1)^2}$ ✓ = 0,72 N·C^{-1} to the left

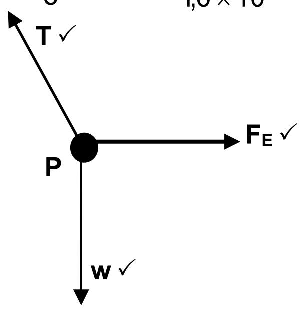
$E_{net} = E_{PM} - E_{PN}$ ✓ = 0,12 – 0,72 = - 0,60 N·C^{-1} ∴ E_{net} = 0,60 N·C^{-1} to the left ✓ (6)

[13]

QUESTION 5

5.1 $n = \frac{Q}{e}$ ✓ ∴ $n = \frac{0{,}5\times10^{-6}}{1{,}6\times10^{-19}}$ ✓ = 3,13 x 10^{12} elektrone ✓ ....(3)

5.2



Accepted labels	
w	F_g / F_w / weight / mg / gravitational force
T	F_T / tension
FE	Electrostatic force/F_C/ Coulombic force/F_Q /$F_{RP/PR}$

(3)

5.3 The (magnitude) of the electrostatic force exerted by one point charge on another point charge is directly proportional to the product (of the magnitudes) of the charges ✓ and inversely proportional to the square of the distance between them.✓ (2)

5.4 $F_E = k\frac{Q_1Q_2}{r^2}$ ✓

$\frac{T\sin\theta}{T\cos\theta} = F_E$

∴ $\frac{T\sin 7°}{T\cos 83°}$ ✓ = $\frac{(9\times10^9)(0{,}5\times10^{-6})(0{,}9\times10^{-6})}{(0{,}2)^2}$ ✓ ✓ ∴T = 0,83 N ✓ (5)

[13]

QUESTION 6

6.1 $E_X = E_2 + E_{(-8)}$ ✓ = $\frac{kQ_2}{r^2} + \frac{kQ_{-8}}{r^2}$ ✓ correct equation

$= \frac{(9\times10^9)(2\times10^{-5})}{(0{,}25)^2}$ ✓ + $\frac{(9\times10^9)(8\times10^{-6})}{(0{,}15)^2}$ ✓

= 2,88 x 10^6 + 3,2 x 10^6 = 6,08 x 10^6 N·C^{-1} ✓ to the east/right ✓

OR

$E = \frac{kQ}{r^2}$ ✓

$E_2 = \frac{(9\times10^9)(2\times10^{-5})}{(0{,}25)^2}$ ✓ = 2,88x 10^6 NC^{-1} to the east/right

$E_{-8} = \frac{(9\times10^9)(8\times10^{-6})}{(0{,}15)^2}$ ✓ = 3,2 x 10^6 N·C^{-1} to the east/right

$E_X = E_2 + E_{(-8)}$ = (2,88 x 10^6 + 3,2 x 10^6) ✓ = 6,08 x 10^6 N·C^{-1} ✓ to the east/right ✓ (6)

6.2

OPTION 1	OPTION 2
$F_E = QE$ ✓ $= (-2 \times 10^{-9})(6{,}08 \times 10^{6})$ ✓ $= -12{,}16 \times 10^{-3}$ N $F_E = 1{,}22 \times 10^{-2}$ N ✓ to the west/left ✓	$F_{(-2)Q1} = qE_{(2)}$ ✓ $= (2 \times 10^{-9})(2{,}88 \times 10^{6})$ $= 5{,}76 \times 10^{-3}$ N to the west/left $F_{(-2)Q2} = qE_{(8)}$ $= (2 \times 10^{-9})(3{,}2 \times 10^{6})$ $= 6{,}4 \times 10^{-3}$ N to the west/left $F_{net} = 5{,}76 \times 10^{-3} + 6{,}4 \times 10^{-3}$ ✓ $= 1{,}22 \times 10^{-2}$ N ✓to the west/left

(4)

6.3 $2{,}44 \times 10^{-2}$ N ✓ / twice / double (1)

[11]

QUESTION 7

7.1 The magnitude of the charges is equal. ✓ (1)

7.2 The (magnitude) of the electrostatic force exerted by one point charge on another point charge is directly proportional to the product (of the magnitudes) of the charges ✓ and inversely proportional to the square of the distance between them.✓ (2)

7.3.1 $T\cos 20° = w$✓

$= mg$

$= (0{,}1)(9{,}8)$✓ $= 0{,}98$ N

$\therefore T = 1{,}04$ N✓ (3)

7.3.2

$F_{electrostatic/elektrostaties} = T\sin 20°$✓

$\frac{kQ_1Q_2}{r^2}$ ✓$= (1{,}04)\sin 20°$

$\frac{kQ_1Q_2}{r^2} = 0{,}356$

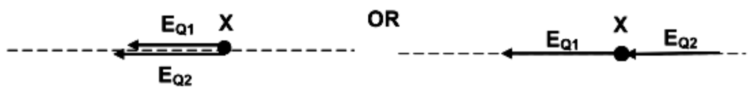
$\frac{(9 \times 10^{9})(250 \times 10^{-9})(250 \times 10^{-9})}{r^2}$ ✓$= 0{,}356$✓

$\therefore r = 0{,}0397$ m ✓ (5)

[11]

QUESTION 8

8.1



Vectors E_{Q1} and E_{Q2} in the same direction. ✓✓

Correct drawing of vectors E_{Q1} and E_{Q2}. ✓✓ The fields due to the two charges add up because they come from the same direction. Hence the field cannot be zero. (4)

8.2 $E = k\frac{Q}{r^2}$✓

$E_{2,5\mu C} = k\frac{Q}{r^2} = \frac{(9 \times 10^{9})(2{,}5 \times 10^{-6})}{(0{,}3)^2}$✓$= 250\ 000$ N.C^{-1} to the left/*na links*

$E_{6\mu C} = k\frac{Q}{r^2} = \frac{(9 \times 10^{9})(6 \times 10^{-6})}{(1{,}3)^2}$✓$= 31\ 952{,}66$ N.C^{-1} to the left/*na links*

$E_P = E_{6\mu C} + E_{2,5\mu C}$ ✓

$= 31\ 952{,}66 + 250\ 000$

$= 281\ 952{,}66$ N.C^{-1} ✓to the left/*na links* ✓ (6)

[10]

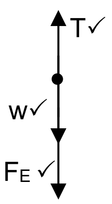
QUESTION 9

9.1

$n = \frac{Q}{e}$✓ $= \frac{-32 \times 10^{-9}}{-1{,}6 \times 10^{-19}}$✓ $= 2 \times 10^{11}$ ✓electrons	$n = \frac{Q}{e}$✓ $= \frac{32 \times 10^{-9}}{1{,}6 \times 10^{-19}}$ ✓ $= 2 \times 10^{11}$ ✓ electrons

(3)

9.2



Accepted labels	
w	F_g/F_w/weight/mg/gravitational force
T	F_T/tension
F_E	$F_{electrostatic}$/F_{Q1Q2} /Coulomb force/F

(3)

9.3 $F_{net} = mg + F_E - T = 0 \therefore mg + k\frac{Q_1Q_2}{r^2} - T = 0$ ✓ ✓

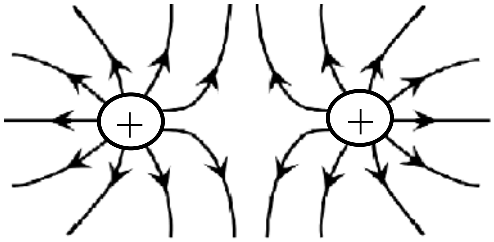
$\therefore (0{,}007)(9{,}8)$ ✓ $+ (9 \times 10^9)\frac{(32\times10^{-9})(55\times10^{-9})}{(0{,}025)^2}$ ✓ $= T$ $\therefore$ $T = 9{,}39(4) \times 10^{-2}$ N ✓ (5)

[11]

QUESTION 10

10.1 The (electrostatic) force experienced by a unit positive charge (placed at that point). ✓✓ (2)

10.2



Marking guidelines	
Lines must not cross / Lines must touch the spheres but not enter spheres	✓
Arrows point outwards	✓
Correct shape	✓

(3)

10.3 $E = \frac{kQ}{r^2}$ ✓

$E_{Q1x} = \frac{(9\times10^9)(30\times10^{-6})}{(x)^2}$ ✓ & $E_{Q2x} = \frac{(9\times10^9)(45\times10^{-6})}{(0{,}15+x)^2}$ ✓

$E_{net} = 0 \therefore E_{Q1x} = E_{Q2x} \therefore \frac{(9\times10^9)(30\times10^{-6})}{(x)^2} = \frac{(9\times10^9)(45\times10^{-6})}{(0{,}15+x)^2}$ ✓

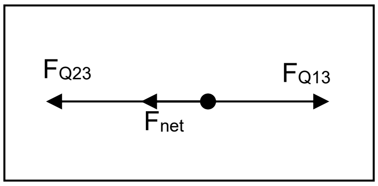
$\therefore x = 0{,}67$ m ✓ (0,667 m) (5)

[10] **QUESTION 11**

11.1 The magnitude of the electrostatic force exerted by one point charge on another point charge <u>is directly proportional to the product of the (magnitudes of the) charges</u> ✓ and <u>inversely proportional to the square of the distance between them.</u> ✓ (2)

11.2.1 Negative ✓✓ (2)

11.2.2 $F = k\frac{Q_1Q_3}{r^2}$ ✓



$0{,}012 = \frac{(9\times10^9)Q_1(2\times10^{-6})}{(2{,}5)^2}$ ✓ $\therefore Q_1 = 4{,}17 \times 10^{-6}$ C ✓

$F_{net} = F_{Q13} + F_{Q23}$ ✓

$-0{,}3$ ✓ $= 0{,}012 - \frac{(9\times10^9)(Q_2)(2\times10^{-6})}{1^2}$ ✓ **OR** $0{,}3 = -0{,}012 + \frac{(9\times10^9)(Q_2)(2\times10^{-6})}{1^2}$

$\therefore Q_2 = 1{,}6 \times 10^{-5}$ C ✓ (7)

[11]

QUESTION 12

12.1.1 The magnitude of the electrostatic force exerted by one point charge on another point charge is directly proportional to the product of the (magnitudes of the) charges ✓ and inversely proportional to the square of the distance between them. ✓ (2)

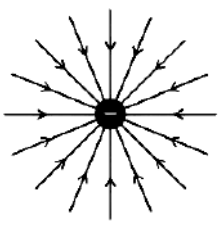
12.1.2 F_E/Electrostatic force ✓ (1)

12.1.3 The electrostatic force is inversely proportional to the square of the distance between the charges. ✓ (1)

12.1.4 Slope $= \frac{\Delta F_E}{\Delta \frac{1}{r^2}}$ ✓ $= \frac{0{,}027 - 0}{5{,}6 - 0}$ ✓ $= 4{,}82 \times 10^{-3}$ N·m^2

Slope $= F_Er^2 = kQ_1Q_2 = kQ^2$ ✓ $\therefore 4{,}82 \times 10^{-3}$ ✓ $=$ <u>$9 \times 10^9 Q^2$</u> ✓ $\therefore Q = 7{,}32 \times 10^{-7}$C ✓ (6)

12.2.1



Criteria for drawing electric field:	
Direction	✓
Field lines radially inward	✓

(2)

12.2.2 $E = \frac{kQ}{r^2}$ ✓

Right as positive:

$E_{PA} = \frac{(9 \times 10^9)(0,75 \times 10^{-6})}{(0,09)^2}$ ✓ = 8,33 x 10^5 N·C^{-1} to the left

$E_{PB} = \frac{(9 \times 10^9)(0,8 \times 10^{-6})}{(0,03)^2}$ ✓ = 8 x 10^6 N·C^{-1} to the left

$E_{net} = E_{PA} + E_{PC}$ = [-8,33 x 10^5 + (- 8 x 10^6)] ✓✓ = - 8,83 x 10^6 = 8,83 x 10^6 N·C^{-1} ✓

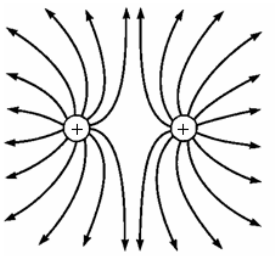
Left as positive: $E_{net} = E_{PA} + E_{PC}$ = (8,33 x 10^5 + 8 x 10^6) ✓✓ = 8,83 x 10^6 N·C^{-1} ✓ (5)

[17]

QUESTION 13

13.1 Electric field is a region of space in which an electric charge experiences a force. ✓✓ (2)

13.2



Marking criteria	
Correct shape as shown.	✓
Direction away from positive	✓
Field lines start on spheres and do not cross.	✓

(3)

13.3 $E_{PA} = \frac{kQ}{r^2}$ ✓ = $\frac{(9 \times 10^9)(5 \times 10^{-6})}{(1,25)^2}$ ✓ = 2,88 x 10^4 N·C^{-1} to the right

$E_{PB} = \frac{kQ}{r^2} = \frac{(9 \times 10^9)(5 \times 10^{-6})}{(0,75)^2}$ ✓ = 8,00 x 10^4 N·C^{-1} to the left

$E_{net} = E_{PA} + E_{PB}$ = 2,88 x 10^4 + (-8,00 x 10^4) = 5,12 x 10^4 N·C^{-1} ✓ (5)

[10]

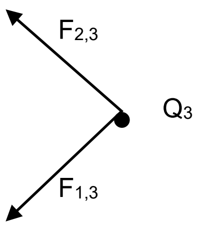
QUESTION 14

14.1.1 Removed ✓ (1)

14.1.2 $n = \frac{Q}{e}$ ✓ = $\frac{6 \times 10^{-6}}{1,6 \times 10^{-19}}$ ✓ = 3,75 x 10^{13} ✓electrons (3)

14.2.1 Negative ✓ (1)

14.2.2



(2)

14.2.3 $F = \frac{kQ_1Q_2}{r^2}$ ✓

$F_{1,3x} = \frac{(9 \times 10^9)(2 \times 10^{-6})(6 \times 10^{-6})}{r^2}(\cos 45°)$ ✓ $= \frac{(0,0764)}{r^2}$ ✓ *(3)*

14.2.4 $F = \frac{kQ_1Q_2}{r^2}$

$F_{2,3x} = \frac{(9 \times 10^9)(2 \times 10^{-6})(6 \times 10^{-6})}{r^2}$ ✓ $(\cos 45°) = \frac{0,0764}{r^2}$

$F_x = F_{1,3x} + F_{2,3x}$

$F_x = \frac{0,0764}{r^2} + \frac{0,0764}{r^2} = 2\frac{0,0764}{r^2}$ ✓ Addition

NOTE: $F_{y\ net} = 0$

(0,12) ✓ = $\frac{0,1528}{r^2}$ ∴ r = 1,128 m ✓ (4)

14.3.1 The electric field at a point is the <u>(electrostatic) force experienced</u> ✓<u>per unit positive charge</u> ✓ placed at that point. (2)

14.3.2 $E = \frac{kQ}{r^2}$ ✓ ∴ $100 = \frac{(9\times10^9)Q}{(0,6)^2}$ ✓ ∴ $Q = 4 \times 10^{-9}$ C

When the electric field strength 50 is N·C^{-1}:

$E = \frac{kQ}{r^2}$ ∴ $50 = \frac{(9 \times 10^9)(4\times10^{-9})}{r^2}$ ✓ ✓ equation

∴ r = 0,85 m ✓ (0,845) m (5)

[21]

QUESTION 15

15.1 The magnitude of the electrostatic force exerted by one point charge on another point charge <u>is directly proportional to the product of the (magnitudes of the) charges</u> ✓ and <u>inversely proportional to the square of the distance between them.</u> ✓ (2)

15.2 **<u>OPTION 1</u>**

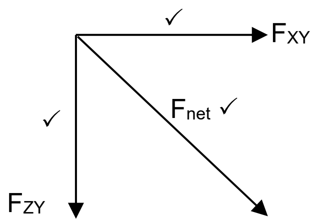
$F = \frac{kQ_1Q_2}{r^2}$ ✓ $= \frac{(9\times10^9)(6\times10^{-6})(8\times10^{-6})}{(0,2)^2}$ ✓ ✓ = 10,8 N ✓

<u>OPTION 2</u>

Both ✓ { $E = \frac{kQ}{r^2} = \frac{(9\times10^9)(8\times10^{-6})}{(0,2)^2}$ ✓ $= 1,8 \times 10^4$ N·C^{-1}

F = Eq = $(1,8 \times 10^4)(6 \times 10^{-6})$ ✓ = 10,8 N ✓ } (4)

15.3



Marking criteria	
$F_{Z\ op\ Y}$ if correct direction	✓
$F_{X\ op\ Y}$ if correct direction	✓
Resultant vector	✓

(3)

15.4 **<u>OPTION 1</u>**

$F_{net}^2 = F_{XY}^2 + F_{ZY}^2$
$15,20^2 = 10,8^2 + F_{ZY}^2$ } ✓Any one

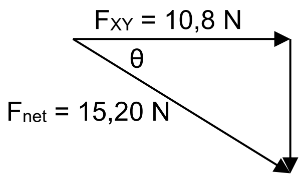
F_{ZY} = 10,696 N

$F_{ZY} = k\frac{Q_ZQ_Y}{r^2}$ ∴ 10,696✓ = $9\times10^9 \times \frac{8\times10^{-6}\times Q_Z}{(0,30)^2}$ ✓ ∴ $Q_Z = 1,34 \times 10^{-5}$ C✓

<u>OPTION 2</u>

$\cos\theta = \frac{10,8}{15,2}$ ∴ θ = 44,72°

$\sin 44,72 = \frac{F_{ZY}}{15,2}$ ✓ **OR** $\tan 44,72 = \frac{F_{ZY}}{F_{XY}}$



∴ F_{ZY} = 10,696 N

$F_{ZY} = k\frac{Q_ZQ_Y}{r^2}$

∴ 10,696 ✓ = $9\times10^9 \times \frac{8\times10^{-6}\times Q_Z}{(0,30)^2}$ ✓

∴ $Q_Z = 1,34 \times 10^{-5}$ C ✓ (4)

[13]

QUESTION 16

16.1 Electric field at a point is the force per unit positive charge placed at that point. ✓✓ (2)

16.2 $E = \frac{kQ}{r^2}$ ✓

$E_{net} = (E_A + E_B)$

$= 9\times10^9 \frac{(1,5\times10^{-6})}{(0,4)^2} + 9\times10^9 \frac{(2,0\times10^{-6})}{(0,3)^2}$ ✓ ✓

$= 2,84 \times 10^5$ N·C^{-1} ✓ (4)

16.3 $F_E = qE$ ✓

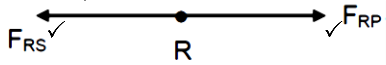
$= (3,0 \times 10^{-9})(2,84 \times 10^5)$ ✓

$= 8,52 \times 10^{-4}$ N ✓ (3)

[9]

QUESTION 17

17.1 The magnitude of the electrostatic force exerted by one point charge on another point charge is directly proportional to the product of the (magnitudes of the) charges ✓ and inversely proportional to the square of the distance between them. ✓ (2)

17.2 

(2)

17.3 To the right as positive:

$F = k\frac{Q_1Q_2}{r^2}$ ✓

$F_{netR} = F_{PR} + F_{SR}$

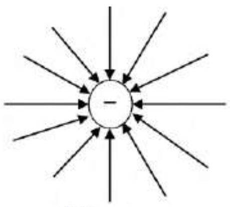
$F_{net} = \frac{kQ_1Q_2}{r^2} + \frac{kQ_1Q_2}{r^2}$

$-1,27\times10^{-6} = \left\{\frac{(9\times10^9)(1,5\times10^{-9})(Q)}{(0,3)^2} - \frac{(9\times10^9)(2\times10^{-9})(Q)}{(0,2)^2}\right\}$ ✓ ✓ ✓

$-1,27 \times 10^{-6} = 150Q - 450Q$ ✓ ∴ $4,23 \times 10^{-9}$ C ✓ (7)

[11]

QUESTION 18

18.1 

Marking criteria:
Shape (radial) ✓
Polarity of A ✓ (2)

18.2 $E = \frac{kQ}{r^2}$ ✓

$3 \times 10^7 = \frac{(9\times10^9)(Q)}{(0,5)^2}$ ✓

$Q = 8,33 \times 10^{-4}$ C ✓ (3)

18.3 $Q = ne$ ✓

$= (10^5)(1,6\times10^{-19})$ ✓

$= 1,6 \times10^{-14}$ C

$E = \frac{F}{Q}$ ✓

$3 \times 10^7 = \frac{F}{1,6\times10^{-14}}$ ✓

$F = 4,8 \times10^{-7}$ N ✓ Right/*Regs* ✓

Positive marking from Q8.2 for this option.

$F = k\frac{Q_1Q_2}{r^2}$ ✓

$F = (9\times10^9)\frac{(8,33\times10^{-4})(1,6\times10^{-14})}{(0,5)^2}$ ✓

$= 4,8 \times 10^{-7}$ N ✓ Right/*Regs* ✓ (6)

[11]

QUESTION 19

19.1 The two forces must be equal in magnitude ✓ but in opposite directions. ✓ (2)

19.2 The magnitude of the electrostatic force exerted by one point charge on another point charge is directly proportional to the product of the (magnitudes of the) charges ✓ and inversely proportional to the square of the distance between them. ✓ (2)

19.3 $F = k\frac{Q_1Q_2}{r^2}$ ✓

$F_{PQ} = \frac{(9\times10^9)(Q)(5\times10^{-6})}{(x)^2}$ ✓ $= \frac{45\times10^3 Q}{x^2}$

$F_{VQ} = \frac{(9\times10^9)(Q)(7\times10^{-6})}{(1-x)^2}$ ✓ $= \frac{63\times10^3 Q}{(1-x)^2}$

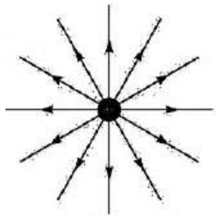
$(F_{net} = F_{PQ} - F_{VQ} = 0)$

$\frac{45\times10^3 Q}{x^2} = \frac{63\times10^3 Q}{(1-x)^2}$ ✓ $\therefore$ 6,708(1 - x) = 7,937x $\therefore$ *x* = 0,46 m away from P (5)

[9]

QUESTION 20

20.1



Criteria for sketch	
Lines are directed away from the charge.	✓
Lines are radial, start on sphere and do not cross.	✓

(2)

20.2 Q = ne ✓ = $(8 \times 10^{13})(-1,6 \times 10^{-19})$ ✓ or $(8 \times 10^{13})(1,6 \times 10^{-19}) = -12,8 \times 10^{-6}$ C

Net charge on the sphere $Q_{net} = (+6 \times 10^{-6}) + (-12,8 \times 10^{-6})$ ✓ $= -6,8 \times 10^{-6}$ C

$E = \frac{kQ}{r^2}$ ✓

$E = \frac{(9\times10^9)(6,8\times10^{-6})}{(0,5)^2}$ ✓

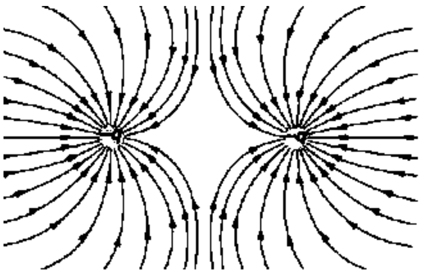
$= 2,45 \times 10^5$ N·C^{-1} ✓ towards sphere ✓ (7)

[9]

QUESTION 21

21.1 $Q_{net} = \frac{Q_1 + Q_2 + Q_3}{3}$ $\therefore$ $-3 \times 10^{-9} = \frac{-15\times10^{-9} + Q + 2\times10^{-9}}{3}$ ✓ $\therefore Q = +4 \times 10^{-9}$ C ✓ (2)

21.2



Correct shape ✓
Correct direction ✓
Lines must not cross and must touch spheres ✓

(3)

21.3 The magnitude of the electrostatic force exerted by one point charge on another point charge is directly proportional to the product of the (magnitudes) of the charges and inversely proportional to the square of the distance between them. ✓✓ (2)

21.4

OPTION 1

$F = \frac{kQ_1Q_2}{r^2}$ ✓

$F_{SP} = \frac{(9\times10^9)(3\times10^{-9})(3\times10^{-9})}{(0,1)^2}$ ✓

= 8,1 x 10^{-6} N downwards

$F_{TP} = \frac{(9\times10^9)(3\times10^{-9})(3\times10^{-9})}{(0,3)^2}$ ✓

= 9 x 10^{-7} N left

$F_{net}^2 = (F_{SP})^2 + (F_{TP})^2$

$F_{net} = \sqrt{(F_{SP})^2 + (F_{TP})^2}$

$F_{net} = \sqrt{(8,1\times10^{-6})^2 + (0,9\times10^{-6})^2}$ } ✓ for any

F_{net} = 8,15 x 10^{-6} N ✓

OPTION 2

$E_s = \frac{kQ}{r^2}$ ✓ $= \frac{(9\times10^9)(3\times10^{-9})}{(0,1)^2}$

= 2 700 N.C^{-1}

$E_T = \frac{kQ}{r^2} = \frac{(9\times10^9)(3\times10^{-9})}{(0,3)^2}$ ✓

= 300 N.C^{-1}

$E_{net} = \sqrt{E_S^2 + E_T^2} = \sqrt{(2700)^2 + (30)^2}$ ✓

= 2 716,62 N.C^{-1}

F = Eq = (2 716,62)(3 x 10^{-9}) ✓

= 8,15 x 10^{-6} N ✓ (5)

21.5 $E = \frac{F}{q}$ ✓ $= \frac{8,15\times10^{-6}}{3\times10^{-9}}$ ✓

= 2,72 x 10^3 N·C^{-1} ✓ (3)

21.6.1 Sphere P or T ✓ (1)

21.6.2 **<u>SPHERE P:</u>** $n_e = \frac{Q}{q_e}$ or $n_e = \frac{Q}{e} = \frac{-15\times10^{-9}}{-1,6\times10^{-19}}$ ✓ = 9,38 x 10^{10}

mass gained = n_em_e = (9,38 x 10^{10})(9,11 x 10^{-31}) ✓ = 8,55 x 10^{-20} kg ✓

<u>SPHERE T:</u>

$n_e = \frac{Q}{q_e}$ or $n_e = \frac{Q}{e} = \frac{-5\times10^{-9}}{-1,6\times10^{-19}}$ ✓ = 3,125 x 10^{10}

mass gained = n_em_e = (3,125 x 10^{10})(9,11 x 10^{-31}) ✓ = 2,85 x 10^{-20} kg ✓ (3)

[19]

QUESTION 22

22.1 The electric field at a point is the <u>electrostatic force</u> experienced <u>per unit positive charge</u> placed at that point. ✓✓ (2)

22.2 q_2 is positive ✓

<u>The electric field due to q_1 points to the right because q_1 is negative.</u> ✓ Since the net field is zero, the <u>field due to q_2 must point to the left away from q_2</u>, ✓ hence q_2 is positive.

OR Since E_{net} is zero,<u>E_1 and E_2 are in opposite directions</u> therefore q_1 and q_2 are oppositely charged. (3)

22.3 $E = k\frac{Q}{r^2}$ ✓

$E_{net} = 0$

$\therefore k\frac{q_1}{r_1^2} = k\frac{q_2}{r_2^2}$ **OR** $\frac{q_1}{r_1^2} = \frac{q_2}{r_2^2}$

$\frac{(9\times10^9)(3\times10^{-9})}{(0,1)^2} = \frac{(9\times10^9)q_2}{(0,4)^2}$ ✓✓

q_2 = + 4,8 x 10^{-8} C ✓ (4)

22.4 The electrostatic force (of attraction/repulsion) between two point charges is <u>directly proportional to the product of the charges</u> and <u>inversely proportional to the square of the distance between them</u>. ✓✓ (2)

22.5 $F = \frac{kQ_1Q_2}{r^2}$ ✓

$F = \frac{(9\times10^9)(3\times10^{-9})(4,8\times10^{-8})}{(0,3)^2}$ ✓

= 1,44 x 10^{-5} N ✓ (3)

22.6 Yes ✓

<u>Both</u> charges are <u>equal and positive</u> ✓ (2)

[16]

QUESTION 23

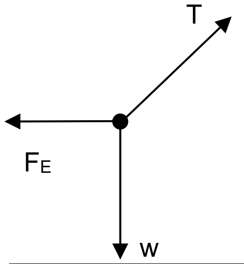
23.1.1 Positive ✓ (1)

23.1.2 $F = \frac{kQ_1Q_2}{r^2}$ ✓

$3,05 = \frac{(9 \times 10^9)(6 \times 10^{-6})Q}{0,2^2}$ ✓

$Q = 2,259 \times 10^{-6}$ C ✓ ($2,26 \times 10^{-6}$ C) (3)

23.1.3



Accepted labels	
w✓	F_g / F_w / weight / mg / gravitational force
T✓	F_T / tension
F_E✓	Electrostatic force/ Coulomb force/ $F_{E\ Field}$

(3)

23.1.4

OPTION 1	OPTION 2
$F_{net} = 0$ $F_E = T\sin 10°$ $F_E = T\cos 80°$ } ✓Any one $3,05 = T\sin 10°$ $= T\cos 80°$ } ✓Any one T = 17,56 N ✓ (17,564 N)	$\frac{T}{\sin 90°} = \frac{F_E}{\sin 10°}$ ✓ $\frac{T}{1} = \frac{3,05}{\sin 10°}$ ✓ T = 17,56 N ✓

(3)

23.2.1 The electric field at a point is the <u>(electrostatic) force</u> ✓ experienced <u>per unit positive charge</u> placed at that point. ✓ (2)

23.2.2 Electric field at **M** due to **A** ($+2 \times 10^{-5}$ C):

$E_A = \frac{kQ}{r^2}$ ✓ $= 9 \times 10^9 \frac{(2 \times 10^{-5})}{(0,2)^2}$ ✓ $= 4,5 \times 10^6\ N \cdot C^{-1}$ (to the right)

Electric field at **M** due to **B** (-4×10^{-5} C):

$E_B = \frac{kQ}{r^2}$

$= 9 \times 10^9 \frac{(4 \times 10^{-5})}{(0,2)^2}$ ✓

$= 9 \times 10^6\ N \cdot C^{-1}$ (to the right)

OR $q_B = 2x\ q_A$

$E_B = 2x\ E_A$✓

$= 9 \times 10^6\ N \cdot C^{-1}$ (to the right)

E_{net} at **M** = $E_A + E_B = (4,5 \times 10^6 + 9 \times 10^6)$ ✓ $= 1,35 \times 10^7\ N \cdot C^{-1}$ ✓ to the right ✓ (6)

[18]

QUESTION 24

24.1

$n = \frac{Q}{e}$ ✓

$= \frac{-4x10^{-6}}{-1,6x10^{-19}}$ ✓

$= 2,5x10^{13}$ ✓

A negative answer not accepted; substitute so that a positive answer is obtained.

(3)

24.2

$F = \frac{kQ_1Q_2}{r^2}$ ✓

$= \frac{(9x10^9)(4x10^{-6})(3x10^{-6})}{0,2^2}$ ✓

$= 2,7\ N$ ✓

(3)

24.3 Electric field is a <u>region</u> (in space) where (in which) an <u>(electric) charge experiences a (electric) force</u>. ✓✓ (2)

24.4

OPTION 1

Electric field at M due to: -4×10^{-6} C

$$E_{AM} = \frac{kQ}{r^2} \checkmark$$

$$= \frac{(9x10^9)(4x10^{-6})}{0{,}3^2} \checkmark$$

$$= 4x10^5\ N \cdot C^{-1}\ (to\ left)$$

Electric field at M due to: $+3 \times 10^{-6}$ C

$$E_{BM} = \frac{kQ}{r^2}$$

$$= \frac{(9x10^9)(3x10^{-6})}{0{,}1^2} \checkmark$$

$$= 2{,}7x10^6\ N \cdot C^{-1}\ (to\ right)$$

Net electric field at M

$E_{net} = E_{BM} + E_{AM}$

$= 4{,}0 \times 10^5 – 2{,}7 \times 10^6$ ✓

$= 2{,}3 \times 10^6$ N·C^{-1} ✓(right)

OR

Net electric field at M

$E_{net} = E_{BM} + E_{AM}$

$= -4{,}0 \times 10^5 + 2{,}7 \times 10^6$ ✓

$= - 2{,}3 \times 10^6$ N·C^{-1}

$= 2{,}3 \times 10^6$ N·C^{-1} ✓ (right)

OPTION 2

$$F_{AM} = \frac{kQ_1Q_2}{r^2}$$

$$= \frac{(9x10^9)(4x10^{-6})Q}{0{,}3^2} \checkmark$$

$$= (4x10^5)(Q)$$

$$F_{BM} = \frac{kQ_1Q_2}{r^2}$$

$$= \frac{(9x10^9)(3x10^{-6})Q}{0{,}1^2} \checkmark$$

$$= (2{,}7x10^6)(Q)$$

$F_{net} = 2{,}7 \times 10^6Q + (-4 \times 10^5Q)$✓ $= 2{,}3 \times 10^6Q$

$$E = \frac{F}{Q} \checkmark$$

$$= \frac{2{,}3x10^6Q}{Q}$$

$$= 2{,}3x10^6\ N \cdot C^{-1} \checkmark\ (right)$$

(5)

24.5 Positive (1)

24.6

$(F_{net})^2 = (F_{AD})^2 + (F_{AB})^2$
$(7{,}69)^2 = (F_{AD})^2 + (2{,}7)^2$ ✓
$F_{AD} = 7{,}2$ N

$$F_{AD} = \frac{kQ_1Q_2}{r^2}$$
$$7{,}2 = \frac{(9 \times 10^9)(4 \times 10^{-6})Q}{0{,}15^2} \checkmark$$
$$Q_D = 4{,}5 \times 10^{-6}\ C \checkmark$$

OR

$$F_{AD} = \frac{kQ_1Q_2}{r^2}$$
$$= \frac{(9 \times 10^9)(4 \times 10^{-6})Q}{0{,}15^2} \checkmark$$
$$= 1{,}6 \times 10^6\ Q$$
$$F_{net} = \sqrt{(F_{AB}^2 + F_{AD}^2)}$$
$$7{,}69 = \sqrt{2{,}7^2 + (1{,}6 \times 10^6 Q)^2} \checkmark$$
$$Q = 4{,}50 \times 10^{-6}\ C \checkmark$$

(3)
[17]

QUESTION 25

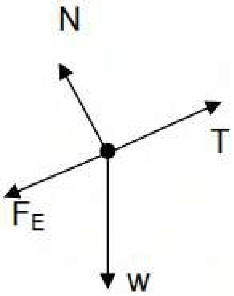
25.1 The magnitude of the electrostatic force exerted by one point charge (Q_1) on another point charge (Q_2) is directly proportional to the product of the (magnitudes) of the charges ✓ and inversely proportional to the square of the distance (r) between them. ✓ (2)

25.2

$$F = \frac{kQ_1Q_2}{r^2} \checkmark$$
$$1{,}2 \times 10^{-3} = \frac{(9 \times 10^9)(6 \times 10^{-9})(5 \times 10^{-9})}{r^2} \checkmark$$
$$r = 0{,}015\ m \checkmark$$

(3)

25.3



(4)

25.4.1

Up, parallel to the incline, is positive.
$F_{net} = ma$ ✓
$T + F_E + w_{||} = ma$
$T - 1{,}2 \times 10^{-3}$ ✓ $- (0{,}01)(9{,}8)(\sin 25°)$ ✓ $= 0$
$T = 0{,}04$ N ✓ (0,0426 N)

(4)

25.4.2

$$E_{net} = E_R + E_S \checkmark$$
$$E_{net} = \frac{kQ_R}{r^2} + \frac{kQ_S}{r^2}$$
$$= \frac{(9 \times 10^9)(5 \times 10^{-9})}{(0{,}015 + 0{,}03)^2} \checkmark - \frac{(9 \times 10^9)(6 \times 10^{-9})}{0{,}03^2} \checkmark$$
$$= -37\ 777{,}78\ N \cdot C^{-1}$$
$$E_{net} = 37\ 777{,}78\ N \cdot C^{-1} \checkmark \text{ down the incline} \checkmark$$

(5)
[18]

QUESTION 26

26.1.1 Added ✓ (1)

26.1.2

$$n = \frac{Q}{q_e} \checkmark$$
$$= \frac{-1{,}95 \times 10^{-6}}{-1{,}6 \times 10^{-19}} \checkmark$$
$$= 1{,}22 \times 10^{13} \checkmark$$

(3)

26.1.3 The (electrostatic) force experienced per unit positive charge placed at that point. ✓✓ (2)

26.1.4

$$E = \frac{kQ}{r^2} ✓$$
$$= \frac{(9x10^9)(1,95x10^{-6})}{0,5^2} ✓$$
$$= 7,02x10^4\ N \cdot C^{-1} ✓$$

(3)

26.2

WEST +

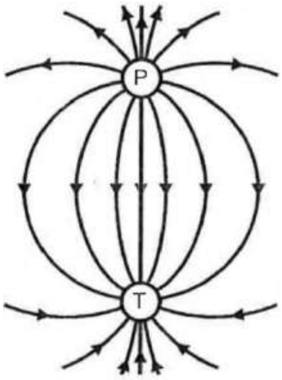
$$F_{net} = F_{q2} + F_{q1}$$
$$= \left(+\frac{kQ_1Q_2}{r^2}\right) + \left(-\frac{kQ_1Q_2}{r^2}\right) ✓$$
$$1,38 ✓ = \left(+\frac{(9x10^9)(1,95x10^{-6})q_2}{0,03^2}\right) + \left(-\frac{(9x10^9)(1,95x10^{-6})q_2}{0,05^2}\right) ✓✓$$
$$q_2 = 1,11x10^{-7}\ C ✓$$

(5)
[14]

QUESTION 27

27.1.1 The magnitude of the electrostatic force exerted by one point charge (Q_1) on another point charge (Q_2) is directly proportional to the product of the (magnitudes) of the charges ✓ and inversely proportional to the square of the distance (r) between them. ✓ (2)

27.1.2



(3)

27.1.3 Positive ✓ (1)

27.1.4

$$F_{net}^2 = F_{TP}^2 + F_{TS}^2$$
$$= \left(\frac{kQ_1Q_2}{r^2}\right)^2 ✓ + \left(\frac{kQ_1Q_2}{r^2}\right)^2$$
$$10^2 = \left(\frac{(9x10^9)(3x10^{-6})(3x10^{-6})}{0,1^2}\right)^2 ✓ + \left(\frac{(9x10^9)(3x10^{-6})Q_2}{0,15^2}\right)^2 ✓✓$$
$$Q_2 = 4,887x10^{-6}\ C$$

$$Q_S = ne$$
$$4,887x10^{-6} = n(1,6x10^{-19}) ✓$$
$$n = 3,05x10^{13}\ electrons ✓$$

(6)

27.2.1

E is directly proportional to $\frac{1}{r^2}$.

OR

$E\ \alpha\ \frac{1}{r^2}$

(1)

27.2.2

$$Gradient = \frac{\Delta E}{\Delta\left(\frac{1}{r^2}\right)} ✓$$
$$680 ✓ = \frac{E_A - 0}{\left(\frac{1}{0,04^2}\right) - 0} ✓$$
$$E_A = 4,25x10^5\ N \cdot C^{-1} ✓$$

(4)

27.2.3 Greater than ✓

For the same $\frac{1}{r^2}$, E is greater for sphere **B**. ✓✓ (3)

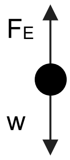
[20]

QUESTION 28

28.1 The magnitude of the electrostatic force exerted by one point charge on another is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance between them. ✓✓ (2)

28.2 Negative ✓ (1)

28.3



Acceptable labels	
w✓	F_g/F_w/w/weight/mg/ gravitational force /gravity
F_E✓	$F_{electrostatic}$ /F/ $F_{M\ on\ N}$ / Electrostatic force

(2)

28.4

$F = \frac{kQ_MQ_N}{r^2}$ ✓

$(2{,}04x10^{-3})(9{,}8)$ ✓✓ $= \frac{(9x10^9)(Q_M)(8{,}6x10^{-8})}{0{,}3^2}$ ✓

$Q_M = 2{,}33x10^{-6}\ C$ ✓

(5)

28.5.1 Equal **OR** The same ✓ (1)

28.5.2 Opposite **OR** upwards ✓ (1)

28.6

<u>OPTION 1</u>: UPWARDS POSITIVE

For $E = \frac{kQ}{r^2}$ ✓

$E_{net} = E_M + E_N$

$E_{net} = \frac{kQ_M}{r^2} + \frac{kQ_N}{r^2}$

$= \frac{(9x10^9)(2{,}33x10^{-6})}{0{,}4^2}$ ✓ $- \frac{(9x10^9)(8{,}6x10^{-8})}{0{,}1^2}$ ✓

$= 5{,}37x10^4\ N\cdot C^{-1}$

$E_{net} = 5{,}37x10^4\ N\cdot C^{-1}$ ✓; upwards ✓

<u>OPTION 2</u>: DOWNWARDS POSITIVE

For $E = \frac{kQ}{r^2}$ ✓

$E_{net} = E_M + E_N$

$E_{net} = \frac{kQ_M}{r^2} + \frac{kQ_N}{r^2}$

$= -\frac{(9x10^9)(2{,}33x10^{-6})}{0{,}4^2}$ ✓ $+ \frac{(9x10^9)(8{,}6x10^{-8})}{0{,}1^2}$ ✓

$= -5{,}37x10^4\ N\cdot C^{-1}$

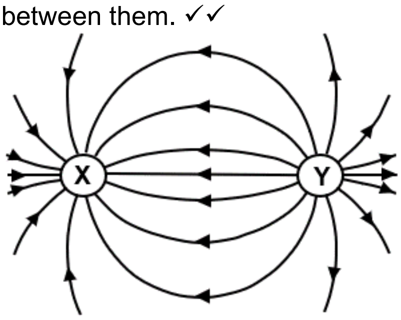
$E_{net} = 5{,}37x10^4\ N\cdot C^{-1}$ ✓; upwards ✓

(5)
[17]

QUESTION 29

29.1 The magnitude of the electrostatic force between two point charges is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance between them. ✓✓ (2)

29.2



Marking criteria
Correct shape ✓
Correct direction from **Y** to **X** ✓
Lines must not cross and must touch the spheres. ✓

(3)

29.3

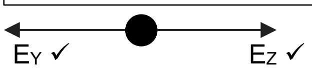
$F = \frac{kQ_YQ_X}{r^2}$ ✓

$= \frac{(9x10^9)(7{,}2x10^{-9})(7{,}2x10^{-9})}{0{,}03^2}$ ✓

$= 5{,}184x10^{-4}\ C$ ✓

(3)

29.4



(2)

29.5

OPTION 1

$E_{net} = E_Z + E_Y$

$E_{net} = \frac{kQ_Z}{r^2} \checkmark + \frac{kQ_Y}{r^2}$

$4{,}91x10^5 \checkmark = \frac{(9x10^9)Q_Z}{0{,}01^2} - \checkmark \frac{(9x10^9)(7{,}2x10^{-9})}{0{,}03^2} \checkmark$

$Q_7 = 6{,}25x10^{-9}\ C \checkmark$

OPTION 2

$E = \frac{F}{Q} \checkmark$

$4{,}91x10^5 = \frac{F}{7{,}2x10^{-9}}$

$F_{net} = 3{,}54x10^{-3}\ N$

$F_{net} = F_{Z\ on\ X} + F_{Y\ on\ X}$

$F_{net} = \frac{kQ_ZQ_X}{r^2} + \frac{kQ_YQ_X}{r^2}$

$3{,}54x10^{-3} \checkmark = \frac{(9x10^9)(7{,}2x10^{-9})Q_Z}{0{,}01^2} \checkmark - \checkmark 5{,}18x10^{-4}$

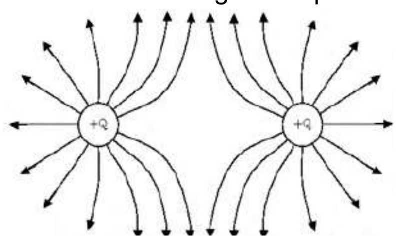
$Q_Z = 6{,}26x10^{-9}\ C \checkmark$

(5)
[15]

QUESTION 30

30.1 Electric field is a region in space in which an electric charge experiences a force. ✓✓ (2)

30.2



Marking criteria
Correct direction of field lines. ✓
Correct shape of the electric field lines. ✓
No field lines crossing each other. Field lines must touch the charges but must not go inside. ✓

(3)

30.3

OPTION 1

$E = \frac{kQ}{r^2} \checkmark$

$E_A = \frac{(9x10^9)(3x10^{-9})}{r^2} \checkmark$

$E_B = \frac{(9x10^9)(3x10^{-9})}{(2r)^2} \checkmark$

RIGHT AS POSITIVE

$E_{net} = E_A + E_B$

$27 = \frac{(9x10^9)(3x10^{-9})}{r^2} + \left[-\frac{(9x10^9)(3x10^{-9})}{(2r)^2}\right] \checkmark$

$r = 0{,}87\ m \checkmark$

OPTION 2

$F = \frac{kQ_1Q_2}{r^2} \checkmark$

$F_A = \frac{(9x10^9)(3x10^{-9})(Q)}{r^2} \checkmark$

$F_B = \frac{(9x10^9)(3x10^{-9})(Q)}{(2r)^2} \checkmark$

RIGHT AS POSITIVE

$F_{net} = F_A + F_B$

$27Q = \frac{(9x10^9)(3x10^{-9})(Q)}{r^2} + \left[-\frac{(9x10^9)(3x10^{-9})(Q)}{(2r)^2}\right] \checkmark$

$r = 0{,}87\ m \checkmark$

(5)

30.4

OPTION 1

$F = EQ \checkmark$

$= (27)(1{,}6x10^{-19}) \checkmark$

$= 4{,}32x10^{-18}\ N \checkmark$

OPTION 2

$F = \frac{kQ_1Q_2}{r^2} \checkmark$

RIGHT AS POSITIVE

$F_{net} = F_A + F_B$

$= \frac{(9x10^9)(3x10^{-9})(1{,}6x10^{-19})}{0{,}87^2} + \left[-\frac{(9x10^9)(3x10^{-9})(1{,}6x10^{-19})}{(2x0{,}87)^2}\right] \checkmark$

$= 4{,}28x10^{-18}\ m \checkmark$

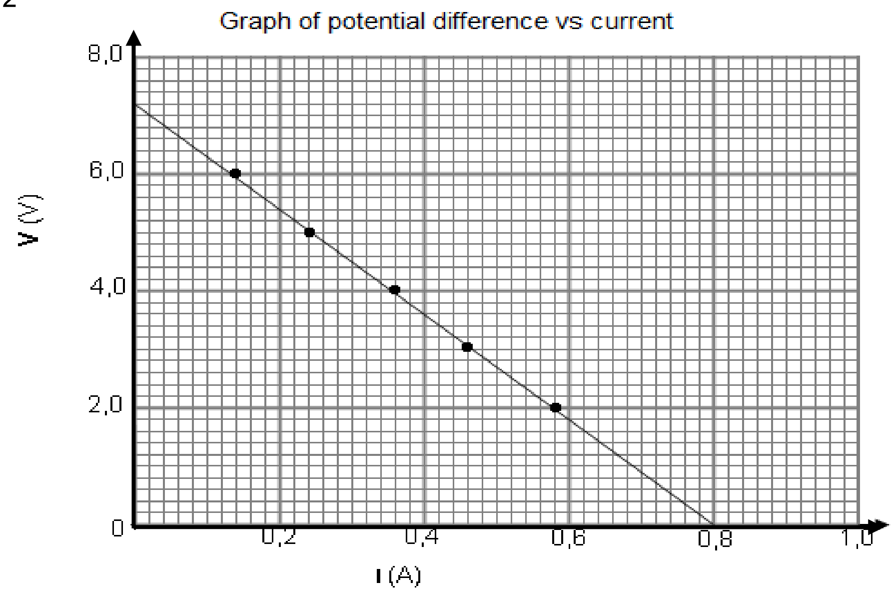
(3)
[16]

ELECTRIC CIRCUITS

QUESTION 1

1.1.1 Keep the temperature (of battery) constant. ✓ (1)

1.1.2



Criteria for drawing line of best fit:	
ALL points correctly plotted (at least 4 points)	✓✓
Correct line of best fit if 3 plotted points are used.	✓

(3)

1.1.3 7,2 V✓
(Accept any readings between 7,0 V and 7,4 V or the value of the y-intercept.) (1)

1.1.4 Slope = $\frac{\Delta V}{\Delta I} = \frac{0 - 7,2}{0,8 - 0}$ ✓✓ = - 9 ∴ r = 9 Ω ✓ (3)

1.2.1 P = VI ✓ ∴ 100 = 20(I) ✓ ∴ I = 5 A ✓ (3)

1.2.2 $P = \frac{V^2}{R}$ ✓ ∴ $R = \frac{(20)^2}{150}$ ✓ = 2,67 Ω ✓ (3)

1.2.3 P = VI **OR** $P = I^2R$

∴ $I_{150W} = \frac{150}{20}$ ✓ = 7,5 A ∴ $I_{150W} = \sqrt{\frac{150}{2,67}}$ ✓ = 7,5 A

I_{tot} = (5 + 7,5) ✓
ε = I(R + r) ✓ ∴ 24 = 12,5(R + r)
24 = V_{ext} + V_{ir} ∴ 24 = 20 + 12,5(r) ✓ ∴ r = 0,32 Ω ✓ (5)

1.2.4 Device Z is a voltmeter. ✓ (1)

1.2.5 Device **Z** should be a voltmeter (or a device with very high resistance) because <u>it has a very high resistance</u>✓ <u>and will draw very little current.</u> ✓ The current through **X** and **Y** will remain the same hence the device can operate as rated. (2)

[22]

QUESTION 2

2.1.1 Same length of wires.✓
Same thickness/cross-sectional area of wires. ✓ (2)

2.1.2 Wire **A** (Resistor A)/*Draad A* ✓

$R = \frac{\Delta V}{\Delta I}$ ✓

$R_A = \frac{4{,}4}{0{,}4}$ ✓ $= 11\ \Omega$✓

Accept any correct coordinates chosen from the graph *Aanvaar enige korrekte koördinate van die grafiek gekies.*

$R_B = \frac{2{,}2}{0{,}4}$✓ $= 5{,}5\ \Omega$✓

$E = I^2 R\Delta t$✓

For the same time and current, the heating in A will be higher because its resistance is higher than that of B. ✓ (8)

2.2.1

OPTION 1/*OPSIE 1*	OPTION 2/*OPSIE 2*
$I_{5,5\Omega} : I_{11\Omega}$ 2 : 1 $I_{5,5\Omega} = (0{,}2)(2)$ ✓✓ $= 0{,}4$ A✓	$V = IR$ $V_{11\ \Omega} = 0{,}2 \times 11$ $= 2{,}2$ V✓ $V_{5,5} = V_{11} = 2{,}2$ V✓ $I_{5,5} = \frac{2{,}2}{5{,}5}$ $= 0{,}4$ A✓

(3)

2.2.2

OPTION 1/OPSIE 1	OPTION 2/*OPSIE 2*
$V = IR$ $I_{tot} = (0{,}4 + 0{,}2)$ ✓ $= 0{,}6$ A $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$✓ $\frac{1}{Rp} = \frac{1}{11} + \frac{1}{5{,}5}$ ✓ $R_P = 3{,}67\ \Omega$ $R_T = R_P + R_A$ $= 3{,}67 + 11$✓ $= 14{,}67\Omega$ $\varepsilon = I(R + r)$ ✓ $9 = 0{,}6(14{,}67 + r)$ ✓ $r = 0{,}33\ \Omega$ ✓	$I_{tot} = (0{,}4 + 0{,}2)$ ✓ $= 0{,}6$ A $V_{ext} = V_{11\ \Omega} + V_{//}$ ✓ $= [I_{tot}(R_{11}) + 2{,}2]$ $= 0{,}6\ (11)$ ✓ $+ 2{,}2$ $= 8{,}8$V✓ $\mathcal{E} = V_{ext} + I_{tot}(r)$ ✓ $9 = 8{,}8 + 0{,}6r$✓ $r = 0{,}33\ \Omega$✓

(7)

2.2.3 Decrease ✓
The total resistance increases. ✓ (2)
[22]

QUESTION 3

3.1 Negative ✓ (1)

3.2 $I_{2\Omega} = \frac{V}{R}$ ✓ $= \frac{1{,}36}{(4+2)}$ ✓ $= 0{,}23$ A ✓ (3)

3.3

OPTION 1	OPTION 2
$I_{3\Omega} = \frac{V}{R} = \frac{1{,}36}{3}$ ✓ $= 0{,}45$ A $I_T = I_2 + I_3 = 0{,}23 + 0{,}45$ ✓ $= 0{,}68$ A $V_{int/\text{"lost"}} = \varepsilon - V_{ext}$✓ $= 1{,}5 - 1{,}36$ ✓ $= 0{,}14$ V $V_{int/\text{"lost"}} = Ir$ ✓ $0{,}14 = (0{,}68)r$ ✓ $\therefore r = 0{,}21\ \Omega$ ✓	$I_3 = \frac{V}{R} = \frac{1{,}36}{3}$ ✓ $= 0{,}45$ A $I_T = I_2 + I_3 = 0{,}23 + 0{,}45$ ✓ $= 0{,}68$ A $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$ ✓ $\therefore \frac{1}{R_p} = \frac{1}{6} + \frac{1}{3}$ ✓ $\therefore R_P = 2\ \Omega$ $\varepsilon = I(R + r)$ ✓ $\therefore 1{,}5 = 0{,}68(2 + r)$ ✓ $\therefore r = 0{,}21\ \Omega$ ✓

(7)

3.4 Decreases ✓ Effective resistance across parallele circuit decreases. ✓ Terminal poetantial difference decreases. ✓ Resistance in ammeter branch remains constant. ✓ (4)
[15]

QUESTION 4

4.1 The potential difference across a conductor is directly proportional to the current ✓ in the conductor at constant temperature. ✓ (2)

4.2

OPTION 1	OPTION 2
$V_8 = IR$ ✓ $= (0,5)(8) = 4$ V $= V_{16}$ $I_{16} = \frac{V}{R} = \frac{4}{16} = 0,25$ A $I_{tot//} = I_{A1} = (0,5 + 0,25)$ ✓ $= 0,75$ A ✓	$V_8 = IR$ ✓ $= (0,5)(8)$ ✓ $= 4$ V $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{8} + \frac{1}{16}$ ✓ ∴ R = 5,33 Ω $I_{tot//} = \frac{4}{5,33} = I_{A1} = 0,75$ A ✓

(4)

4.3

OPTION 1	OPTION 2

$V_{20\Omega} = IR = (0,75)(20)$ ✓ $= 15$ V
$V_{//tot} = (15 + 4)$ ✓ $= 19$ V
$V_R = 19$ V
P = VI ✓
∴ $12 = (19)I_R$ ✓
∴ $I_R = I_{A2} = 0,63$ A ✓
	$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{8} + \frac{1}{16}$ ✓ ∴ R = 5,33 Ω
	$R_{//} + R_{20} = (5,33 + 20)$ ✓ $= 25,33$ Ω
	$V_{//tot} = I(R_{//} + R_{20}) = (0,75)(25,33) = 19$ V
	P = VI ✓ ∴ $12 = (19)I_R$ ✓
	∴ $I_R = I_{A2} = 0,63$ A ✓

(5)

4.4

OPTION 1	OPTION 2
$\varepsilon = I(R + r)$ ✓ $= V_{//tot} + V_{int}$ $= 19 + (0,75 + 0,63)(1)$ ✓ $= 20,38$ V ✓	$V_{int} = Ir = (0,75 + 0,63)(1)$ ✓ $= 1,38$ V $\varepsilon = V_{//tot} + V_{int}$ ✓ $= 19 + 1,38 = 20,38$ V ✓

(3)

[14]

QUESTION 5

5.1.1 V = IR✓
$= (0,2)(4+8)$✓
$= 2,4$ V✓
(3)

5.1.2

V = IR $2,4 = I_2(2)$ ✓ $I_{2\Omega} = 1,2$ A✓ $I_T = I_2 + 0,2$ A✓ $= 1,4$ A✓	OR $I_2 = 6 \times 0,2$ ✓ $I_2 = 1,2$ A✓ $I_T = I_2 + 0,2$ ✓ $= 1,4$ A✓

(4)

5.1.3

OPTION 1	OPTION 2
$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$ ✓ $\frac{1}{R_p} = \frac{1}{12} + \frac{1}{2}$ $R_P = 1,72$ Ω✓ $\varepsilon = I(R+r)$ ✓ $= 1,4(1,72 + 0,5)$ ✓ $= 3,11$ V✓	$V_{int} = Ir$✓ $= (1,4)(0,5)$ $= 0,7$ V✓ $\varepsilon = V_{ext/eks} + V_{int}$✓ $= 2,4 + 0,7$✓ $= 3,1$ V✓

(5)

5.2 Removing the 2 Ω resistor increases the total resistance of the circuit. ✓ Thus otal current decreases, decreasing the V_{int} (V_{lost}). ✓ Therefore the voltmeter reading V increases. ✓ (3)

[15]

QUESTION 6

6.1.1

OPTION 1	OPTION 2	OPTION 3
$P = \frac{V^2}{R}$ ✓ $4 = \frac{V^2}{R} = \frac{(12)^2}{R}$ ✓R = 36 Ω ✓	P = VI 4 = I(12) I = 0,33...A V = IR ✓ 12 = 0,33R ✓ ∴R = 36,36 Ω ✓	P = V I 4 = I(12) ∴ I = 0,33 ..A $P = I^2 R$ ✓ $4 = (0,33^2)R$ ✓ ∴R = 36,73 Ω ✓

(3)

6.1.2 Increase (1)

6.1.3 No change ✓ Same potential difference ✓ (and resistance) (2)

6.2.1 V = IR ✓ ∴ 5 = I(6) ✓ ∴ I = 0,83 A

$V_{\text{"lost"}} = Ir$
1 = (0,83)r ✓
r = 1,20 Ω✓

OR

$\varepsilon = I(R + r)$
6 = (0,83)(6 + r) ✓
r = 1,23 Ω ✓
(4)

6.2.2 Maximum work done (or energy provided) ✓ by a cell per unit charge passing through it. ✓ (2)

6.2.3

OPTION 1	OPTION 2

$V_{\text{"lost"}} = Ir$
$1,5 ✓ = I(1,2)$
$I = 1,25$ A
 	
$V_{\|\|} = I_6R_6$
$4,5 = I_6(6)$
$I_6 = 0,75$ A
 	
$V_x = IR_x$ ✓
$4,5 = (1,25 – 0,75)R_x$ ✓
$R_x = 9\ \Omega$ ✓
	$V_{\text{"lost"}} = Ir$
	$1,5 ✓ = I(1,2)$ ∴ $I = 1,25$ A
	$V_{\|\|} = I_pR_p$
	$4,5 = (1,25)R_p$ ✓
	$R_p = 3,6\ \Omega$
	$\frac{1}{R_{//}} = \frac{1}{R_x} + \frac{1}{R_6}$ ✓
	$\frac{1}{R_{//}} = \frac{1}{R_x} + \frac{1}{6}$ ✓
	$\therefore R_{//} = \frac{6R_x}{R_x + 6} = 3,6$ ∴ $R_x = 9\ \Omega$ ✓

(5)
[17]

QUESTION 7

7.1.1 Maximum work done (or energy transferred) by a battery per unit charge passing through it. ✓✓ (2)

7.1.2 12 V ✓ (1)

7.1.3 0 V / Zero ✓ (1)

7.1.4

OPTION 1	OPTION 2
$\varepsilon = I(R + r)$ **OR** $\varepsilon = V_{ext} + V_{int}$ ✓ $12 = 11,7 + Ir$ $\underline{0,3 = I_{tot}(0,2)}$ ✓ ∴ $I_{tot} = 1,5$ A ✓	$V = IR$ ✓ $\underline{0,3 = I_{tot}(0,2)}$ ✓ $I_{tot} = 1,5$ A ✓

(3)

7.1.5 $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{10} + \frac{1}{15}$ ✓ ∴ $R = 6\ \Omega$ ✓ (2)

7.1.6

OPTION 1	OPTION 2
$V = IR$ ✓ $11,7$✓ $= \underline{1,5(6 + R)}$ ✓ $R = 1,8\ \Omega$ ✓	$V = IR$ ✓ $\underline{11,7 = 1,5R}$ ✓ $R = 7,8\ \Omega$ and $R_R = 7,8 – 6$ ✓✓ $= 1,8\ \Omega$ ✓

(4)

7.2.1

OPTION 1	OPTION 2	OPTION 3
$P_{ave} = Fv_{ave}$ ✓$= mg(v_{ave})$ $= (0,35)(9,8)(0,4)$ ✓ $= 1,37$ W ✓	$P = \frac{W_{nc}}{\Delta t}$ ✓$= \frac{\Delta E_k + \Delta E_p}{\Delta t}$ $= \frac{0 + (0,35)(9,8)(0,4 - 0)}{1}$ ✓ $= 1,37$ W ✓	$P = \frac{W}{\Delta t}$ ✓$= \frac{\Delta E_p}{\Delta t}$ $= \frac{(0,35)(9,8)(0,4)}{1}$ ✓ $= 1,37$ W ✓

(3)

7.2.2

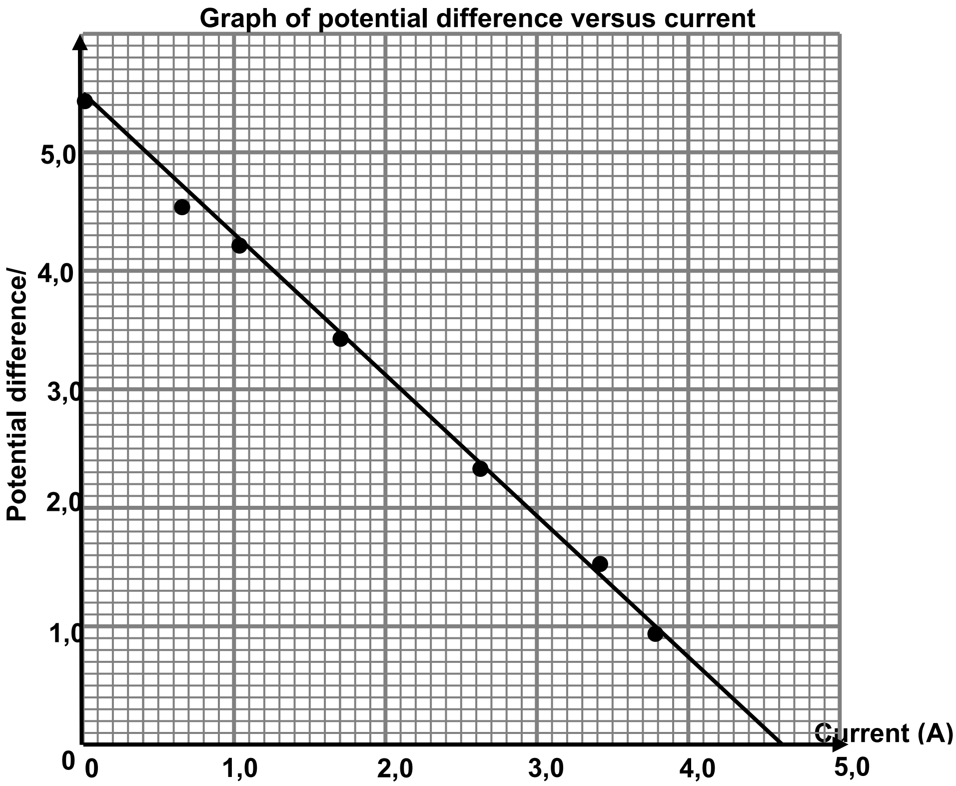
OPTION 1	OPTION 2
$P = VI$ $\underline{1,37 = (3)I}$ ✓ $I = 0,46$ A ✓Any one $\varepsilon = V_{ext} + V_{int}$ $= V_T + V_X + V_{int}$ $\underline{12 = V_T + 3 + (0,2)(0,46)}$ ✓ $V_T = 8,91$ V $V_T = IR_T$ $\underline{8,91 = (0,46)R_T}$ ✓ ∴ $R_T = 19,37\ \Omega$ ✓	$P = \frac{V^2}{R}$ ✓Any one $1,37 = \frac{3^2}{R}$ ✓ $R = 6,57\ \Omega$ $P = VI$ $\underline{1,37 = (3)I}$ ✓ $I = 0,46$ A $\varepsilon = I(R + r)$ $\underline{12 = 0,46(6,57 + R_T + 0,2)}$ ✓ ∴ $R_T = 19,38\ \Omega$ ✓

(5)
[21]

QUESTION 8

8.1.1 The <u>potential difference across a conductor is directly proportional to the current in the conductor</u> ✓ at <u>constant temperature.</u> ✓ (2)

8.1.2



Straight line passing through 4 or five points. ✓ Straight line with intercepts on both axes. ✓

(2)

8.1.3 5,5 V (Accept any value from 5,4 V to 5,6 V.) **NOTE:** The value must be the y-intercept. (1)

8.1.4 Slope = $\frac{\Delta V}{\Delta I}$ ✓ or $\frac{y_2 - y_1}{x_2 - x_1} = \frac{5,5 - 0}{0 - 4,6}$ ✓ = - 1,2 ∴ Internal resistance(r) = 1,2 Ω ✓

NOTE: Any correct pair of coordinates chosen from the line drawn (3)

8.2.1 V = IR ∴ 21,84 = I_{tot}(8) ✓ ∴ I_{tot} = 2,73 A ✓ (3)

8.2.2 $\frac{1}{R_{//}} = \frac{1}{R_{30}} + \frac{1}{R_{20}}$ ∴ $\frac{1}{R_{//}} = \frac{1}{30} + \frac{1}{20}$ ✓ ∴ $R_{//}$ = 12 Ω ✓ (2)

8.2.3

OPTION 1

R_{tot} = (8 + 12 + *r*) ✓ = (20 + *r*)

Ɛ = I(R +r) ✓ ∴ 60 = 2,73(20 + *r*) ✓ ∴ *r* = 1,98 Ω✓

OPTION 2

$V_{//}$ = I_{tot} x $R_{//}$ = 2,73(12) ✓ = 32,76 V

$V_{terminal}$ = (32,76 + 21,84) ✓
= 54,6 V
"V_{lost}" = 60 - 54,6 = 5,4 V
V = IR ∴ 5,4 = 2,73 r ∴ r = 1,98 Ω ✓

OR

Ɛ = V_{lost} + $V_{//}$ + V_8
60 = (V_{lost} + 32,76 + 21,84) ✓
V_{lost} = 5,4 V

(4)

8.2.4

OPTION 1	**OPTION 2**	**OPTION 3**
W = $\frac{V^2}{R}\Delta t$ ✓ W = $\frac{(54,6)^2}{20}(0,2)$ ✓ = 29,81 J✓	W = $I^2R\Delta t$✓ = $(2,73)^2$ (20)(0,2) ✓ = 29,81 J✓	W = VIΔt✓ = (54,6)(2,73)(0,2) ✓ = 29,81 J ✓

(3)
[20]

QUESTION 9

9.1.1 <u>**P** and **Q** burn with the same brightness</u> ✓ same potential difference/same current. ✓ (2)

9.1.2 <u>**P** is dimmer (less bright) than **R**./**R** is brighter than **P**.</u>✓
<u>**R** is connected across the battery alone</u> <u>therefore the voltage (terminal pd) is the same as the emf source</u> (energy delivered by the source). ✓
OR: The potential difference across **R** is twice (larger/greater than) that of **P**./The current through **R** is twice (larger/greater than) that of **P.** (2)

9.1.3 **T** does not light up at all. ✓ **R** is brighter than **T**. ✓ **Reason:** The wire acts as a short circuit. ✓
OR: The potential difference across T / current in T is zero.✓ (2)

9.2.1 $\frac{1}{R_{//}} = \frac{1}{R_5} + \frac{1}{R_{10}}$ ✓ = $\frac{1}{5} + \frac{1}{10}$ ∴ $R_{//}$ = 3,33 Ω (3,333 Ω)

OR

$R_{//} = \frac{R_5 R_{10}}{R_5 + R_{10}}$ ✓ = $\frac{(5)(10)}{(5+10)}$ ✓ = 3,33 Ω (3,333 Ω)

$R_{tot} = R_8 + R_{//} + r$ = (8 + 3,33 + 1) ✓
= 12,33 Ω

$I_{tot} = \frac{V}{R}$ ✓ = $\frac{20}{12,33}$ ✓ = 1,62 A

∴ I_8 = 1,62 A ✓

$R = R_8 + R_{//}$ = 8 + 3,33 = 11,33 Ω

ε = I(R + r)✓
20 = I[(11,33 + 1)✓] ✓
I = 1,62 A ✓ (6)

9.2.2

OPTION 1
V = IR
V_5 = Ɛ – (V_8 + V_1) } ✓Any one
= 20✓ – [1,62(8 + 1)] ✓ = 5,42 V ✓

OPTION 2
$R_{//} = \frac{(5)(10)}{(5+10)}$ = 3,33 Ω

$V_{R//} = \frac{R_{//}}{R_{tot}} \times V_{tot}$ ✓ ∴ $V_{R//} = \frac{(3,33)}{(12,33)}(20)$ ✓✓ = 5,41 V✓

$V_{||} = IR_{||}$ ✓
= (1,62)(3,33) ✓✓
= 5,39 V ✓

9.2.3

OPTION 1	OPTION 2

P = IV ✓
= (1,62)(20) ✓
= 32,4 W ✓
	$P = I^2R$ ✓
	$P_{tot} = P_{8Ω} + P_{//} + P_{1Ω}$
	$= I^2(R_8 + R_{//} + R_1)$
	= $(1,62)^2$[8 +3,33 + 1)] ✓ = 32,36 W ✓

(3)
[19]

QUESTION 10

10.1.1 The potential difference (voltage) across a conductor is directly proportional to the current in the conductor at constant temperature. ✓✓ (1)

10.1.2 Equivalent resistance ✓ (1)

10.1.3 Gradient = $\frac{\Delta V}{\Delta I}$ = $\frac{2-0}{0,5-0}$ ✓ = 4 (Ω) ✓ **NOTE:** Any correctly chosen pair of coordinates. (2)

10.1.4

OPTION 1	OPTION 2
In series $R_1 + R_2$ = 4 Ω ✓................(1) In parallel $\frac{R_1R_2}{R_1+R_2}$ = 1 Ω ✓✓ ....(2) R_1R_2 = 4 Ω ∴ $R_1 = R_2$ = 2 Ω ✓	For graph X: $R_1 + R_2$ = 4 ✓ ....(1) For graph Y: $\frac{1}{R_{//}} = \frac{1}{R_1} + \frac{1}{R_2}$ $\left\{\left(\frac{1}{R_1} + \frac{1}{R_2}\right) = \left(\frac{1}{1}\right)\right\}$ ✓✓..................(2) $R_1^2 - 4R_1 + 4 = 0$ ∴ R_1 = 2 Ω✓

(4)

10.2.1 $I = \frac{V}{R}$ ✓ $= \frac{5}{(R_M + R_N)}$ $= \frac{5}{(6)}$ ✓ = 0,83 A ✓ (3)

10.2.2

OPTION 1	OPTION 2
Ɛ = I(R + r) ✓ = 0,83[(6 +1,5) ✓+ 0,9✓] = 6,997 V = 7(,00) V ✓ (6,972 – 7,00 V)	Ɛ = (V_s + $V_{//}$ + V_r) ✓ / V_{ext} + V_{int} = [5 + (0,833 x 1,5) ✓+ (0,9 x 0,833)] ✓✓ = 6,999 V = 7(,00) V ✓ (6,972 – 7,00 V)

(4)

10.2.3 The resistance R_N will be 3 Ω ✓
The voltage divides (proportionately) in a series circuit. Since the voltage across **M** is half the total voltage, it means the resistances of **M** and **N** are equal. ✓ (2)
[18]

QUESTION 11

11.1.1 The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature. (2)

11.1.2 Graph X. ✓ Graph X is a straight line (passing through the origin) therefore potential difference is directly proportional to current. ✓ (2)

11.2.1 $\frac{1}{R_{//}} = \frac{1}{R_{10}} + \frac{1}{R_{15}}$

$\frac{1}{R_{//}} = \frac{1}{10} + \frac{1}{15}$ ✓

$R_{//} = 6\ \Omega$

R = 10 + 6 + 2 ✓
= 18 Ω

$R = \frac{V}{I}$ ✓

$I = \frac{6}{18}$ ✓
= 0,33 A ✓ (5)

11.2.2 Decrease ✓
The total resistance of the circuit increases. ✓ (2)

11.2.3 Increase ✓ (1)

11.2.4 The total resistance in the external circuit increases, ✓
Current decreases ✓
"Lost" volts decreases ✓ (3)
[15]

QUESTION 12

12.1.1 The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature.
OR The ratio of potential difference across a conductor to the current in the conductor is constant, provided the temperature remains constant. (2)

12.1.2 V_1 = IR ✓ = (0,6)(4) ✓ = 2,4 V ✓ (3)

12.1.3

OPTION 1	OPTION 2	OPTION 2
$I_{6\Omega} = \frac{V}{R} = \frac{2,4}{6}$ ✓ = 0,4 A ✓	$\frac{6}{10}(I) = 0,6$ ✓ ∴ I = 1 A ∴$I_{6\Omega}$ = 0,4 A ✓	$V_{4\Omega} = V_{6\Omega}$ ∴ $I_{4\Omega}R_1 = I_{6\Omega}R_2$ (0,6)(4) = $I_{6\Omega}$(6) ✓ $I_{6\Omega}$ = 0,4 A ✓

(2)

12.1.4 V_2 = IR = (0,4 + 0,6)(5,8) ✓ = 5,8 V ✓ (2)

12.1.5

OPTION 1	OPTION 2
V_{ext} = (5,8 + 2,4) ✓ = 8,2 V V_{int} = Ir = (1) (0,8) ✓ = 0,8 V Emf = 0,8 + 8,2 = 9 V✓	$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{6} + \frac{1}{4} = \frac{5}{12}$ ∴R_p = 2,4 Ω R_{ext} = (2,4 + 5,8) ✓ = 8,2 Ω Emf = I(R + r) = 1 (8,2 + 0,8) ✓ = 9 V ✓

(3)

12.1.6

OPTION 1	OPTION 2	OPTION 3
W = V I Δt ✓ = (0,8)(1) (15) ✓ = 12 J ✓	W = I²R Δt ✓ = (1)² (0,8)(15) ✓ = 12 J ✓	$W = \frac{V^2 \Delta t}{R}$ ✓ $= \frac{0,8^2 (15)}{0,8}$ ✓ = 12 J ✓

(3)

12.2.1 $R = \frac{V}{I} = \frac{2,8}{0,7}$ ✓ = 4 Ω ✓ (2)

12.2.2 Increases ✓
Total resistance decreases,✓ current/power increases, ✓ motor turns faster (3)
[20]

QUESTION 13

13.1 The battery supplies 12 J per coulomb/per unit charge. ✓✓
OR The potential difference of the battery in an open circuit is 12 V. (2)

13.2

OPTION 1	OPTION 2	OPTION 3
V_{lost} = Ir ✓ = (2)(0,5) = 1 V V_{ext} = Emf– V_{lost} = (12 - 1) ✓ = 11 V✓	ε = I(R + r) ✓ 12 = $V_{ext/eks}$ +(2)(0,5) ✓ $V_{ext/eks}$ = 11 V✓	ε = I(R + r) ✓✓ 12 = 2(R + 0,5) R = 5,5 Ω V = IR = 2(5,5) ✓ = 11 V ✓

(3)

13.3

OPTION 1	OPTION 2	OPTION 3/*OPSIE 3*
$R = \frac{V}{I}$ ✓ $= \frac{11}{2}$ = 5,5 Ω ✓	0,5 : R = 1:11 ✓ R = 5,5 Ω ✓	$\frac{1}{0,5} = \frac{11}{R}$ ✓ R = 5,5 Ω✓

OPTION 4 $V_{total} = IR_{total}$ $12 = (2)R_{total}$ $R_{total} = 6\ \Omega$ $R = 6 – 0,5$ ✓ $= 5,5\ \Omega$ ✓	**OPTION 5** $\varepsilon = I(R + r)$ $12 = 2(R + 0,5)$ ✓ $R = 5,5\ \Omega$ ✓

(2)

13.4 Decreases ✓
Total resistance decreases. ✓
Current increases. ✓
"Lost volts" increases, ✓emf the same **OR** in $\varepsilon = V_{ext} + Ir$, Ir increases ✓, ε is constant
External potential difference decreases $\therefore V_{ext/eks}$ decreases (4)

[11]

QUESTION 14

14.1 Temperature ✓ (1)

14.2 $r = 3\ \Omega$ ✓✓ (2)

14.3 **Any correct values from the graph**

OPTION 1 ε = slope (gradient) of the graph ✓ $\varepsilon = \frac{7,5-(-3)}{1,5-0}$ ✓ $= 7\ V$ ✓	**OPTION 2** $R = \frac{\varepsilon}{I} - r$ ✓ $7,5 = 1,5\varepsilon - 3$ ✓ $\varepsilon = 7\ V$ ✓	**OPTION 3** $\varepsilon = I(R + r)$ ✓ $= 0,5(11 + 3)$ ✓ $\varepsilon = 7\ V$ ✓

(3)

[6]

QUESTION 15

15.1.1 The rate at which (electrical) energy is converted (to other forms) (in a circuit). ✓✓
OR: The rate at which energy is used./Energy used per second.
OR: The rate at which work is done. (2)

15.1.2

$P = \frac{V^2}{R}$ ✓ $6 = \frac{(12)^2}{R}$ ✓ $R = 24\ \Omega$ ✓	$W = \frac{V^2\Delta t}{R}$ ✓ $6 = \frac{(12)^2(1)}{R}$ ✓ $R = 24\ \Omega$ ✓	$P = VI$ $6 = (12)(I)$ $\therefore I = 0,5\ A$ $P = I^2R$ ✓ $6 = (0,5)^2 R$ ✓ $R = 24\ \Omega$ ✓	$P = VI$ ✓ $6 = (12)(I)$ $\therefore I = 0,5\ A$ $V = IR$ $12 = (0,5)R$ ✓ $R = 24\ \Omega$ ✓

(3)

15.1.3

OPTION 1
$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$
$= \frac{1}{24} + \frac{1}{24}$ ✓
$R_{//} = 12\ \Omega$
$R_{ext} = (R_s + R_{//})$
$R_{ext} = (24 + 12)$ ✓
$= 36\ \Omega$
$V = IR$ **OR** $\varepsilon = I(R + r)$ ✓
$12 = I(36 + 2)$ ✓
$I = 0,32\ A$ ✓ (0,316 A)
	OPTION 2
	$R_{ext} = (R_s + R_{//})$
	$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$
	$= \frac{1}{24} + \frac{1}{24}$ ✓ $\therefore R_{//} = 12\ \Omega$
	$R_{ext} = (24 + 12)$ ✓ $= 36\ \Omega$
	$P = I^2R = \frac{V^2}{R}$ ✓
	$I^2(36+2) = \frac{(12)^2}{38}$ ✓
	$I = 0,32\ A$ ✓ (0,316)

(5)

15.1.4

OPTION 1
$V = IR$
$V = I(R_A + r)$
$= 0,316(26)$ ✓
$= 8,216\ V$ (8,32 V)
$V_{//} = (12 – 8,216)$ ✓
$= 3,784\ V$ (3,68 V)
$\therefore V_C = 3,78\ V$ (3,68 V) ✓
	OPTION 2
	$V = IR$
	For the parallel portion (or from 8.1.3):
	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ OR $R = \frac{R_1R_2}{(R_1+R_2)}$
	$R = \frac{(24)(24)}{48} = 12\ \Omega$
	$V_{//} = V_C$ ✓
	$V = IR_{//} = (0,316)(12)$ ✓ $= 3.79\ V$ (3,84 V)✓

OPTION 3 $I_A = I_B + I_C = 2\ I_B$ $0,316 = 2I_B$ ✓ $I_B = 0,158\ A$ $V = 0,158\ (24)$ ✓ $= 3,79\ V$✓	

(3)

15.1.5 **OPTION 1**

$P = \frac{V^2}{R}$ **OR** For a given resistance, power is directly proportional to V^2. ✓

Since the potential difference across light bulb C is less than the operating voltage, ✓ the output/power will be less. ✓

OPTION 2

$P = I^2R$ OR For a given resistance, power is directly proportional to I^2. ✓

In the circuit, the current in light bulb C is less than the optimum current required (0,5 A). ✓ The output power will be less.✓

OPTION 3

P = IV **OR** Power is directly proportional/equal to product of V and I. ✓

The voltage across light bulb C, as well as the current in the bulb are less than the optimum values ✓ hence power is less ✓ and brightness is less. (3)

15.2.1 The total current passes through resistor A. ✓ For the parallel portion, the current branches, therefore only a portion of the total current passes through resistor C. ✓ (2)

15.2.2 The current in B is equal ✓ to the current in A. The circuit becomes a series circuit. ✓ (2)

[21]

QUESTION 16

16.1 Maximum work done (or energy provided) ✓ by a battery per unit charge passing through it. ✓ (2)

16.2 13 V ✓ (1)

16.3.1 $R = \frac{V}{I}$ ✓ $\therefore 5,6 = \frac{10,5}{I}$ ✓ $\therefore$ I = 1,88 A ✓ (1,875 A) (3)

16.3.2

OPTION 1	**OPTION 2**
P = VI ✓ = (10,5)(1,88) ✓ = 19,74 W ✓ (19,688 W)	$P = I^2R$ ✓ $= (1,88)^2(5,6)$ ✓ = 19,79 W ✓ (19,688 W)
OPTION 3 $P = \frac{V^2}{R}$ ✓ $= \frac{10,5^2}{5,6}$ ✓ = 19,79 W ✓ (19,688 W)	

(3)

16.3.3

OPTION 1	**OPTION 2**
Ɛ = I(R + r) ✓ 13 = 1,88 (5,6 + r) ✓ r = 1,31 Ω ✓	$r = \frac{V_{internal}}{I}$ ✓ $= \frac{2,5}{1,88}$ ✓ = 1,33 Ω ✓

(3)

16.4.1 Decreases ✓

$V_{internal\ resistance}$/Internal volts increase ✓ (2)

16.4.2

OPTION 1	**OPTION 2**
Ɛ = I(R + r) ✓ 13 = 4 (R_{ext} + 1,31) ✓ R_{ext} = 1,94 Ω (1,92 Ω) $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$ $\frac{1}{1,94} = \frac{1}{5,6} + \frac{1}{R_2}$ ✓ R_2 = 2,97 Ω (2,92 Ω) $X = \frac{1}{2}(2,97)$ ✓ = 1, 49 Ω ✓ (1,46 – 1,49 Ω)	Ɛ = I(R + r) ✓ 13 = 4(R_{ext} + 1,31) ✓ R_{ext} = 1,94 Ω (1,92 Ω) $R_p = \frac{R_1 R_2}{R_1 + R_2}$ $1,94 = \frac{5,6 R_2}{5,6 + R_2}$ ✓ R_2 = 2,97 Ω (2,92 Ω) $X = \frac{1}{2}(2,97)$ ✓ = 1,49 Ω ✓ (1,46 – 1,49 Ω)

OPTION 3

$\mathcal{E} = I(R + r)$ ✓

$\underline{13 = 4(R_{ext} + 1{,}31)}$ ✓

$R_{ext} = 1{,}94\ \Omega$ (1,92 Ω)

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{1{,}94} = \frac{1}{5{,}6} + \frac{1}{2X}$$ ✓

$2X = 2{,}97\ \Omega$ (2,92 Ω)

$$X = \frac{1}{2}(2{,}97)$$ ✓

$= 1{,}49\ \Omega$ ✓ (1,46 – 1,49 Ω)

OPTION 4

$\mathcal{E} = I(R + r)$ ✓

$\underline{13 = 4(R_{ext} + 1{,}31)}$ ✓

$R_{ext} = 1{,}94\ \Omega$ (1,92 Ω)

$$R_p = \frac{R_1 R_2}{R_1 + R_2}$$

$$1{,}94 = \frac{(5{,}6)(2X)}{5{,}6 + 2X}$$ ✓✓

$(1{,}94)(5{,}6 + 2X) = 11{,}2\ X$

$X = 1{,}49\ \Omega$ ✓

(5)
[19]

QUESTION 17

17.1 (Maximum) energy provided (work done) by a battery per coulomb/unit charge passing through it. ✓✓
OR Work done by the battery to move a unit coulomb of charge in the circuit. (2)

17.2 Energy (per coulomb of charge) is converted to heat in the battery due to the internal resistance. ✓✓ (2)

17.3.1

$$I = \frac{V}{R}$$ ✓

$$= \frac{1{,}5}{0{,}5}$$ ✓

$= 3\ A$ ✓

(3)

17.3.2

OPTION 1

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$$ ✓

$$\frac{1}{R_p} = \frac{1}{25} + \frac{1}{15}$$ ✓

$R_p = 9{,}375\ \Omega$

$R_{ext} = 9{,}375 \underline{+ 4}$ ✓ $= 13{,}38\ \Omega$ ✓ (13,375 Ω)

OPTION 2

$$R_p = \frac{R_1 R_2}{R_1 + R_2}$$ ✓

$$R_p = \frac{(25)(15)}{25 + 15}$$ ✓

$R_p = 9{,}375\ \Omega$

$R_{ext} = 9{,}375 \underline{+ 4}$ ✓ $= 13{,}38\ \Omega$ ✓ (13,375 Ω)

(4)

17.3.3

OPTION 1

$\mathcal{E} = I(R + r)$ ✓

$= 3(13{,}38 + 0{,}5)$ ✓

$= 41{,}64$ V ✓ (Range*:* 41,625 – 41,64)

OPTION 2

$\mathcal{E} = V_{ext/} + V_{int}$ ✓

$= (3)(13{,}38) + 1{,}5$ ✓

$= 41{,}64$ V ✓ (Range*:* 41,625 – 41,64)

(3)

17.4

Yes. ✓
For the same voltage/potential difference, ✓
a larger current will flow through a smaller resistor ($I = \frac{V}{R}$) ✓
OR
$I \; \alpha \; \frac{1}{R}$ ✓, V = constant ✓
I is inversely proportional to R and V is constant.
OR
$V_{||} = IR$
$= (3)(9{,}38)$
$= 28{,}14$ V
$I_{R2} = \frac{V}{R} = \frac{28{,}14}{25} = 1{,}13\ A$ ✓
$I_{R3} = \frac{V}{R} = \frac{28{,}14}{15} = 1{,}88\ A$ ✓
OR
V is the same ✓
$I_{15\Omega} = \frac{25}{40}I$, $I_{25\Omega} = \frac{15}{40}I$ ✓

(3)

17.5 Remains the same. (1)

[18]

QUESTION 18

18.1 (a) electrical energy
(b) unit charge (2)

18.2

$R_S = R_1 + R_2$
$= 4 + 3$ ✓
$= 7\ \Omega$
$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$ ✓
$\frac{1}{R_p} = \frac{1}{7} + \frac{1}{7}$ ✓
$R_p = 3{,}5\ \Omega$ ✓

(4)

18.3.1

Switch open
$I = \frac{V}{R}$ ✓
$I = \frac{2{,}8}{7}$ ✓
$= 0{,}4\ A$
$\varepsilon = I(R + r)$ ✓
$\varepsilon = 0{,}4(7 + r)$ ✓
$\varepsilon = 2{,}8 + 0{,}4r$

Switch closed
$I = \frac{V}{R}$
$I = \frac{2{,}63}{3{,}5}$ ✓
$= 0{,}751\ A$
$\varepsilon = I(R + r)$
$\varepsilon = 0{,}751(3{,}5 + r)$ ✓
$\varepsilon = 2{,}629 + 0{,}751r$

$2{,}8 + 0{,}4r = 2{,}629 + 0{,}751r$ ✓
$r = 0{,}49\ \Omega$ ✓

(8)

18.3.2

$\varepsilon = 2{,}8 + 0{,}4r$
$= 2{,}8 + (0{,}4)(0{,}49)$ ✓
$= 3\ V$ ✓

OR

$\varepsilon = 2{,}629 + 0{,}751r$
$= 2{,}629 + (0{,}751)(0{,}49)$ ✓
$= 3\ V$ ✓

(2)
[16]

QUESTION 19

19.1.1 12 V ✓ (1)

19.1.2 0 V ✓ (1)

19.2 The rate at which work is done or energy is expended/transferred. ✓✓ (2)

19.3

OPTION 1

$P = I^2R$ ✓

$5{,}76 = (1{,}2^2)R$ ✓

$R = 4\ \Omega$ ✓

OPTION 2

$P = VI$

$5{,}76 = (1{,}2)V$

$V = 4{,}8\ \text{V}$

→ $P = \frac{V^2}{R}$ ✓

$5{,}76 = \frac{(4{,}8)^2}{R}$ ✓

$R = 4\ \Omega$ ✓

OR

→ $V = RI$ ✓

$4{,}8 = R(1{,}2)$ ✓

$R = 4\ \Omega$ ✓

(3)

19.4

$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$

$\frac{1}{R_p} = \frac{1}{6} + \frac{1}{8{,}4}$ ✓

$R_p = 3{,}5\ \Omega$

$R_T = 3{,}5 + 4$ ✓ $= 7{,}5\ \Omega$ ✓

(3)

19.5

$V_P = I_T R_P = (1{,}2)(3{,}5)$ ✓ $= 4{,}2\ V$

$I = \frac{V}{R}$

$= \frac{4{,}2}{8{,}4}$ ✓

$= 0.5\ A$

$V_2 = IR$ ✓

$= (0{,}5)(6)$ ✓

$= 3\ V$ ✓

(5)

19.6 Decreases ✓

Total resistance decreases. ✓

Total current increases. ✓

$V_{internal}$ /Internal voltage ("lost volts") increases. ✓

$V_{external}$ /external voltage decreases. (4)

[19]

QUESTION 20

20.1 A conductor (resistor) which obeys Ohm's law. ✓✓ (2)

20.2.1

$R = \frac{V}{I}$ ✓

$4 = \frac{3,2}{I}$ ✓

$I = 0,8\ A$ ✓

(3)

20.2.2

OPTION 1

$\varepsilon = I(R + r)$ ✓

$= 0,8[(4 + 8)$✓ $+ 0,5]$ ✓

$= 10\ V$ ✓

OPTION 2

$V_8 = IR$

$= (0,8)(8)$

$= 6,4\ V$

$V_{int} = Ir$

$= (0,8)(0,5)$ ✓

$= 0,4\ V$

$V_{ext} = 3,2 + 6,4$

$= 9,6\ V$

$V_{emf} = V_{ext} + V_{int}$ ✓

$= 9,6 + 0,4$ ✓

$= 10\ V$ ✓

(4)

20.3.1

$V_{int} = 10 - 8,8$

$= 1,2\ V$

$V_{int} = I_{tot}r$

$1,2 = I_{tot}(0,5)$ ✓

$I_{tot} = 2,4\ A$

$I_{serie\ branch} = \frac{V}{R}$

$= \frac{8,8}{8 + 4}$ ✓

$= 0,733\ A$

$I_R = I_{tot} - I_{serie\ branch}$

$= 2,4 - 0,733$ ✓

$= 1,667\ A$

$R = \frac{V}{I_R}$

$= \frac{8,8}{1,667}$ ✓

$= 5,28\ \Omega$ ✓

(5)

20.3.2 There is a short circuit.
The resistance of the connecting wire is very low. / The total resistance decreases. ✓
The current delivered by the battery is very high. ✓
Higher current produces more heat. ✓ (3)

[17]

QUESTION 21

21.1 The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature. ✓✓ (2)

21.2.1

$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$ ✓

$= \frac{1}{1} + \frac{1}{5}$ ✓

$R_P = 0,833\ \Omega$

$R_{ext} = R_P + R_4$

$= 0,833 + 4$ ✓

$= 4,833\ \Omega$ ✓

(4)

21.2.2

OPTION 1

$R_{ext} = \frac{V_1}{I_T}$ ✓

$4,833 = \frac{V_1}{3,5}$ ✓

$V_1 = 16,916\ V$ ✓

OPTION 2

$R_P = \frac{V_2}{I_T}$ ✓ $R_4 = \frac{V}{I_T}$

$0,833 = \frac{V_2}{3,5}$ ✓ $4 = \frac{V}{3,5}$

$V_2 = 2,916\ V$ $V = 14\ V$

$V_1 = V_2 + V$

$= 2,916 + 14$

$= 16,916\ V$ ✓

(3)

21.2.3 Smaller than ✓ (1)

21.3.1 Maximum energy supplied by the battery per unit charge. ✓✓ **OR**
The total amount of electric energy supplied by the battery per coulomb / per unit charge. (2)

21.3.2 No ✓ (1)

21.3.3 The battery has internal resistance. **OR**
Some energy per coulomb of charge/volts is used to overcome internal resistance. **OR**
There is a potential drop/lost volts inside the battery. ✓ (1)

21.4.1 Decreases ✓ (1)

21.4.2 Increases ✓ (1)

21.5 When the voltmeter is connected:

- The resistance of the parallel branch increases. **OR** No/very small current through the 1 Ω branch. **OR** Branch with 1 Ω resistor is disabled/bypassed. **OR** A voltmeter has a very high resistance. ✓
- (Total) resistance of the circuit increases. ✓
- Current in circuit decreases. ✓
- $V_{internal}$/ Internal volts/ V_{lost} decreases. ✓
- Therefore, external volts increase for a constant emf. (4)

[20]

QUESTION 22

22.1 The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature (provided all other physical conditions remain constant). ✓✓ **OR**
The ratio of potential difference to current is constant at constant temperature. **OR**
The current in a conductor is directly proportional to the potential difference across the conductor at constant temperature (provided all other physical conditions remain constant). (2)

22.2.1

OPTION 1

$R = \frac{V}{I}$ ✓

$7 = \frac{V}{1{,}5}$ ✓

$V = 10{,}5\ V$ ✓

OPTION 2

$R = \frac{V}{I}$ ✓ $\quad 2 = \frac{V}{1{,}5} \quad V = 3\ V$

$R = \frac{V}{I} \quad 5 = \frac{V}{1{,}5}$ ✓ $\quad V = 7{,}5\ V$

$V_T = V_1 + V_2 = 3 + 7{,}5 = 10{,}5\ V$ ✓

(3)

22.2.2

OPTION 1

$R = \frac{V}{I_3}$ ✓

$3 = \frac{10{,}5}{I_3}$ ✓

$I_3 = 3{,}5\ A$

$I_T = 1{,}5 + 3{,}5$ ✓ $= 5\ A$ ✓

OPTION 2

$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$ ✓

$= \frac{1}{7} + \frac{1}{3}$ ✓

$R_P = 2{,}1\ \Omega$

$R_P = \frac{V}{I_T}$

$2{,}1 = \frac{10{,}5}{I_T}$ ✓

$I_T = 5\ A$ ✓

(4)

22.2.3

OPTION 1

$P = VI$ ✓

$= (10{,}5)(3{,}5)$ ✓

$= 36{,}75\ W$ ✓

OPTION 2

$P = I^2R$ ✓

$= (3{,}5^2)(3)$ ✓

$= 36{,}75\ W$ ✓

OPTION 3

$P = \frac{V^2}{R}$ ✓

$= \frac{10{,}5^2}{3}$ ✓

$= 36{,}75\ W$ ✓

(3)

22.3

OPTION 1

$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$

$= \frac{1}{7} + \frac{1}{3}$

$R_P = 2{,}1\ \Omega$

S$_1$ and S$_2$ closed

$\varepsilon = I(R_P + r)$ ✓

$= 5(2{,}1 + r)$ ✓ ... (1)

S2 open

$\varepsilon = I(R_3 + r)$

$= 3{,}64(3 + r)$ ✓ ... (2)

(1) = (2)

$5(2{,}1 + r) = 3{,}64(3 + r)$ ✓

$r = 0{,}309\ \Omega$

$\varepsilon = I(R_P + r) = 5(2{,}1 + 0{,}309) = 12{,}05\ \Omega$ ✓ **OR** $\varepsilon = I(R_P + r) = 3{,}64(3 + 0{,}309) = 12{,}04\ \Omega$

OPTION 2

$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$

$= \frac{1}{7} + \frac{1}{3}$

$R_P = 2{,}1\ \Omega$

S$_1$ and S$_2$ closed

$\varepsilon = I(R_P + r)$ ✓

$= 5(2{,}1 + r)$

$r = \frac{\varepsilon - 10{,}5}{5}$ ✓ ... (1)

S2 open

$\varepsilon = I(R_3 + r)$

$= 3{,}64(3 + r)$

$r = \frac{\varepsilon - 10{,}92}{3{,}64}$ ✓ ... (2)

(1) = (2)

$\frac{\varepsilon - 10{,}5}{5} = \frac{\varepsilon - 10{,}92}{3{,}64}$ ✓

$\varepsilon = 12{,}04\ \Omega$ ✓

(5)

22.4 Increases ✓
Total resistance increases. ✓
Current decreases. ✓
$V_{internal}$ /Internal volts decreases. ✓ (4)
[21]

QUESTION 23

23.1 The potential difference (voltage) across a conductor is directly proportional to the current in the conductor at constant temperature. ✓✓ **OR**
The current in a conductor is directly proportional to the potential difference (voltage) across the conductor if temperature is constant. (2)

23.2.1

$$\frac{1}{R_{p(1\&2)}} = \frac{1}{R_1} + \frac{1}{R_2} \checkmark$$
$$= \frac{1}{10} + \frac{1}{10} \checkmark$$
$$R_{p(1\&2)} = 5\ \Omega$$

$$R_{1\&2\&L} = R_{p(1\&2)} + R_L$$
$$= 5 + 10 \checkmark$$
$$= 15\ \Omega$$

$$\frac{1}{R_{ext}} = \frac{1}{R_{1\&2\&L}} + \frac{1}{R_3}$$
$$= \frac{1}{15} + \frac{1}{15} \checkmark$$
$$= 7{,}5\ \Omega \checkmark$$

(5)

23.2.2

OPTION 1

$$\varepsilon = I(R + r) \checkmark$$
$$12 = I(7{,}5 + 0{,}5) \checkmark$$
$$I = 7{,}5\ A \checkmark$$

OPTION 2

$$R = \frac{V}{I} \checkmark$$
$$7{,}5 + 0{,}5 = \frac{12}{I} \checkmark$$
$$I = 7{,}5\ A \checkmark$$

(3)

23.2.3

$$R_{ext} = \frac{V_{ext}}{I_T}$$
$$7{,}5 = \frac{V_{ext}}{1{,}5}$$
$$V_{ext} = 11{,}25\ V$$

AND

$$R_3 = \frac{V_{ext}}{I_3}$$
$$15 = \frac{11{,}25}{I_3}$$
$$I_3 = 0{,}75\ A$$

OR

$$I_3 = \frac{1}{2} I_T$$
$$= \frac{1}{2}(1{,}5)$$
$$= 0{,}75\ A$$

→

OPTION 1

$$P = I^2 R \checkmark$$
$$= (0{,}75^2)(15) \checkmark\checkmark$$
$$= 8{,}44\ W \checkmark$$

OPTION 2

$$P = \frac{V^2}{R} \checkmark$$
$$= \frac{11{,}25^2 \checkmark}{15 \checkmark}$$
$$= 8{,}44\ W \checkmark$$

OPTION 2

$$P = VI \checkmark$$
$$= (11{,}25)(0{,}75) \checkmark\checkmark$$
$$= 8{,}44\ W \checkmark$$

(4)

23.3.1 Increases ✓ (1)

23.3.2 Total resistance of the circuit increases and current in circuit decreases.✓
$V_{internal}$/internal volts/V_{lost} decreases and $V_{external}$/external volts /V_{RL} increases. ✓
Power output increases ✓ therefore brightness increases. (3)
[18]

ELECTRICAL MACHINES

QUESTION 1

1.1 Electromagnetic induction ✓ (1)

1.2 Rotate coil faster./Increase number of coils./Increase the strength of the magnetic field. ✓ (1)

1.3 Slip rings ✓ (1)

1.4 The <u>AC potential difference/voltage</u> ✓ that produces the <u>same amount of electrical energy as an equivalent DC potential difference/voltage</u>. ✓ (2)

1.5 $V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓ $= \frac{339,45}{\sqrt{2}}$ ✓ $\therefore V_{rms} = 240,03$ V ✓ (3)

[8]

QUESTION 2

2.1.1

OPTION 1	**OPTION 2**
$P_{ave} = \frac{V_{rms}^2}{R}$ ✓ 100 ✓ $= \frac{(\frac{340}{\sqrt{2}})^2}{R}$ ✓ ✓ $R = 578\ \Omega$ ✓	$V_{rms} = \frac{V_{max}}{\sqrt{2}} = \frac{340}{\sqrt{2}}$ ✓ $= 240,04$ $P_{ave} = \frac{V_{rms}^2}{R}$ ✓ 100 ✓ $= \frac{(240,04)^2}{R}$ ✓ $\therefore R = 578\ \Omega$ ✓

(5)

2.1.2

OPTION 1	**OPTION 2**
$P_{ave} = I_{rms}V_{rms}$ ✓ $100 = I_{rms}\frac{340}{\sqrt{2}}$ ✓ $\therefore I_{rms} = 0,417$ A ✓	$V_{rms} = I_{rms}R$ ✓ $\frac{340}{\sqrt{2}} = I_{rms}(578)$ ✓ $\therefore I_{rms} = 0,417$ A ✓

(3)

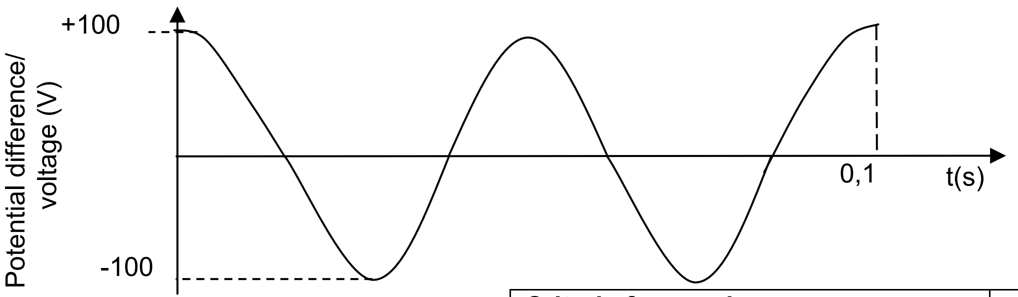
2.2 Can be stepped up or down. / Can be transmitted with less power loss. ✓ (1)

[9]

QUESTION 3

3.1.1 Anticlockwise ✓ (1)

3.1.2



Criteria for graph:	
Two full cycles with correct shape.	✓
Showing the maximum voltage.	✓
Showing the time 0,1s for two cycles.	✓

(3)

3.1.3 Decrease the frequency/ speed of rotation ✓(1)

3.2 $P_{ave} = V_{rms}I_{rms}$ ✓ $\therefore$ <u>$1\,500 = (220)(I_{rms})$</u> ✓ $\therefore I_{rms} = 6,82$ A

$I_{rms} = \frac{I_{max}}{\sqrt{2}}$ ✓ $\therefore I_{max} = \sqrt{2}\,(6,82)$ ✓ $= 9,65$ A ✓ (5)

[10]

QUESTION 4

4.1.1 Move the bar magnet <u>very quickly</u>✓✓ **OR** up and down <u>inside the coil.</u> (2)

4.1.2 Electromagnetic induction ✓ (1)

4.1.3 Commutator ✓ (1)

4.2.1

OPTION 1 $P_{ave} = \frac{V_{rms}^2}{R}$ ✓ $= \frac{(220)^2}{40{,}33}$ ✓✓ $= 1\ 200{,}10\ W\ (J{\cdot}s^{-1})$ ✓	$W = \frac{V_{rms}^2}{R}\Delta t$ ✓ $= \frac{(220)^2}{40{,}33}(1)$ ✓✓ $= 1200{,}10\ J$ ✓
OPTION 2 $I_{rms} = \frac{V_{rms}}{R}$ ✓ $= \frac{220}{40{,}33}$ ✓ $= 5{,}45\ A$ $P_{ave} = I_{rms}^2R = (5{,}45)^2 40{,}33$ ✓ $= 1\ 197{,}9\ W\ /1\ 200{,}10\ W$ ✓	$I_{rms} = \frac{V_{rms}}{R}$ ✓ $= \frac{220}{40{,}33}$ ✓ $= 5{,}45\ A$ $W = I_{rms}^2 R\Delta t = (5{,}45)^2(40{,}33)(1)$ ✓ $= 1\ 197{,}9\ J\ /\ 1\ 200{,}10\ J$ ✓

(4)

4.2.2

OPTION 1 $V_{rms} = \frac{V_{max}}{\sqrt{2}}$ $220 = \frac{V_{max}}{\sqrt{2}}$ $V_{max} = 311{,}13\ V$ $I_{max} = \frac{V_{max}}{R} = \frac{331{,}13}{40{,}33}$ ✓ $= 7{,}71\ A$ ✓ **OR** $P_{ave} = \frac{V_{max}I_{max}}{2}$ $1200{,}1 = \frac{311{,}13 I_{max}}{2}$ $\therefore I_{max} = 7{,}71\ A$ ✓ any formula	**OPTION 2** $P_{ave} = V_{rms}I_{rms}$ ✓ $1200{,}1 = (220)I_{rms}$ ✓ $I_{rms} = 5{,}455\ A$ $I_{max} = \sqrt{2}\ (5{,}455)$ $= 7{,}71\ A$ ✓ (7,715 A)
OPTION 3 $P_{ave} = I_{rms}^2R$ ✓ $1200{,}1 = I_{rms}^2(40{,}33)$ ✓ $I_{rms} = 5{,}455\ A$ $I_{max} = \sqrt{2}\ I_{rms} = \sqrt{2}\ (5{,}455) = 7{,}71\ A$ ✓	**OPTION 4** $V_{rms} = I_{rms}R$ ✓ $220 = I_{rms}(40{,}33)$ ✓ $I_{rms} = 5{,}455\ A$ $I_{max} = \sqrt{2}\ I_{rms} = \sqrt{2}\ (5{,}455) = 7{,}71\ A$ ✓

(3)
[11]

QUESTION 5

5.1.1 North pole ✓ (1)

5.1.2 Q to P ✓ (1)

5.2.1

OPTION 1 $I_{rms} = \frac{I_{max}}{\sqrt{2}}$ ✓ $= \frac{8}{\sqrt{2}}$ ✓ $= 5{,}66\ A$ $V_{rms} = I_{rms}R$ ✓ $220 = 5{,}66R$ ✓ $\therefore R = 38{,}87\ \Omega$ ✓	**OPTION 2** $V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓ $\therefore 220 = \frac{V_{max}}{\sqrt{2}}$ ✓ $\therefore V_{max} = 311{,}12\ V$ $V_{max} = I_{max}R$ ✓ $311{,}12 = 8R$ ✓ $\therefore R = 38{,}89\ \Omega$ ✓

(5)

5.2.2

OPTION 1 $P_{ave} = V_{rms}I_{rms}$ ✓ $= (220)(5{,}66)$ ✓ $= 1\ 245{,}2\ W$ $P = \frac{W}{\Delta t}$ ✓ $1\ 245{,}22 = \frac{W}{7200}$ ✓ $W = 8\ 965\ 584\ J$ ✓	**OPTION 2** $P_{ave} = I_{rms}^2 R$ ✓ $= (5{,}66)^2(38{,}87)$ ✓ $= 1\ 245{,}22\ W$ $P = \frac{W}{\Delta t}$ ✓ $1\ 245{,}22 = \frac{W}{7200}$ ✓ $W = 8\ 965\ 584\ J$ ✓	**OPTION 3** $P_{ave} = \frac{V_{rms}^2}{R}$ ✓ $= \frac{(220)^2}{38{,}87}$ ✓ $= 1\ 245{,}18\ W$ $P = \frac{W}{\Delta t}$ ✓ $1\ 245{,}22 = \frac{W}{7200}$ ✓ $W = 8\ 965\ 584\ J$ ✓

(5)
[12]

QUESTION 6

6.1.1 a to b ✓ (1)

6.1.2 Fleming's left hand rule /Left hand motor rule ✓ (1)

6.1.3 Split rings /commutator ✓ (1)

6.2.1 Mechanical/Kinetic energy to electrical energy ✓✓ (2)

6.2.2

OPTION 1

$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓ $= \frac{430}{\sqrt{2}}$ ✓ $= 304,06$ V

$I = \frac{V}{R}$ ✓ $= \frac{304,06}{400}$ ✓ $= 0,76$ A ✓

OPTION 2

$V_{max} = I_{max}R$ ✓

$430 = I_{max}(400)$ ✓

$I_{max} = 1,075$

$I_{rms} = \frac{I_{rms}}{\sqrt{2}}$ ✓ $= \frac{1,075}{\sqrt{2}}$ ✓ $= 0,76$ A ✓

OPTION 3

$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓ $= \frac{430}{\sqrt{2}}$ ✓ $= 304,06$ V

$P_{ave} = \frac{V_{rms}^2}{R} = \frac{(304,06)^2}{400} = 231,13$ W

$P_{ave} = I_{rms}V_{rms}$ ✓

$231,13 = I_{rms}(304,06)$ ✓ $\therefore I_{rms} = 0,76$ A ✓

OPTION 4

$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓ $= \frac{430}{\sqrt{2}}$ ✓ $= 304,06$ V

$P_{ave} = \frac{V_{rms}^2}{R} = \frac{(304,06)^2}{400} = 231,13$ W

$P_{ave} = I^2_{rms}R$ ✓

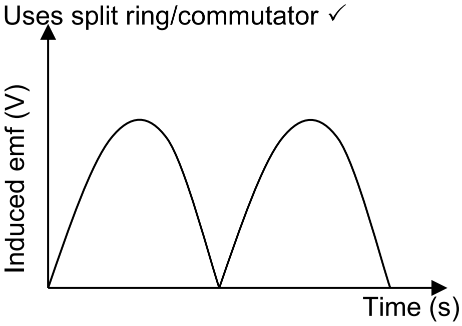
$231,13 = I^2_{rms}(400)$ ✓ $\therefore I_{rms} = 0,76$ A ✓

(5)
[10]

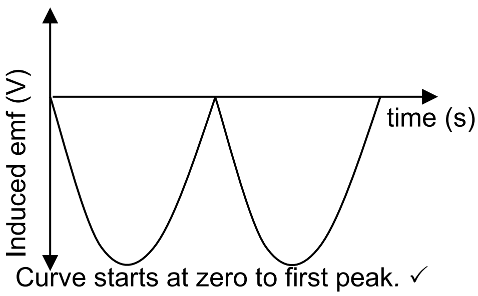
QUESTION 7

7.1.1 DC-generator ✓
Uses split ring/commutator ✓ (2)

7.1.2



OR



Curve starts at zero to first peak. ✓
Shape and one complete DC cycle. ✓ (2)

7.2.1

OPTION 1

$V_{rms} = \frac{V_{max}}{\sqrt{2}} = \frac{340}{\sqrt{2}} = 240,416$ V

$P_{ave} = V_{rms}I_{rms}$ ✓

$800 = I_{rms}(240,416)$ ✓

$I_{rms} = 3,33$ A ✓

OPTION 2

$V_{rms} = \frac{V_{max}}{\sqrt{2}} = \frac{340}{\sqrt{2}}$

$P_{ave} = V_{rms}I_{rms}$ ✓

$800 = \frac{340}{\sqrt{2}} I_{rms}$ ✓ $\therefore I_{rms} = 3,33$ A ✓

OPTION 3

$P_{ave} = \frac{V_{rms}^2}{R} = \frac{V_{max}^2}{2R}$

$800 = \frac{(340)^2}{(\sqrt{2})^2 R}$ $\therefore R = 72,25\ \Omega$

$V_{rms} = I_{rms}R$ ✓

$I_{rms} = \frac{240,416}{72,25}$ ✓ $= 3,33$ A ✓

OPTION 4

$P_{ave} = I^2_{rms}R$ ✓

$800 = I^2_{rms}(72,25)$ ✓

$I_{rms} = 3,33$ A ✓

(3)

7.2.2

OPTION 1

For the kettle:

$P_{ave} = V_{rms}I_{rms}$ ✓

$2000 = \frac{340}{\sqrt{2}} I_{rms}$ ✓ $\therefore I_{rms} = 8,32$ A

$I_{tot} = (8,32 + 3,33)$ ✓
$= 11,65$ A ✓

OPTION 2

$P_{ave} = V_{rms}I_{rms}$ ✓ $= \frac{V_{max}I_{max}}{2}$

$2\,800 = \frac{340}{2} I_{max}$ ✓ $\therefore I_{max} = 16,47$ A

$I_{rms} = \frac{I_{max}}{\sqrt{2}} = \frac{16,47}{\sqrt{2}}$ ✓ $\therefore I_{rms} = 11,65$ A ✓

(4)
[11]

QUESTION 8

8.1.1 **R:** armature/coil(s) ✓
T: Carbon brushes ✓
X: Slip rings ✓ (3)

8.1.2 Faraday's Law ✓ (1)

8.2.1 15 V ✓ (1)

8.2.2

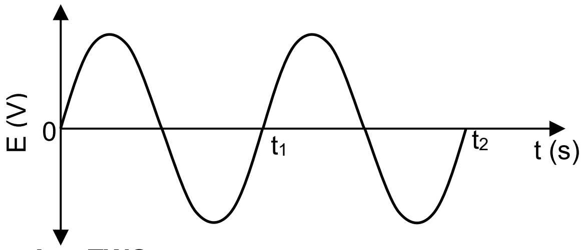
OPTION 1	OPTION 2
$V_{rms} = I_{rms}R$ $I_{rms} = \frac{15}{45}$ ✓ $= 0{,}333$ A $I_{rms} = \frac{I_{max}}{\sqrt{2}}$ (✓any one) $I_{max} = (0{,}333)\sqrt{2}$ ✓ $= 0{,}47$ A ✓	$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ $V_{max} = (15)\sqrt{2}$ ✓ $= 21{,}213$ V (✓any one) $V_{max} = I_{max}R$ $I_{max} = \frac{21{,}213}{45}$ ✓ $= 0{,}47$ A ✓

(4)
[9]

QUESTION 9

9.1 Slip rings ✓ (1)

9.2



Marking criteria	
Sine graph starts from 0.	✓
Two complete waves (between t_0 and t_2)	✓

(2)

9.3 **Any TWO:**
Increase the speed of rotation. ✓
Increase the number of coils (turns). ✓
Use stronger magnets. (2)

9.4 The AC potential difference/voltage ✓ that produces the same amount of electrical energy as an equivalent DC potential difference/voltage. ✓ (2)

9.5

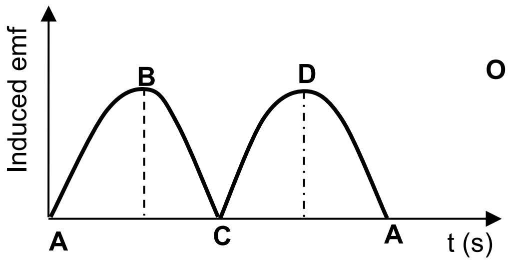
OPTION 1	OPTION 2
$P_{ave} = I_{rms}V_{rms}$ ✓ $1500 = I_{rms/wgk}(240)$ ✓ $I_{rms} = \frac{1500}{240} = 6{,}25$ A ✓	$P_{ave} = \frac{V^2}{R}$ ✓ $\therefore 1500 = \frac{240^2}{R}$ $\therefore R = 38{,}4\ \Omega$ $I_{rms} = \frac{V}{R} = \frac{240}{38{,}4}$ ✓ $= 6{,}25$ A✓

(3)
[10]

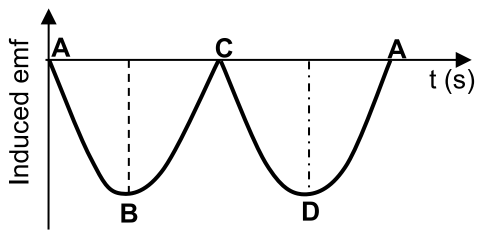
QUESTION 10

10.1.1 Mechanical to electrical ✓ (1)

10.1.2



OR



Criteria for graph	
Correct DC shape, starting from zero	✓
Positions ABCDA correctly indicated on the graph	✓

(2)

10.2.1 20,5 Ω ✓ (1)

10.2.2

OPTION 1

$I_{rms} = \frac{V_{rms}}{R}$ ✓ $= \frac{25}{20,5}$ ✓ = 1,22 (1,2195) A

$P_{ave} = I_{rms}^2 R$ $=(1,22)^2(0,5)$ = 0,74 W $P_{ave} = \frac{V_{rms}^2}{R}$ ✓ $= \frac{(25)^2}{20,5}$ ✓ = 30,49 W Actual energy delivered per second(power) = (30,49– 0,74) = 29,75 W ✓	$P_{ave} = I_{rms}^2 R$ ✓ $= (1,22)^2(20)$ ✓ = 29,77 W ✓ **OR** $V_{rms\ device} = \frac{20}{20,5} \times 25$ ✓ = 24,39 V $P_{ave} = V_{rms}I_{rms}$ ✓ = (24,39)(1,22) = 29,76 W ✓	$W = I^2_{rms} R\Delta t$ $= (1,22)^2 (0,5)(1)$ = 0,74 J $P_{ave} = \frac{V_{rms}^2}{R}$ ✓ $= \frac{(25)^2}{20,5}$ ✓ = 30,49 W Actual energy delivered per second(power) = (30,49 – 0,74) = 29,75 W✓

OPTION 2

$V_{rms\ device} = \frac{20}{20,5} \times 25$ ✓ = 24,39 V $\qquad P_{ave} = \frac{V_{rms}^2}{R}$ ✓ $= \frac{(24,39)^2}{20}$ ✓✓ = 29,74 W ✓ (5)

[9]

QUESTION 11

11.1.1 **ANY THREE**

Permanent magnets; coils (armature); commutator; brushes; power supply/battery (3)

11.2.1 The <u>AC potential difference/voltage</u> ✓ that produces the <u>same amount of electrical energy as an equivalent DC potential difference/voltage</u>. ✓ (2)

11.2.2

OPTION 1	**OPTION 2**
$V_{rms} = I_{rms}R$ $240 = I_{rms}(11)$ ✓ $I_{rms} = 21,82\ A$ $I_{rms} = \frac{I_{max}}{\sqrt{2}}$ $21,82 = \frac{I_{max}}{\sqrt{2}}$ ✓ $I_{max} = 30,86\ A$ ✓ ✓	$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ $240 = \frac{V_{max}}{\sqrt{2}}$ $V_{max} = 339,41$ $V_{max} = I_{max}R$ $339,41 = I_{max}(11)$ $I_{max} = 30,86\ A$ ✓

(4)

[9]

QUESTION 12

12.1.1 Split ring/commutator ✓ (1)

12.1.2 Anticlockwise ✓✓ (2)

12.1.3 Electrical energy ✓to mechanical (kinetic) energy ✓ (2)

12.2.1 DC generator: split ring/commutator and AC generator has slip rings ✓ (1)

12.2.2 $V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓ $= \frac{320}{\sqrt{2}}$ ✓ = 226,27 V ✓ (3)

12.2.3 $I_{max} = \frac{V_{max}}{R} = \frac{320}{35}$ ✓ = 9,14 A $\quad \therefore I_{rms} = \frac{I_{max}}{\sqrt{2}}$ ✓ $= \frac{9,14}{\sqrt{2}}$ ✓ = 6,46 A ✓ (4)

[13]

QUESTION 13

13.1.1 Y to/*na* X ✓ (1)

13.1.2 Faraday's Law Electromagnetic Induction ✓

OR Electromagnetic induction/Faraday's Law ✓ (1)

13.1.3 Mechanical (kinetic) energy ✓to electrical energy ✓ (2)

13.2.1 340 V ✓ (1)

13.2.2 $V_{rms/wgk} = \frac{V_{max/maks}}{\sqrt{2}}$ ✓ $= \frac{340}{\sqrt{2}}$ ✓ $\therefore V_{rms/wgk}$ = 240,42 V ✓ (3)

13.2.3

OPTION 1	**OPTION 2**
$P_{ave/gemid} = \frac{V^2_{rms/wgk}}{R}$ ✓ $1\ 600 = \frac{(240,42)^2}{R}$ ✓ $\therefore$ R = 36,13 Ω ✓	$P_{ave/gemid} = \frac{V^2_{rms/wgk}}{R}$ ✓ $= \frac{\frac{V^2_{max/maks}}{2}}{R} = \frac{V^2_{max/maks}}{2R}$ $\therefore 1\ 600 = \frac{(340)^2}{2R}$ ✓ $\therefore$ R = 36,13 Ω ✓

(3)

[11]

QUESTION 14

14.1 Slip rings ✓ (1)

14.2 B ✓ (1)

14.3 $V_{rms/wgk} = \frac{V_{max/maks}}{\sqrt{2}}$ ✓ $= \frac{312}{\sqrt{2}}$ ✓ $= 220,62$ V ✓ (3)

14.4.1

OPTION 1

$P_{aver/gemid} = \frac{V_{rms/wgk}^2}{R}$ ✓ $= \frac{(220,62)^2}{40}$ ✓ $= 1216,83$ W ✓

OPTION 2

$I_{rms} = \frac{V_{rms/wgk}}{R}$

$= \frac{(220,62)}{40}$

$= 5,515$

$P_{ave} = I^2_{rms}R$

✓ any one

$= (5,515)^2(40)$ ✓

$= 1216,61$ W ✓

OR

$P_{ave} = V_{rms}I_{rms} = (220,62)(5,515)$ ✓ $= 1216,72$ W✓ (3)

14.4.2

OPTION 1

$I_{max} = \frac{V_{max/maks}}{R}$ ✓

$= \frac{312}{40}$ ✓✓

$= 7,8$ A ✓

OPTION 2

$P_{ave} = V_{rms}I_{rms}$

$1\,216,83 = 220,62\, I_{rms}$ ✓

$I_{rms} = 5,515$ A

$I_{rms} = \frac{I_{max/maks}}{\sqrt{2}}$

✓ Any one

$5,515 = \frac{I_{max/maks}}{\sqrt{2}}$ ✓ ∴ $I_{max} = 7,8$ A ✓

(4)

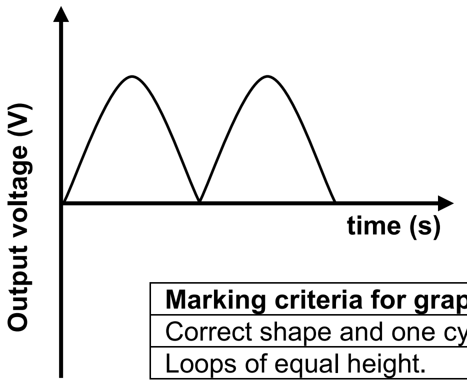
[12]

QUESTION 15

15.1.1 DC ✓ (1)

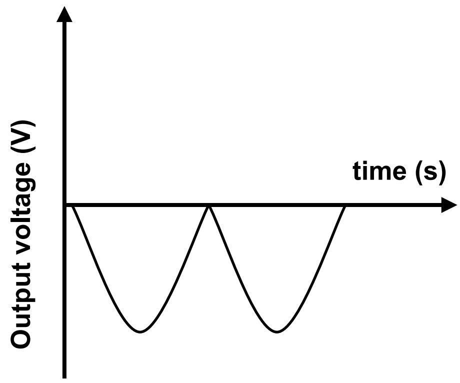
15.1.2 Emf is induced as a result of the rate of change of magnetic flux linked ✓✓ with the coil. (2)

15.1.3



Marking criteria for graph:	
Correct shape and one cycle.	✓
Loops of equal height.	✓

OR



(2)

15.2.1 The AC potential difference/voltage ✓ that produces the same amount of electrical energy as an equivalent DC potential difference/voltage. ✓ (2)

15.2.2

OPTION 1	OPTION 2	OPTION 3
$W = \frac{V^2}{R}\Delta t$ ✓ $500 = \frac{V^2}{200}(10)$ ✓ $V = V_{rms} = 100$ V	$W = I^2R\Delta t$ ✓ $500 = I^2(200)(10)$ $I = I_{rms} = 0,5$ A $P_{ave} = V_{rms}I_{rms}$ $\frac{500}{10} = V_{rms}(0,5)$ ✓ $V_{rms} = 100$ V	$P_{ave} = I^2_{rms}R$ ✓ $\frac{500}{10} = I^2_{rms}(200)$ $I_{rms} = 0,5$ A $P_{ave} = V_{rms}I_{rms}$ $\frac{500}{10} = V_{rms}(0,5)$ ✓ ∴ $V_{rms} = 100$ V

$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓ ∴ $100 = \frac{V_{max}}{\sqrt{2}}$ ✓ ∴ $V_{max} = 141,42$ V ✓

(5)
[12]

QUESTION 16

16.1.1 (DC) motor ✓ (1)

16.1.2 Electrical to mechanical/kinetic (energy). (2)

16.1.3 Split ring/commutator (1)

16.1.4 Anticlockwise (2)

16.2.1 The AC voltage/potential difference which dissipates the same amount of energy/heat/power as an equivalent DC voltage/potential difference. ✓✓ (2)

16.2.2

OPTION 1	OPTION 2	OPTION 3
$P_{ave} = \frac{V^2_{rms}}{R}$ ✓ $200 = \frac{220^2}{R}$ ✓ $R = 242\ \Omega$ ✓	$P_{ave} = V_{rms}I_{rms}$ ✓ $200 = I_{rms}(220)$ $I_{rms} = 0,909\ A$ $R = \frac{V_{rms}}{I_{rms}}$ $= \frac{220}{0,909}$ ✓ $= 242\ \Omega$ ✓	$P_{ave} = V_{rms}I_{rms}$ ✓ $200 = I_{rms}(220)$ $I_{rms} = 0,909\ A$ $P_{ave} = I^2_{rms}R$ $200 = (0,909)^2R$ ✓ $R = 242\ \Omega$ ✓

(3)

16.2.3

OPTION 1	OPTION 5	
$W = \frac{V^2\Delta t}{R}$ ✓✓ $= \frac{(150^2)(10x60)}{242}$ ✓ ✓ $= 55\,785,12\ J$ ✓	$P_{ave} = \frac{V^2_{rms}}{R}$ ✓ $= \frac{150^2}{242}$ ✓ $= 92,975\ W$	$P_{ave} = I^2_{rms}R$ $92,975 = I^2_{rms}(242)$ $I_{rms} = 0,6198\ A$ $W = I^2R\Delta t$ ✓ $= (0,6198)^2(242)(10)(60)$ ✓ $= 55\,778,88\ J$ ✓

OPTION 2	OPTION 3	OPTION 4
$P_{ave} = \frac{V^2_{rms}}{R}$ ✓ $= \frac{150^2}{242}$ ✓ $= 92,975\ W$ $P = \frac{W}{\Delta t}$ ✓ $92,975 = \frac{W}{(10)(60)}$ ✓ $W = 55\,785,12\ J$ ✓	$R = \frac{V_{rms}}{I_{rms}}$ ✓ $242 = \frac{150}{I_{rms}}$ ✓ $I_{rms} = 0,620\ A$ $P_{ave} = I_{rms}V_{rms}$ $= (0,62)(150)$ $= 92,97\ W$ $P = \frac{W}{\Delta t}$ ✓ $92,975 = \frac{W}{(10)(60)}$ ✓ $W = 55\,785,12\ J$ ✓	$R = \frac{V_{rms}}{I_{rms}}$ ✓ $242 = \frac{150}{I_{rms}}$ ✓ $I_{rms} = 0,620\ A$ $W = I^2R\Delta t$ ✓ $= (0,62)^2(242)(10)(60)$ ✓ $= 55\,814,88$ J ✓ (55 785,12 – 55 896 J) **OR/*OF*** $W = VI\Delta t$ $= (150)(0,62)(600)$ $= 55\,800$ J

(5)
[16]

QUESTION 17

17.1 Slip rings ✓ (1)

17.2 Allows the slips rings to rotate while maintaining contact with the external circuit. ✓ **OR**
Transfer/conduct current to the external circuit. **OR**
Connection between external circuit and coil/slip rings/internal circuit. (1)

17.3 According to the principle of electromagnetic induction, an emf/current is induced as a result of the change in the magnetic flux linkage ✓✓ with the coil. (2 or 0) (2)

17.4 P to Q ✓✓ (2)

17.5

$$T = \frac{1}{f} = \frac{1}{50} \checkmark$$
$$= 0{,}02\ s$$

$$t = (1{,}5)(0{,}02) \checkmark$$
$$= 0{,}03\ s \checkmark$$

OR

$$t = 0{,}02 + \left(\frac{1}{2}\right)(0{,}02) \checkmark$$
$$= 0{,}03\ s \checkmark$$

(3)

17.6

$$V_{rms} = \frac{V_{max}}{\sqrt{2}} = \frac{311}{\sqrt{2}} \checkmark = 219{,}91\ V$$

$$I_{rms} = \frac{V_{max}}{\sqrt{2}} = \frac{219{,}91}{100} \checkmark = 2{,}1991\ V$$

OPTION 1

$$W = \frac{V^2\Delta t}{R} \checkmark$$
$$= \frac{(219{,}91^2)(60)}{100} \checkmark\checkmark$$
$$= 29\ 016{,}24\ J \checkmark$$

OPTION 2

$$W = VI\Delta t \checkmark$$
$$= (219{,}91)(2{,}20)(60) \checkmark\checkmark$$
$$= 29\ 028{,}12\ J \checkmark$$

OPTION 3

$$W = I^2R\Delta t \checkmark$$
$$= (2{,}20^2)(100)(60) \checkmark\checkmark$$
$$= 29\ 040\ J \checkmark$$

(5)
[14]

QUESTION 18

18.1 Slip rings ✓ (1)

18.2 Y to X ✓✓ (2)

18.3 The AC potential difference which dissipates the same amount of energy as an equivalent DC potential difference. ✓✓ (2)

18.4

OPTION 1

$$V_{rms;wgk} = \frac{V_{max;maks}}{\sqrt{2}} = \frac{100}{\sqrt{2}} \checkmark = 70{,}71\ V$$

$$I_{rms;wgk} = \frac{V_{rms;wgk}}{R} \checkmark = \frac{70{,}71}{25} \checkmark = 2{,}83\ A \checkmark$$

OPTION 2

$$I_{max;maks} = \frac{V_{max;maks}}{R} = \frac{100}{25} \checkmark = 4\ A$$

$$I_{rms;wgk} = \frac{I_{max;maks}}{\sqrt{2}} \checkmark = \frac{4}{\sqrt{2}} \checkmark = 2{,}83\ A \checkmark$$

(4)

18.5

OPTION 1

$$P_{ave;gem} = \frac{V^2_{rms;wgk}}{R} \checkmark = \frac{70{,}71^2}{25} \checkmark = 200\ W \checkmark$$

OPTION 2

$$P_{ave;gem} = V_{rms;wgk}I_{rms;wgk} \checkmark$$
$$= (70{,}71)(2{,}83) \checkmark$$
$$= 200{,}11\ W \checkmark$$

OPTION 3

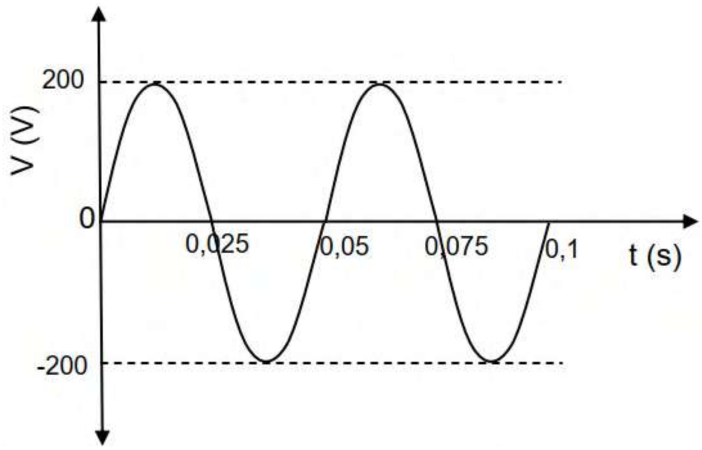
$$P_{ave;gem} = I^2_{rms;wgk}R \checkmark$$
$$= (2{,}83)(25) \checkmark$$
$$= 200{,}22\ W \checkmark$$

OPTION 4

$$P_{ave;gem} = \frac{V_{max;maks}I_{max;maks}}{2} \checkmark = \frac{(100)(4)}{2} \checkmark = 200\ W \checkmark$$

(3)

18.6



(3)
[15]

QUESTION 19

19.1.1 Electrical to mechanical/kinetic/rotational ✓ (1)

19.1.2 DC ✓ (1)

19.1.3 Ensures continuous rotation of the coil. ✓ **OR**
Ensures the change in direction of the current in the coil. (1)

19.2.1

OPTION 1

$P_{ave} = \frac{V_{rms}^2}{R}$ ✓

$100 = \frac{220^2}{R}$ ✓

$R = 484\ \Omega$ ✓

OPTION 2

$P_{ave} = V_{rms}I_{rms}$

$100 = 220I_{rms}$

$I_{rms} = 0{,}4545\ A$

$I_{rms} = \frac{V_{rms}}{R}$ ✓

$0{,}4545 = \frac{220}{R}$ ✓

$R = 484{,}05\ \Omega$ ✓

OPTION 3

$P_{ave} = V_{rms}I_{rms}$

$100 = 220I_{rms}$

$I_{rms} = 0{,}4545\ A$

$P_{ave} = I_{rms}^2 R$ ✓

$100 = (0{,}4545^2)R$ ✓

$R = 484{,}10\ \Omega$ ✓

(3)

19.2.2

For resistor Y

$P_{ave} = \frac{V_{rms}^2}{R}$

$80 = \frac{V_{rms}^2}{484}$

$V_{rms} = 196{,}774\ V$

$I_{rms} = \frac{V_{rms}}{R}$

$= \frac{196{,}774}{484}$ ✓

$= 0{,}407\ A$

For resistor Z

$V_{rms} = 220 - 196{,}77$ ✓

$= 23{,}226\ V$

$I_{rms} = \frac{V_{rms}}{R}$

$0{,}407 = \frac{23{,}226}{R}$ ✓

$R = 57{,}066\ \Omega$

Power rating of Z

$P_{ave} = \frac{V_{rms}^2}{R}$ ✓

$= \frac{220^2}{57{,}066}$ ✓

$= 848{,}14\ W$ ✓

[847,21 W to 854,22 W]

(6)
[12]

QUESTION 20

20.1.1 Split ring/commutator ✓ (1)

20.1.2 Y to X **OR** No current ✓ (1)

20.1.3

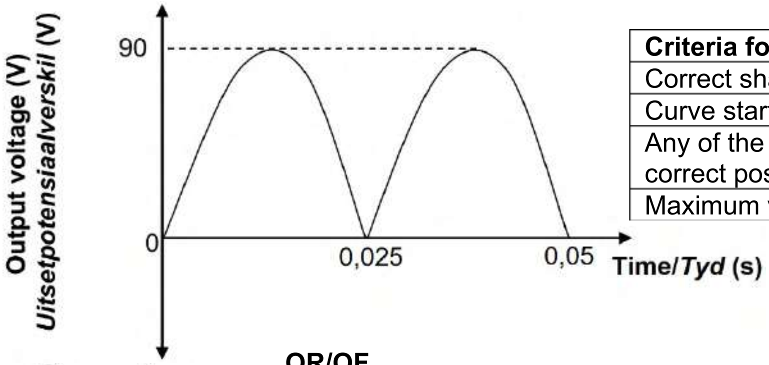
$T = \frac{1}{f}$

$= \frac{1}{20}$

$= 0{,}05\ s$ ✓

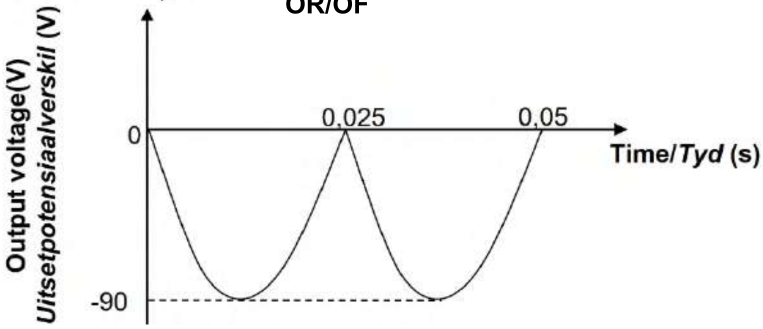
(1)

20.1.4



Criteria for graph	
Correct shape with one full cycle.	✓
Curve starts at zero to first peak.	✓
Any of the correct time values at the correct position.	✓
Maximum voltage of 90 V or -90 V.	✓

OR/OF



(4)

20.2

OPTION 1

$$W_{ave} = \frac{V_{rms}^2 \Delta t}{R} \checkmark$$
$$= \frac{(220^2)(120) \checkmark}{32 \checkmark}$$
$$= 181\ 500\ J \checkmark$$

Other energy and power formulae may be used.

OPTION 3

$$R = \frac{V_{rms}}{I_{rms}}$$
$$32 = \frac{220}{I_{rms}} \checkmark$$
$$= 6{,}875\ A$$
$$W_{ave} = V_{rms} I_{rms} \Delta t \checkmark$$
$$= (220)(6{,}875)(120) \checkmark$$
$$= 181\ 500\ J \checkmark$$

OPTION 2

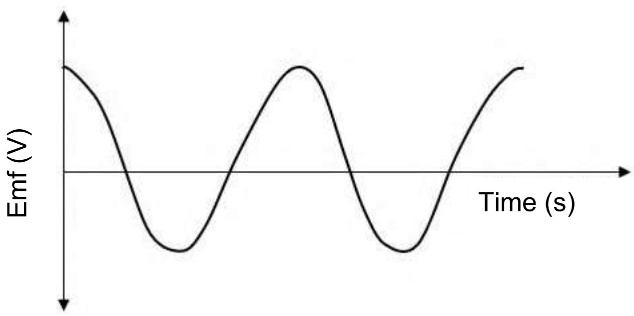
$$P_{ave} = \frac{V_{rms}^2}{R}$$
$$= \frac{220^2}{32} \checkmark$$
$$= 1\ 512{,}5\ W$$

$$P = \frac{W}{\Delta t} \checkmark$$
$$1\ 512{,}5 = \frac{W}{120} \checkmark$$
$$W = 181\ 500\ J \checkmark$$

(4)
[11]

QUESTION 21

21.1.1 North pole ✓ (1)
21.1.2 Y to X ✓ (1)
21.1.3



Marking criteria
Correct shape ✓
Graph starts from maximum value. ✓
Two complete waves ✓

(3)

21.2.1

OPTION 1

$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓

$200 = \frac{V_{max}}{\sqrt{2}}$ ✓

$V_{max} = 282{,}84\ V$

$R = \frac{V}{I}$

$= \frac{282{,}84}{6}$ ✓

$= 47{,}14\ \Omega$ ✓

OPTION 2

$I_{rms} = \frac{I_{max}}{\sqrt{2}}$ ✓

$= \frac{6}{\sqrt{2}}$ ✓

$I_{max} = 4{,}24\ A$

$R = \frac{V}{I}$

$= \frac{200}{4{,}24}$ ✓

$= 47{,}17\ \Omega$ ✓

(4)

21.2.2

OPTION 1

$W = I^2R\Delta t$ ✓

$= (4{,}24^2)(47{,}17)(7\ 200✓)$ ✓

$= 6{,}11x10^6\ J$ ✓

OPTION 2

$W = VI\Delta t$ ✓

$= (200)(4{,}24)(7\ 200✓)$ ✓

$= 6{,}11x10^6\ J$ ✓

OPTION 3

$W = \frac{V^2\Delta t}{R}$ ✓

$= \frac{(200^2)(7\ 200✓)}{47{,}17}$ ✓

$= 6{,}11x10^6\ J$ ✓

(4)
[13]

QUESTION 22

22.1.1 Split ring/Commutator ✓ (1)
22.1.2 Electrical to mechanical/kinetic ✓ (1)
22.1.3 Clockwise ✓✓ (2)
22.1.4 Any two of the following: ✓✓

- Increase the strength of the magnetic field, e.g., use stronger magnets or bring magnets closer.
- Increase the current.
- Increase the area of the coil.
- Increase the number of turns in the coil.
- Use a battery with a higher potential difference. (2)

22.2.1 Root-mean-square current is the alternating current that dissipates the same amount of energy as an equivalent DC current. ✓✓ (2)

22.2.2

$I_{rms} = \frac{I_{max}}{\sqrt{2}}$ ✓

$= \frac{3{,}6}{\sqrt{2}}$ ✓

$= 2{,}55\ A$ ✓

(3)

22.2.3

OPTION 1

$W = VI_{rms}\Delta t$ ✓

$= (220)(2{,}62)(120)$ ✓

$= 69\ 168\ J$ ✓

OPTION 2

$V = IR$

$220 = 2{,}62R$

$R = 83{,}969\ \Omega$

$W = I_{rms}^2R\Delta t$ ✓

$= (2{,}62^2)(83{,}969)(120)$ ✓

$= 69\ 168\ J$ ✓

OR

$W = \frac{V_{rms}^2\Delta t}{R}$ ✓

$= \frac{(220^2)(120)}{83{,}969}$ ✓

$= 69\ 168\ J$✓

(3)
[14]

OPTICAL PHENOMENA AND PROPERTIES OF MATERIALS

QUESTION 1

1.1 The minimum frequency of light needed to emit electrons ✓ from the surface of a metal. ✓ (2)

1.2 $E = W_o + E_{k(max)}$

$E = W_o + \frac{1}{2}mv^2_{max}$ ✓Any one

$h\frac{c}{\lambda} = hf_o + \frac{1}{2}mv^2_{max}$

$\frac{(6,63 \times 10^{-34})(3 \times 10^8)}{\lambda}$ ✓= (6,63 x 10^{-34})(5,548 x 10^{14}) ✓ + $\frac{1}{2}(9,11 \times 10^{-31})(5,33 \times 10^5)^2$ ✓

$\lambda = 4 \times 10^{-7}$ m ✓ (5)

1.3 Smaller (less) than ✓ (1)

1.4 The wavelength/frequency/energy of the incident light/photon is constant. ✓
Since the speed is higher, the kinetic energy is higher ✓ and the work function / W_0 / threshold frequency smaller. ✓ (3)

[11]

QUESTION 2

2.1 The minimum energy needed to emit an electron ✓ from (the surface of) a metal. ✓ (2)

2.2 $E = W_0 + \frac{1}{2}mv^2_{max}$

$h\frac{c}{\lambda} = W_0 + \frac{1}{2}mv^2_{max}$ Any ONE OF/*ENIGE EEN van*✓

$\frac{(6,63 \times 10^{-34})(3 \times 10^8)}{(\lambda)} = (3,36 \times 10^{-19}) + 2,32 \times 10^{-19}$ ✓ ✓

λ = 3,50 x 10^{-7} m✓ (4)

2.3 $E = W_0 + \frac{1}{2}mv^2_{max}$

OR/*OF*

$h\frac{c}{\lambda} = W_0 + \frac{1}{2}mv^2_{max}$ ✓

$\frac{(6,63 \times 10^{-34})(3 \times 10^8)}{(3,50 \times 10^{-7})}$ ✓ $= (3,65 \times 10^{-19}) + E_k$ ✓

E = 2,03 x 10^{-19} J✓ (4)

2.4.1 Increasing the intensity does not change the energy / frequency / wavelength of the incident photons. ✓
OR: The energy of a photon remains unchanged (for the same frequency). (1)

2.4.2 Increases ✓ (1)

2.4.3 More photons/packets of energy strike the surface of the metal per unit time. ✓ Hence more (photo) electrons ejected per unit time ✓ leading to increased current. (2)

[14]

QUESTION 3

3.1.1 The particle nature of light. ✓ (1)

3.1.2 Shorter wavelength means higher photon energy. ✓
Photon energy is inversely proportional to wavelength ✓ ($E = \frac{hc}{\lambda}$).
For the same metal, kinetic energy is proportional to photon energy. (2)

3.2.1

OPTION 1	**OPTION 2**
$W_o = h\frac{c}{\lambda}$ ✓ $= \frac{(6,63 \times 10^{-34})(3 \times 10^8)}{330 \times 10^{-9}}$ ✓ ∴ W_o = 6,03 x 10^{-19} J ✓	c = fλ ∴ 3 x 10^8 = f_o(330 x 10^{-9}) ✓ ∴ f_o = 9,09 x 10^{14} Hz W_o = hf_o ✓ for both equations = (6,63 x 10^{-34})(9,09 x 10^7) ✓ = 6,03 x 10^{-19} J ✓

(4)

3.2.2

OPTION 1

$E = W_o + E_k$
$hf = hf_o + E_k$
$hf = hf_o + ½ mv^2$
$E = W_o + ½ mv^2$ ✓ Any one

(6,63 x 10^{-34})(1,2 x10^{15}) ✓= (6,03 x 10^{-19}) ✓+ ½(9,11 x 10^{-31})v^2 ✓ ∴ v= 6,5 x 10^5 m·s^{-1} ✓

OPTION 2

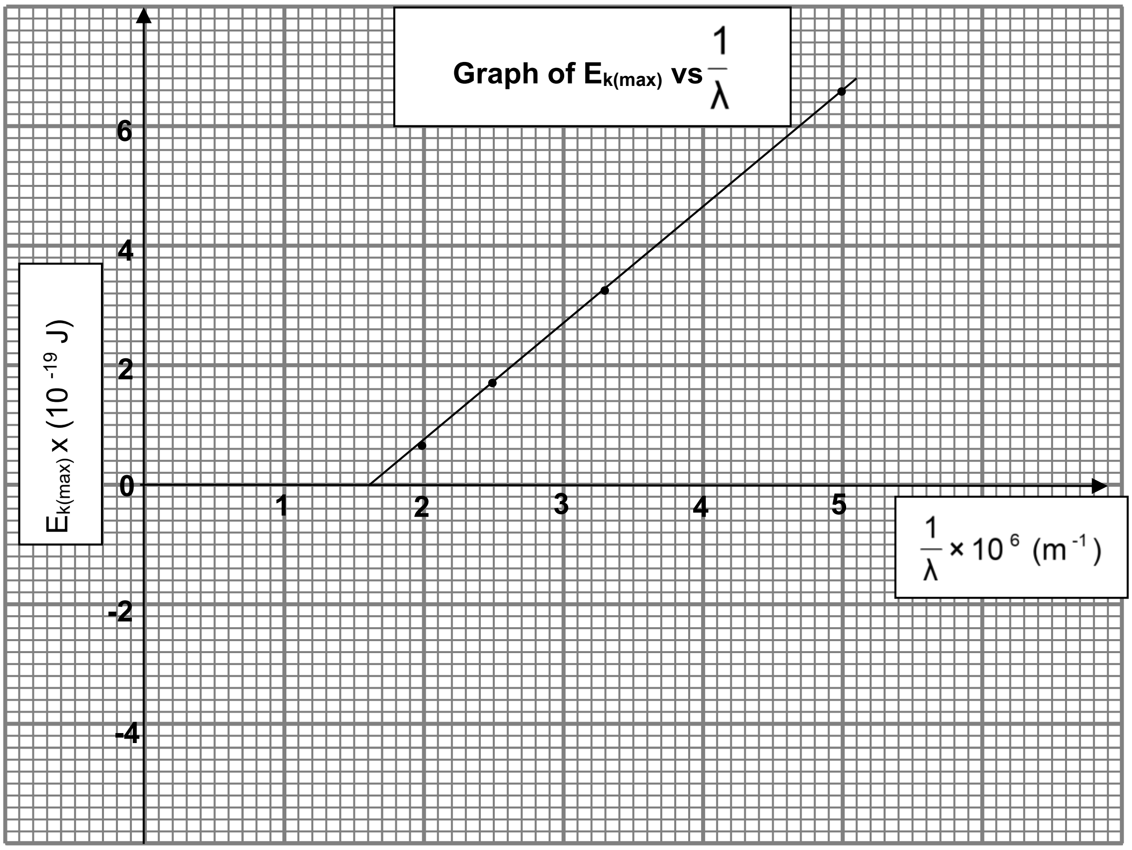
$E_K = E_{light} - W_o$ } ✓ Any one
$= hf_{light} - hf_o$
$= (6{,}63 \times 10^{-34})(1{,}2 \times 10^{15})$ ✓ $- 6{,}03 \times 10^{-19}$ ✓ $= 1{,}926 \times 10^{-19}$ J
$E_K = \frac{1}{2}mv^2$ ∴ $1{,}926 \times 10^{-19} = \frac{1}{2}(9{,}11 \times 10^{-31})v^2$ ✓ ∴ $v = 6{,}5 \times 10^5 \text{ m·s}^{-1}$ ✓ **(5)**

[12]

QUESTION 4

4.1 It is the process whereby electrons are ejected from a metal surface when light of suitable frequency is incident/shines on it. ✓✓ (2)

4.2



Criteria for drawing line of best fit:	
ALL points correctly plotted (at least 3 points)	✓✓
Correct line of best fit if all plotted points are used.	✓

(3)

4.3.1

OPTION 1

$\frac{1}{\lambda} = 1{,}6 \times 10^6$ m^{-1} ✓ (**Accept** $1{,}6 \times 10^6$ m^{-1} to $1{,}7 \times 10^6$ m^{-1})

$f_o = c\frac{1}{\lambda}$ ✓ $= (3 \times 10^8)(1{,}6 \times 10^6)$ ✓ $= 4{,}8 \times 10^{14}$ Hz ✓ (**Accept** $4{,}8 \times 10^{14}$ Hz to $5{,}1 \times 10^{14}$ Hz)

OPTION 2

By extrapolation: y-intercept = $-W_o$
$W_o = hf_o$ ✓
$3{,}2 \times 10^{-19}$ ✓ $= (6{,}63 \times 10^{-34})f_o$ ✓
$f_o = 4{,}8 \times 10^{14}$ Hz ✓ (**Accept** $4{,}8 \times 10^{14}$ Hz to $4{,}83 \times 10^{14}$ Hz)

OPTION 3 **(Points from the graph)**

$E = W_o + E_{k(max)}$ ∴ $\frac{hc}{\lambda} = hf_0 + E_{k(max)}$ ✓

$(6{,}63 \times 10^{-34})(3 \times 10^8)(1{,}6 \times 10^6)$ ✓ $= (6{,}63 \times 10^{-34})f_0 + 0$ ✓ ∴ $f_o = 4{,}8 \times 10^{14}$ Hz ✓
OR $6{,}63 \times 10^{-34})(3 \times 10^8)(5 \times 10^6)$ ✓ $= (6{,}63 \times 10^{-34})f_0 + 6{,}6 \times 10^{-19}$ ✓ ∴ $f_o = 4{,}92 \times 10^{14}$ Hz ✓
OR $6{,}63 \times 10^{-34})(3 \times 10^8)(3{,}3 \times 10^6)$ ✓ $= (6{,}63 \times 10^{-34})f_0 + 3{,}3 \times 10^{-19}$ ✓ ∴ $f_o = 4{,}8 \times 10^{14}$ Hz ✓
OR $6{,}63 \times 10^{-34})(3 \times 10^8)(2{,}5 \times 10^6)$ ✓ $= (6{,}63 \times 10^{-34})f_0 + 1{,}7 \times 10^{-19}$ ✓ ∴ $f_o = 4{,}94 \times 10^{14}$ Hz ✓
OR $6{,}63 \times 10^{-34})(3 \times 10^8)(2{,}2 \times 10^6)$ ✓ $= (6{,}63 \times 10^{-34})f_0 + 0{,}7 \times 10^{-19}$ ✓ ∴ $f_o = 5{,}54 \times 10^{14}$ Hz ✓ (4)

4.3.2

<u>OPTION 1</u> <u>hc = gradient</u> ✓ $= \frac{\Delta y}{\Delta x} = \frac{6,6\times10^{-19}}{(5-1,6)\times10^{6}}$ ✓ $= 1,941 \times 10^{-25}$ (J·m) $h = \frac{\text{gradient}}{c} = \frac{1,941\times10^{-25}}{3\times10^{8}}$ ✓ $= 6,47 \times 10^{-34}$ J·s ✓	**<u>OPTION 2</u>** W_0 = y intercept $= 3,2 \times 10^{-19}$ J } ✓ **Accept:** $3,2 \times 10^{-19}$ J to $3,4 \times 10^{-19}$ J $W_o = hf_o$ $3,2 \times 10^{-19}$ ✓ $= h(4,8 \times 10^{14})$ ✓ $h = 6,66 \times 10^{-34}$ J·s ✓ **Accept:** $6,66 \times 10^{-34}$ J·s to $7,08 \times 10^{-34}$ J·s)
<u>OPTION 3</u> (Points from the graph) $\frac{hc}{\lambda} = W_0 + E_{k(max)} = 3,2 \times 10^{-19}$ ✓ $+ 6,6 \times 10^{-19}$ ✓ $h = \frac{9,8\times10^{-19}}{(3\times10^{8})(5\times10^{6})}$ ✓ $= 6,53 \times 10^{-34}$ J·s ✓ **OR** $\frac{hc}{\lambda} = W_0 + E_{k(max)} = 3,2 \times 10^{-19}$ ✓ $+ 3,3 \times 10^{-19}$ ✓ $h = \frac{6,5\times10^{-19}}{(3\times10^{8})(3,3\times10^{6})}$ ✓ $= 6,57 \times 10^{-34}$ J·s ✓ **OR** $\frac{hc}{\lambda} = W_0 + E_{k(max)} = 3,2 \times 10^{-19}$ ✓ $+ 1,7 \times 10^{-19}$ ✓ $h = \frac{4,7\times10^{-19}}{(3\times10^{8})(2,5\times10^{6})}$ ✓ $= 6,27 \times 10^{-34}$ J·s ✓	**<u>OPTION 4</u>** $W_0 = \frac{hc}{\lambda}$ ✓ $3,2 \times 10^{-19}$ ✓ $= h(3 \times 10^{8})(1,6 \times 10^{6})$ ✓ $h = 6,66 \times 10^{-34}$ J·s ✓

(4)
[13]

QUESTION 5

5.1 The minimum energy needed to emit electrons ✓ from the surface of a certain metal. ✓ (2)

5.2 Frequency/Intensity ✓ (1)

5.3 The <u>minimum frequency (of a photon/light) needed to emit electrons</u> ✓ from the <u>surface of a certain metal</u>. ✓ (2)

5.4
$E = W_0 + E_k$
$hf = hf_0 + E_k$ } ✓ Any one/*Enige een*
$(6,63 \times 10^{-34})(6,50 \times 10^{14})$ ✓ $= (6,63 \times 10^{-34})(5,001 \times 10^{14})$ ✓ $+ \frac{1}{2}(9,11 \times 10^{-31})v^2$ ✓
$\therefore v = 4,67 \times 10^5$ m·s^{-1} ✓

<u>OR/*OF*</u>
$E_K = E_{light} - W_o$
$= hf_{light} - hf_o$ } ✓ Any one/*Enige een*
$= (6,63 \times 10^{-34})(6,50 \times 10^{14} - 5,001 \times 10^{14})$ ✓
$= 9,94 \times 10^{-20}$ J

$E_K = \frac{1}{2}mv^2$ ✓
$v = \sqrt{\frac{2E_k}{m}} = \sqrt{\frac{(2)(9,94\times10^{-20})}{9,11\times10^{-31}}}$ ✓
$v = 4,67 \times 10^5$ m·s^{-1} ✓ (5)

5.5 The photocurrent is directly proportional to the intensity of the incident light. ✓✓ (2)
[12]

QUESTION 6

6.1.1 Light has a particle nature. ✓ (1)

6.1.2 Remains the same. ✓
<u>For the same colour/ frequency/wavelength the energy of the photons will be the same.</u> ✓
(The brightness causes more electrons to be released, but they will have the same maximum kinetic energy.)
OR Maximum kinetic energy of ejected photo-electrons is independent of intensity of radiation. (2)

6.1.3 $E = W_0 + E_k$ **OR** $hf = hf_0 + E_k$ **OR** $hf = hf_0 + \frac{1}{2}mv^2$ **OR** $E = W_0 + \frac{1}{2}mv^2$

$\frac{(6,63\times10^{-34})(3\times10^{8})}{420\times10^{-9}}$ ✓ $= \frac{(6,63\times10^{-34})(3\times10^{8})}{\lambda_o}$ ✓ $+ \frac{1}{2}(9,11\times10^{-31})(4,76\times10^{5})^2$ ✓

∴ $\lambda_o = 5,37 \times 10^{-7}$ m ∴ the metal is sodium ✓ (5)

6.2 **Q** ✓ and **S** ✓

Emission spectra occur when excited atoms /electrons drop from higher energy levels to lower energy levels. ✓✓ (Characteristic frequencies are emitted.) (4)

[12]

QUESTION 7

7.1.1 The minimum frequency of a photon/light needed ✓ to emit electrons from a certain metal surface. ✓ (2)

7.1. 2 Silver ✓

Threshold frequency / cut-off frequency (of Ag) is higher. ✓ and $W_o \propto f_o$ / $W_o = hf_o$ ✓ (3)

7.1.3 Planck's constant ✓ (1)

7.1.4 Sodium ✓ (1)

7.2.1 Energy radiated per second by the blue light = $(\frac{5}{100})(60 \times 10^{-3})$ ✓ $= 3 \times 10^{-3}$ J·s^{-1}

$E_{photon} = \frac{hc}{\lambda}$ ✓ $= \frac{(6,63\times10^{-34})(3\times10^{8})}{470\times10^{-9}}$ ✓ $= 4,232 \times 10^{-19}$ J

Total number of photons incident per second = $\frac{3\times10^{-3}}{4,232\times10^{-19}}$ ✓ $= 7,09 \times 10^{15}$ ✓ (5)

7.2.2 $7,09 \times 10^{15}$ (electrons per second) ✓

OR: Same number as that calculated in Question 7.2.1 above. (1)

[13]

QUESTION 8

8.1 It is the process whereby electrons are ejected from a metal surface when light of suitable frequency is incident/shines on that surface. ✓✓ (2)

8.2 Increase ✓

Increase in intensity means that for the same frequency the number of photons incident per unit time increase. ✓ Therefore the number of electrons ejected per unit time increases. ✓ (3)

8.3

OPTION 1

$E = W_o + E_{k(max)}$ **OR** $hf = hf_o + E_{k(max)}$ **OR** $hf = hf_o + \frac{1}{2}mv^2$ **OR** $E = W_o + \frac{1}{2}mv^2$ ✓

$(6,63 \times 10^{-34} \times 5,9 \times 10^{14})$ ✓ $= \frac{(6,63\times10^{-34})(3\times10^{8})}{\lambda_o} + 2,9 \times 10^{-19}$

$39,117 \times 10^{-20} - 2,9 \times 10^{-19} = \frac{19,89\times10^{-26}}{\lambda_o}$ ∴ $\lambda_o = 1,97 \times 10^{-6}$ m ✓

OPTION 2

$E = W_o + E_{k(max)}$ **OR** $hf = hf_o + E_{k(max)}$ **OR** $hf = hf_o + \frac{1}{2}mv^2$ **OR** $E = W_o + \frac{1}{2}mv^2$ ✓

$((6,63 \times 10^{-34} \times 5,9 \times 10^{14})$ ✓ $= (6,63 \times 10^{-34})f_0 + 2,9 \times 10^{-19}$ ∴ $f_o = 1,52 \times 10^{14}$ Hz

$c = f_o\lambda_o$ ∴ $3 \times 10^8 = (1,52 \times 10^{14})\lambda_0$ ✓ ∴ $\lambda_o = 1,97 \times 10^{-6}$ m ✓

OPTION 3

$E = W_o + E_{k(max)}$ **OR** $hf = hf_o + E_{k(max)}$ **OR** $hf = hf_o + \frac{1}{2}mv^2$ **OR** $E = W_o + \frac{1}{2}mv^2$ ✓

$(6,63 \times 10^{-34} \times 5,9 \times 10^{14})$ ✓ $= W_0 + 2,9 \times 10^{-19}$ ∴ $W_o = 1,01 \times 10^{-19}$ J

$W_o = hf_o$ ∴ $1,01 \times 10^{-19} = (6,63 \times 10^{-34})f_o$ ∴ $f_o = 1,52 \times 10^{14}$ Hz

$c = f_o\lambda_o$ ∴ $3 \times 10^8 = (1,52 \times 10^{14})\lambda_0$ ✓ ∴ $\lambda_o = 1,97 \times 10^{-6}$ m ✓ (5)

8.4 From the photo-electric equation, for a constant work function, ✓ the energy of the photons is proportional to the maximum kinetic energy of the photoelectrons. ✓ (2)

[12]

QUESTION 9

9.1 The minimum frequency of light ✓needed to emit electrons from the surface of a metal. ✓ (2)

9.2 The speed remains unchanged. ✓ (1)

9.3

OPTION 1

$c = f\lambda$ ✓

∴ $3 \times 10^8 = f(6 \times 10^{-7})$ ✓

∴ $f = 5 \times 10^{14}$ Hz ✓

The value of f is less than the threshold frequency of the metal, ✓ therefore photoelectric effect is not observed. ✓

OPTION 2

For the given metal: $W_0 = hf_0$ ✓ = (6,63 x 10^{-34})(6,8 x 10^{14}) ✓ = 4,51 x 10^{-19} J

For the given wavelength:

$E_{photon} = \frac{hc}{\lambda} = \frac{(6,63\times10^{-34})(3\times10^{8})}{6\times10^{-7}}$ ✓ **OR** E_{photon} = hf =(6,63 x 10^{-34})(5 x 10^{14}) ✓✓

= 3,32 x 10^{-19} J = 3,32 x 10^{-19} J

Energy is less than work function ✓ of metal, therefore photoelectric effect not observed.✓ (5)

9.4 $E = W_0 + E_{k(max)}$ **OR** $E = W_o + \frac{1}{2}mv^2_{max}$ **OR** $h\frac{c}{\lambda} = hf_0 + \frac{1}{2}mv^2_{max}$ **OR** $hf = hf_0 + \frac{1}{2}mv^2_{max}$

(6,63 x 10^{-34})(7,8 x 10^{14}) ✓ = (6,63 x 10^{-34})(6,8 x 10^{14}) ✓ + $\frac{1}{2}mv^2_{max}$

½ mv^2_{max} = 6,63 x 10^{-20}J thus ½(9,11 x 10^{-31}) v^2_{max} ✓= 6,63 x 10^{-20} ∴ v_{max} = 3,82 x 10^5 m·s^{-1} ✓ (5)

[13]

QUESTION 10

10.1.1 (Line) emission (spectrum) ✓ (1)

10.1.2 (Line) absorption (spectrum) ✓ (1)

10.2.1 Emission ✓ (1)

10.2.2 Energy released in the transition from E_4 to E_2 = $E_4 – E_2$

$E_4 – E_2$ = (2,044 x 10^{-18} – 1,635 x 10^{-18}) ✓ = 4,09 x 10^{-19} J

E = hf ✓ ∴ 4,09 x 10^{-19} = (6,63 x 10^{-34})f ✓ ∴ f = 6,17 x 10^{14} Hz ✓ (4)

10.2.3 E = W_o + $E_{k(max)}$ **OR** hf = hf_o + $E_{k(max)}$ **OR** hf = hf_o + ½ mv^2 **OR** E = W_o + ½ mv^2 ✓

4,09 x 10^{-19} ✓ = (6,63 x 10^{-34})(4,4 x 10^{14}) ✓ + $E_{k(max)}$ ∴ $E_{k(max)}$ = 1,17 x 10^{-19} J ✓

OR

$E_{k(max)}$ = E_{light} – W_o } ✓ Any one

= hf_{light} – hf_o

= (6,63 x 10^{-34})(6,17 x10^{14}) ✓- (6,63 x 10^{-34})(4,4 x 10^{14}) ✓ = 1,17 x 10^{-19} J ✓ (4)

10.2.4 No ✓

The threshold frequency is greater than the frequency of the photon. ✓

OR: The frequency of the photon is less than the threshold frequency.

OR: Energy of the photon is less than the work function of the metal. (2)

[13]

QUESTION 11

11.1.1 Greater than ✓

Electrons are ejected from the metal plate. ✓ (2)

11.1.2 Increase in intensity implies that, for the same frequency, the number of photons per second increases (ammeter reading increases), ✓ but the energy of the photons stays the same. ✓ Therefore the statement is incorrect.

OR An increase in energy of photons only increases kinetic energy of the photoelectrons and not the number of photoelectrons, thus the ammeter reading will not change. (2)

11.1.3 Light has a particle nature. ✓ (1)

11.2.1 The minimum frequency needed for the emission of electrons from the surafce of a metal. ✓✓ (2)

11.2.2 $W_o = hf_o$ ✓

= (6,63 x 10^{-34})(5,73 x 10^{14}) ✓

= 3,8 x 10^{-19} J ✓ (3)

11.2.3 E = W_o + $E_{k(max)}$ **OR** hf = hf_o + $E_{k(max)}$ **OR** hf = hf_o + ½ mv^2 **OR** E = W_o + ½ mv^2 ✓

(6,63 x 10^{-34})f = 3,8 x 10^{-19} + [½(9,11 10^{-31})(4,19 x 10^5)^2] ✓

f = 9,94 x 10^{14} Hz ✓ (3)

[13]

QUESTION 12

12.1 The minimum energy needed to eject electrons ✓ from the surface of a certain metal. ✓ (2)

12.2 (Maximum) kinetic energy of the ejected electrons ✓ (1)

12.3 Wavelength/Frequency (of light) ✓ (1)

12.4 Silver✓

According to Photoelectric equation, hf = W_o + ½ mv^2

(For a given constant frequency), as the work function increases the kinetic energy decreases.✓

Silver has the smallest kinetic energy✓ and hence the highest work function. (3)

12.5 $hf = W_o + ½mv^2_{max/maks}$ **OR** $h\frac{c}{\lambda} = W_o + E_{k(max/maks)}$ ✓

$\frac{(6,63\times10^{-34})(3\times10^8)}{2\times10^{-8}}$ ✓ = $W_o + 9,58\times10^{-18}$ ✓

$9,945 \times 10^{-18} = W_o + 9,58 \times 10^{-18}$

∴ $W_o = 3,65 \times 10^{-19}$ J ✓ (4)

12.6 Remains the same ✓

Increasing intensity increases number of photons (per unit time), but frequency stays constant ✓ and energy of photon is the same. ✓ Therefore the kinetic energy does not change. (3)

[14]

QUESTION 13

13.1 The minimum energy needed to eject electrons ✓ from the surface of a certain metal. ✓ (2)

13.2 Potassium / K ✓

f_o for potassium is greater than f_o for caesium ✓

OR

Work function is directly proportional to threshold frequency ✓ (2)

13.3

OPTION 1

$c = f\lambda$ ✓ ∴ $3 \times 10^8 = f(5,5 \times 10^{-7})$ ✓ ∴ $f = 5,45 \times 10^{14}$ Hz ∴ $f_{uv} < f_{o\ of\ K(potassium)}$

∴Ammeter in circuit **B** will not show a reading ✓

OPTION 2

$E = \frac{hc}{\lambda} = \frac{(6,63\times10^{-34})(3\times10^8)}{5,5\times10^{-7}} = 3,6164 \times 10^{-19}$ J

$W_o = hf_o$ ✓ $= (6,63 \times 10^{-34})(5,55 \times 10^{14})$ ✓ $= 3,68 \times 10^{-19}$ J

$W_o > E$ or $hf_o > hf$ ∴The ammeter will not register a current ✓

OPTION 3

$c = f_o\lambda_o$ ✓

$3 \times 10^8 = (5,55 \times 10^{14})\lambda$ ✓

$\lambda_o = 5,41 \times 10^{-7}$ m

λ_o(threshold) < λ(incident) ∴ the ammeter will not register a current ✓ (3)

13.4

OPTION 1

$E = W_0 + E_{k(max)}$ ✓ **OR** $hf = hf_o + \frac{1}{2}mv^2_{max}$ **OR** $h\frac{c}{\lambda} = h\frac{c}{\lambda_0} + E_{K(max)}$ ✓

$\frac{(6,63\times10^{-34})(3\times10^8)}{5,5\times10^{-7}}$ ✓ = $(6,63 \times 10^{-34})(5,07 \times 10^{14}) + E_{k(max)}$ ✓

$E_K = 2,55 \times 10^{-20}$ J ✓✓ (Range: $2,52 \times 10^{-20} – 2,6 \times 10^{-20}$ J)

OPTION 2

$E = W_0 + E_{k(max)}$ **OR** $hf = hf_o + \frac{1}{2}mv^2_{max}$ **OR** $h\frac{c}{\lambda} = h\frac{c}{\lambda_0} + E_{K(max)}$ ✓

$(6,63 \times 10^{-34})(5,45 \times 10^{14})$ ✓✓ = $(6,63 \times 10^{-34})(5,07 \times 10^{14}) + E_{k(max)}$ ✓

$E_K = 2,52 \times 10^{-20}$ J ✓ (Range: $2,52 \times 10^{-20} – 2,6 \times 10^{-20}$ J) (5)

13.5 Remains the same ✓ (1)

[13]

QUESTION 14

14.1 The minimum frequency of light needed to eject electrons from a metal surface. ✓✓ (2)

14.2

OPTION 1/	**OPTION 2**
$E = h\frac{c}{\lambda}$ ✓ $= \frac{(6,63\times10^{-34})(3\times10^8)}{5\times10^{-7}}$ ✓ $= 3,98 \times 10^{-19}$ J✓	$c = f\lambda$ ✓Both $3 \times 10^8 = f(5 \times 10^{-7})$ $f = 6 \times 10^{14}$ Hz $E = hf$ $= (6,63 \times 10^{-34})(6 \times 10^{14})$ ✓ $= 3,98 \times 10^{-19}$ J✓

(3)

14.3

OPTION 1

Any one ✓:
- $E = W_0 + E_{kmax}$
- $hf = W_0 + \frac{1}{2}mv^2_{max}$
- $h\frac{c}{\lambda} = W_0 + E_{K(max/maks)}$
- $h\frac{c}{\lambda} = hf_0 + E_{K(max/maks)}$

$3,98 \times 10^{-19} = (6,63 \times 10^{-34})(5,55 \times 10^{14}) + E_{K(max)}$ ✓
$E_{K(max)} = 3,0 \times 10^{-20}$ J ✓
$E_{K(max} > 0$ ✓
(The electrons emitted from the metal plate have kinetic energy to move between the plates, hence the ammeter registers a reading.)

OPTION 2

$W_o = hf_o$ ✓ $= (6,63 \times 10^{-34})(5,55 \times 10^{14})$ ✓ $= 3,68 \times 10^{-19}$ J
$E_{photon} > W_o$ ✓
(The energy of the incident photon is greater than the work function of potassium. From the equation $hf = W_0 + E_{Kmax}$, the ejected photoelectrons will move between the plates, ✓ hence the ammeter registers a reading.) (4)

14.4 The increase in intensity increases the *number* of photons per second.✓
Since each photon releases one electron ✓ the number of ejected electrons per second increases.✓ (3)
[12]

QUESTION 15

15.1 The process whereby electrons are ejected from a metal surface ✓ when light of suitable frequency is incident/shines on the surface. ✓ (2)

15.2 $7,48 \times 10^{-19}$ (J) ✓
$E = W_0 + E_{kmax}$ $(= W_0 + ½mv^2_{max})$ ✓
When $E_k = 0$, $E = W_0$ ✓ (3)

15.3 Mass (of photo-electron) ✓ (1)

15.4

OPTION 1

Gradient = ½m ✓
$\frac{11,98 \times 10^{-19} - 7,48 \times 10^{-19}}{X - 0}$ ✓✓ $= ½(9,11 \times 10^{-31})$ ✓
X = 0,9868 ✓

OPTION 2

$E = W_0 + ½mv^2_{max}$ ✓
$11,98 \times 10^{-19}$ ✓ $= 7,48 \times 10^{-19}$✓ $+ ½(9,11 \times 10^{-31}) v^2$✓ [or $½(9,11 \times 10^{-31})X$]
$4,5 \times 10^{-19} = 4,56 \times 10^{-31}v^2$
$v^2 = 0,9868 \times 10^{12}$
X = 0,9868 ✓ (0,99) (5)

15.5.1 Remains the same ✓ (1)
15.5.2 Increases ✓ (1)
[13]

QUESTION 16

16.1 Photoelectric effect ✓ (1)
16.2 Work function (of potassium) ✓ (1)
16.3 Potassium ✓ It has the lowest work function / threshold frequency / highest threshold wavelength. ✓ (2)
16.4 The work function of a metal is the minimum energy that an electron (in the metal) needs ✓ to be emitted/ejected from the metal / surface. ✓ (2)

16.5.1

$W_o = hf_o$ ✓
$= (6,63 \times 10^{-34})(1,75 \times 10^{15})$ ✓
$= 1,160 \times 10^{-18}$ J ✓
OR/*OF*
$E = W_o + E_{k(max)}$ } ✓ Any one
$hf = W_o + E_{k(max)}$
$(6,63 \times 10^{-34})(1,75 \times 10^{15}) = W_o + 0$ ✓
$W_o = 1,160 \times 10^{-18}$ J ✓

(3)

16.5.2

$E = W_o + E_{k(max)}$ } ✓Any one/
$hf = hf_o + ½mv^2_{max}$
$(6,63 \times 10^{-34})f$ ✓ $= 1,160 \times 10^{-18} + ½(9,11 \times 10^{-31})(5,60 \times 10^5)^2$ ✓
$\therefore f = 1,97 \times 10^{15}$ Hz ✓

(4)
[13]

QUESTION 17

17.1 $11,6 \times 10^{-19}$ J ✓ (1)

17.2 As the wavelength of the incident radiation/light increases the maximum kinetic energy of the emitted electrons decreases. ✓✓ **OR**
As the wavelength of the incident radiation/light decreases the maximum kinetic energy of the emitted electrons increases. **OR**
The maximum kinetic energy is inversely proportional to the wavelength. **OR**
$E_k(\text{max})\ \alpha\ \frac{1}{\lambda}$

(2)

17.3 The work function of a metal/surface is the minimum energy needed to remove/release an electron from a (metal) surface. ✓✓ (2)

17.4

OPTION 1	**OPTION 2**
$W_o = hf_o$ ✓ *OR OF* $W_o = \frac{hc}{\lambda_o}$ $W_o = \frac{(6,63x10^{-34})(3x10^8)}{4,9x10^{-7}}$ ✓ ✓ $W_o = 4,06x10^{-19}\ J$ ✓	$E = W_o + E_{k(max)}$ ✓ *OR OF* $E = \frac{hc}{\lambda_o} + 0$ $W_o = \frac{(6,63x10^{-34})(3x10^8)}{4,9x10^{-7}}$ ✓ ✓ $W_o = 4,06x10^{-19}\ J$ ✓

OPTION 3
Any set of co-ordinates can also be used, for example if wavelength is equal to 4 x 10^{-7} m (refer to the table below 17.5 for the different answers):
$E = W_o + E_{k(max)}$ ✓
$\frac{hc}{\lambda} = W_o + E_{k(max)}$
$\frac{(6,63x10^{-34})(3x10^8)}{4x10^{-7}}$ ✓ $= W_o + 1,6x10^{19}$ ✓
$W_o = 3,3725x10^{-19}\ J$ ✓

(4)

17.5

$E = W_o + E_{k(max)}$ ✓
$\frac{hc}{\lambda} = W_o + E_{k(max)}$
$\frac{(6,63x10^{-34})(3x10^8)}{0,5x10^{-7}}$ ✓ $= 3,3725x10^{-19}$ ✓ $+ E_{k(max)}$
$E_{k(max)} = 3,641x10^{-18}\ J$ ✓

(4)

		Q17.4	Q17.5
λ	$E_{k(max)}$	W_o	$E_{k(max)}$
4,9 x 10^{-7}	0	4,06 x 10^{-19}	3,752 x 10^{-18}
0,75 x 10^{-7} – 0,8 x 10^{-7}	14,0 x 10^{-19}	1,252 x 10^{-18} – 1,086 x 10^{-18}	2,762 x 10^{-18}
1,5 x 10^{-7}	8,0 x 10^{-19}	5,26 x 10^{-19}	3,452 x 10^{-18}
2 x 10^{-7}	6,0 x 10^{-19} – 6,2 x 10^{-19}	3,745 x 10^{-19} – 3,95 x 10^{-19}	3,6035 x 10^{-18} – 3,945 x 10^{-18}
3 x 10^{-7}	3,6 x 10^{-19}	3,03 x 10^{-19}	3,675 x 10^{-18}
4 x 10^{-7}	1,6 x 10^{-19}	3,3725 x 10^{-19}	3,64075 x 10^{-18}

[13]

QUESTION 18

18.1 The minimum frequency of light needed to eject electrons from a metal / surface. ✓✓ (2)

18.2 Greater than ✓ (2)

18.3

$E = W_o + E_{k(max)}$ ✓

$hf = hf_o + E_{k(max)}$

$(6,63x10^{-34})f_x$ ✓ $= (6,63x10^{-34})(10,4x10^{14})$ ✓ $+ 23,01x10^{-19})$ ✓

$f_x = 4,51x10^{15}\ Hz$ ✓

(5)

18.4.1 No effect ✓ (1)

18.4.2 Increases ✓ (1)

18.4.2 No effect ✓ (1)

[12]

QUESTION 19

19.1.1 The process whereby electrons are ejected from a (metal) surface when light of suitable frequency is incident on that surface. ✓✓ (2)

19.1.2

For one photon:

$E = hf$ ✓

$= (6,63x10^{-34})(1,2x10^{15})$ ✓

$= 7,956x10^{-19}\ J$

$Number\ of\ electrons = \frac{total\ energy\ of\ photons}{energy\ of\ one\ photon}$

$= \frac{1,75x10^{-9}}{7,956x10^{-19}}$ ✓

$= 2,20x10^{9}$ ✓

(4)

19.1.3

$E = W_o + K_{max}$ ✓

$hf = hf_o + \frac{1}{2}mv^2_{max}$

$7,96x10^{-19}$ ✓ $= (6,63x10^{-34})(9,09x10^{14})$ ✓ $+ \frac{1}{2}(9,11x10^{-31})v^2_{max}$ ✓

$v_{max} = 6,51x10^{5}\ m \cdot s^{-1}$ ✓

(5)

19.2 An atom (electron) in a higher (excited) energy state/level returns to a lower energy state/level. ✓ Energy is released as light (photons/frequencies of light are released). ✓ (2)

[13]

QUESTION 20

20.1 Light has a particle nature/is quantized. ✓ (1)

20.2 The minimum energy (of incident photons) that can eject electrons from a metal/surface. ✓✓ (2)

20.3

$E = W_o + E_{k(max)}$ ✓

$hf = W_o + E_{k(max)}$

$(6,63x10^{-34})(5,96x10^{14})$ ✓ $= 3,42x10^{-19} + E_{k(max)}$ ✓

$E_{k(max)} = 5,31x10^{-20}\ J$ ✓

(4)

20.4

$I = \frac{Q}{\Delta t}$

$0{,}012 = \frac{Q}{10}$ ✓

$Q = 0{,}12\ C$

$n = \frac{Q}{e}$

$= \frac{0{,}12 ✓}{1{,}6x10^{-19} ✓}$

$= 7{,}5x10^{17}$

$Number\ of\ photons = 7{,}5x10^{17}$ ✓ (4)

20.5 Increases ✓
More photons strike the surface of the metal per unit time/ at a higher rate. ✓
More (photo) electrons ejected per unit time ✓(resulting in increased current). (3)
[14]

QUESTION 21

21.1 6,63 x 10^{-34} (1)

21.2 The minimum energy needed to eject an electron from a (metal) surface. ✓✓ (2)

21.3.1

$W_o = hf_o$ ✓

$= (6{,}63x10^{-34})(5x10^{14})$ ✓

$= 3{,}32x10^{-19}\ J$ ✓ (3)

21.3.2

$E = W_o + E_{k(max)}$ ✓

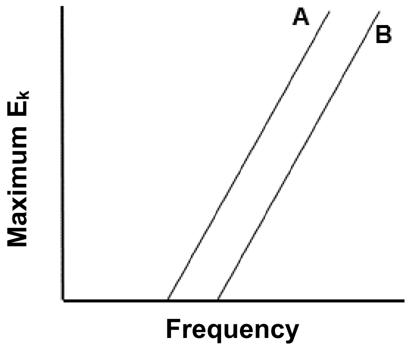
$(6{,}63x10^{-34})(12{,}54x10^{14})$✓ $= 3{,}32x10^{-19} + E_{k(\max)}$✓

$E_{k(max)} = 4{,}99x10^{-19}\ J = X$ ✓ (4)

21.4.1 No effect ✓ (1)

21.4.2 Increases ✓ (1)

21.5



Marking criteria
Graph **B** to the right of graph **A** ✓
Lines are parallel. ✓

(2)
[14]

QUESTION 22

22.1.1 The minimum energy (of incident photons) that can eject electrons from a metal/surface. ✓✓ (2)

22.1.2

OPTION 1

$E = hf$ ✓

$= (6{,}63x10^{-34})(2{,}8x10^{16})$ ✓

$= 1{,}86x10^{-17}\ J$ ✓

E > W_o ✓

OPTION 2

$W_o = hf_o$ ✓

$6{,}63x10^{-19} = (6{,}63x10^{-34})f_o$ ✓

$f_o = 1x10^{15}\ Hz$ ✓

f > f_o ✓

OPTION 3

$E = W_o + E_{k(\max)}$ ✓

$hf = W_o + E_{k(\max)}$

$(6{,}63x10^{-34})(2{,}8x10^{16}) = 6{,}63x10^{-19} + E_{k(\max)}$ ✓

$E_{k(\max)} = 1{,}79x10^{-17}\ J$ ✓

$E_{k(\max)} > 0$ ✓ (4)

22.1.3

$F = \frac{kQ_AQ_B}{r^2}$ ✓

$0{,}027$ ✓ $= \frac{(9x10^9)(5{,}4x10^{-6})Q_B}{0{,}1^2}$ ✓

$Q_B = 5{,}56x10^{-9}\ C$

$n = \frac{Q_B}{e}$ ✓

$= \frac{5{,}56x10^{-9}}{1{,}6x10^{-19}}$ ✓

$= 3{,}47x10^{10}$

Number of electrons $= 3{,}47 \text{ x } 10^{10}$ ✓

(6)

22.2.1 (Line) Absorption ✓ (1)

22.2.2 Continuous spectrum of white light/rainbow of colours ✓ with dark/black lines ✓ (replacing specific frequencies). (2)

22.2.3 Diagram B ✓✓ (2)

[17]

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