Gr 12

2025

PHYSICAL SCIENCE

PHYSICS REVISION BOOK

ANSWERS

Secondary Schools Directorate

education
Department of Education
FREE STATE PROVINCE

In this answer book, only the most obvious solutions are given. The original marking guidelines provide all the solutions for each question that were accepted. It would be good if you also worked through those solutions to improve your understanding.

TABLE OF CONTENTS

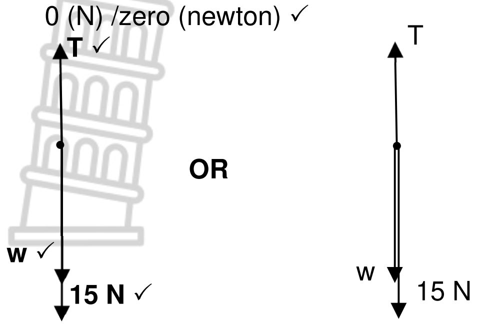
NEWTON'S LAWS

QUESTION 1

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

1.2 0 (N) /zero (newton) ✓ (1)

1.3



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)

1.4 **<u>2 kg block</u>**

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

<u>10 kg block</u>

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

1.5 Smaller than ✓ (1)

1.6 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)

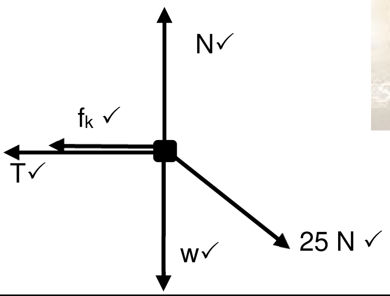
[16]

QUESTION 2

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

2.2 $f_k = \mu_k N$ ✓= $\mu_k mg$ = $(0,15)(3)(9,8)$ ✓ = 4,41 N✓ (3)

2.3



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)

2.4.1

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

(3)

2.4.2 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)

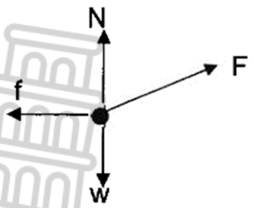
✓either one

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

[18]

QUESTION 3

3.1.1



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_{normal}/F_N/$F_{normaal}$/$F_{reaction/reaksie}$	✓
F	F_A/$F_{applied/toegepas}$	✓

(4)

3.1.2 $f_k = \mu_k N$ ✓
$3 = (0,2)N$ ✓
$N = 15$ N ✓ (3)

3.1.3
$F_{net} = ma$
$N + F_{vert} - w = 0$
$N + F_{vert} = w$
} ✓ Any one

$\underline{F\sin 20^\circ}$ ✓ $= \underline{(2)(9,8) - 15}$ ✓
F = 13.45 N✓ (4)

3.1.4
$F_{net} = ma$
$F\cos 20^\circ - f = ma$
} ✓ Any one

$\underline{13.45\cos 20^\circ - 3 = 2a}$✓
$a = 4,82$ m.s^{-2} ✓ (3)

3.2.1 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)

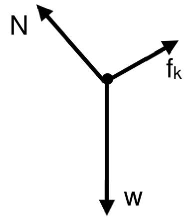
3.2.2 Increases ✓
Gravitational force is inverely proportional to the square of the distance between the centres of the objects. ✓ OR $F \alpha \frac{1}{r^2}$ (2)

[18]

QUESTION 4

4.1 0 N/zero ✓ (1)

4.2



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)

4.3.1
$F_{net} = ma$
$\underline{f_k - mg\sin\theta} = 0$
$\underline{f_k = mg\sin\theta}$
} ✓ 1 mark for any of these

$\underline{f_k} = \underline{(2)(9,8)\sin 7^\circ}$ ✓ ∴ $f_k = 2,39$ N ✓ (2,389) N (3)

4.3.2 $f_k = \mu_k N$
$= \mu_k mg\cos 7^\circ$
} ✓ any one

$2,389 = \underline{\mu_k(2)(9,8)\cos 7^\circ}$ ✓ ∴ $\mu_k = 0,12$ ✓ (3)

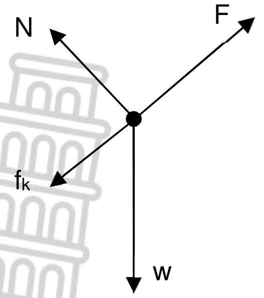
4.3.3 $F_{net} = ma$ OR $- f_k = ma$ OR $\mu_k N = ma$ ✓
$- \mu_k(mg) = ma$
$\underline{- (0,12)(2)(9,8)}$ ✓$\underline{= 2a}$ ✓ ∴ $a = -1,176$ m.s^{-2} (-1,18)
$v_f^2 = v_i^2 + 2a\Delta x$
$\underline{0 = (1,5)^2 + 2(-1,176)\Delta x}$✓ ∴$\Delta x = 0,96$ m ∴ Distance = 0,96 m✓ (5)

[15]

QUESTION 5

5.1.1 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)

5.1.2



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)

5.1.3
$F_{net} = ma$
$F_{net} = 0$
$F+(-f_k) + (-F_{g\parallel}) = ma$
$F- (f_k + F_{g\parallel}) = ma$
} ✓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)

5.1.4

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

(4)

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

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

(4)

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

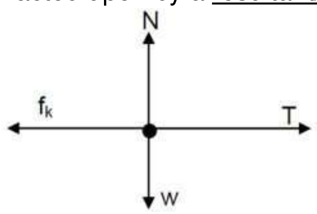
OPTION 1	OPTION 2
$g=\frac{GM}{r^2}$ ✓ ✓ $6=\frac{(6{,}67\times10^{-11})M}{(700\times10^3)^2}$ ✓ M = 4,41 x 10^{22} kg ✓	$F=G\frac{m_1m_2}{r^2}$ $mg=\frac{GmM}{r^2}$ } ✓Any one $(200)(6)$✓$=\frac{(6{,}67\times10^{-11})(200)M}{(700\times10^3)^2}$✓ ∴ M = 4,41 x 10^{22} kg ✓

(4)
[21]

QUESTION 6

6.1 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)

6.2



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)

6.3

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)

6.4 3 s ✓ (1)

6.5 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 7

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

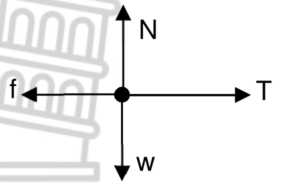
7.2 $\Delta y = v_i\Delta t + ½ a\Delta t^2$✓

<u>0,5 = (0)(3) + ½ (a)(3²)</u> ✓ ∴ a = 0,11 m·s⁻² ✓ (3)

7.3 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)

7.4



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)

7.5

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

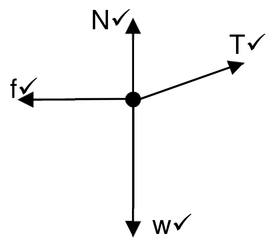
(3)

[15]

QUESTION 8

8.1 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)

8.2



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)

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

8.3.2 <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)

8.3.3 F_{net} = ma

Tcos15° - f = ma
T_x = Tcos15° } ✓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)

8.4 <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)

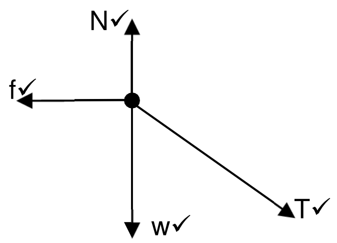
8.5 Yes ✓

The frictional force (coefficient of friction) depends on the nature of the surfaces in contact. ✓ (2)

[17]

QUESTION 9

9.1.1



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)

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

9.1.3

$F_{net} = ma$ $F_{net} = 0$ $F_x = f$ $F_x - f = 0$ $F\cos 40° - f = 0$ (✓ 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)

	OPTION 1	OPTION 2
9.1.4	$v_f = v_i + a\Delta t$ $2 = 0$ ✓ $+ a(3)$ ✓ $a = 0{,}67\ m{\cdot}s^{-2}$ $F_{net} = ma$ ✓ $F\cos40°$ ✓ $- 68{,}94$ ✓ $= 15\ (0{,}67)$ $F = 103{,}11$ N ✓ (103,05 N – 103,11N)	$F_{net}.\Delta t = \Delta p$ ✓ $F\cos 40°$ ✓ $- (68{,}94)$ ✓ (3) ✓ $= 15(2 - 0)$ ✓ $F = 103{,}11$ N ✓

(6)

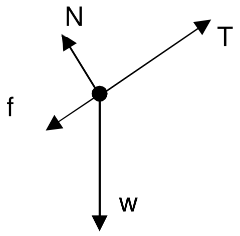
	OPTION 1	OPTION 2
9.2	$F = G\frac{m_1 m_2}{r^2}$ ✓ 20 ✓ $= (6{,}67 \times 10^{-11})\frac{m_{planet}(10)}{(6\times10^5)^2}$ ✓ $m_{planet} = 1{,}08 \times 10^{22}$ kg ✓	$w = mg$ $20 = (10)(g)$ ✓ $g = 2\ m{\cdot}s^{-2}$ $g = \frac{GM}{R^2}$ (✓ Any one) $2 = \frac{(6{,}67\times10^{-11})M}{(6\times10^5)^2}$ ✓ $M = 1{,}08 \times 10^{22}$ kg ✓

(4)
[18]

QUESTION 10

10.1 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)

10.2



	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/$F_{Earth\ on\ block}$/19,6 N/gravitational force
T ✓	Tension/F_T /F_A/F

(4)

10.3 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:

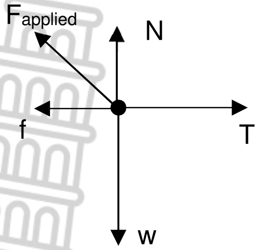
$F_x + (-T) + (-w_{II}) = ma$
$F_x - (T + w_{II}) = ma$
$[40 \cos 25°$ ✓ $- T - (3)(9{,}8)\sin30°$ ✓$]$ ✓ $= 3a$
$36{,}25 - T - 14{,}7 = 3a$
$21{,}55 - T = 3a$ ………….(2)
$9{,}25 = 5a$ $\quad\therefore a = 1{,}85\ m{\cdot}s^{-2}$ ✓ (8)

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

QUESTION 11

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

11.2



(5)

11.3

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)

11.4.1 Decreases ✓ (1)

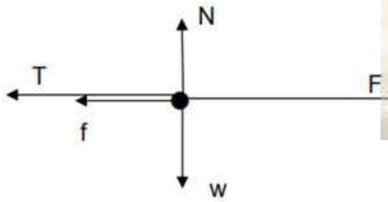
11.4.2 Velocity decreases ✓
Accelerates/Net force to left ✓✓
OR
As the tension decreases, the net force/acceleration acts in the opposite direction of motion /to the left. ✓✓ (3)

[16]

QUESTION 12

12.1 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)

12.2



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)

12.3

<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)

12.4.1

<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)

12.4.2

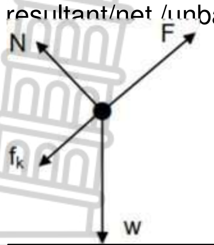
$T - 2(9{,}8) = 2a$		$40 - T = 8a$
$T - 19{,}6 = 2(2{,}04)$ ✓	**OR**	$T = 40 - 8(2{,}04)$ ✓
$T = 23{,}68$ N ✓		$T = 23{,}68$ N ✓

(2)
[17]

QUESTION 13

13.1 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)

13.2



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)

13.3

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} = ΔEk ✓
FΔxcos0° + fΔxcos180° + wΔxcos120° ✓= 0 ✓
FΔx = 18Δx + (20)(9,8)Δx(0,5)
F = 116 N ✓

(4)

13.4 116 N / f + w|| ✓ Down the incline/opposite to direction of motion. ✓ (2)

13.5

Up the incline positive
F_{net} = ma
-116 = 20a ✓
a = -5,80 m·s^{-2}

$v_f^2 = v_i^2 + 2a\Delta x$ ✓
0 =(2)2 + (2)(-5,8)Δx ✓
Δx = 0,34 m ✓

OR

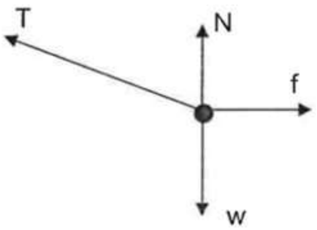
W_{net} = ΔE_K ✓ **OR**
F_{net}Δxcosθ = ½m(v_f^2 - v_i^2)
(116)Δxcos180° ✓= ½(20)(02 – 22) ✓
Δx = 0,34 m ✓

(4)
[16]

QUESTION 14

14.1 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)

14.2



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)

14.3

OPTION 1
F_{net} = ma ✓
Tcos50° - F_f = ma
Tcos50° - 300 ✓ = 0 ✓
T = 466,72 N ✓

OPTION 2
W_{net} = ΔK ✓
TΔxcos0° +fΔxcos180° = 0 ✓
Tcos50° - 300 ✓ = 0
T = 466,72 N ✓

(4)

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

14.5

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

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

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

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

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

$\Delta t = 0,1\ s$

$F_{net}\Delta t = \Delta p$ ✓

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

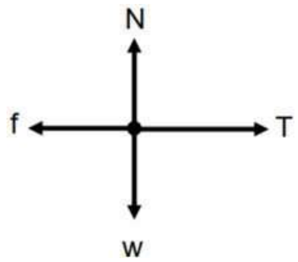
$F_{up} = 679,20\ N$ ✓

(5)
[17]

QUESTION 15

15.1 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)

15.2



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)

15.3.1

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)

15.3.2

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 16

16.1

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

$v_f^2 = v_i^2 + 2a\Delta y$ ✓

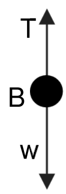
$(-3,41)^2$ ✓ $= 0^2 + 2a(-1,5)$ ✓

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

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

(3)

16.2



	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)

16.3 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)

16.4

$F_{net} = ma$ ✓	$F_{net} = ma$
$m_Bg - T = m_Ba$	$T - mg = ma$
$(7{,}5)(9{,}8) - T$ ✓ $= (7{,}5)(3{,}88)$ ✓	$44{,}4 - 9{,}8m = 3{,}88m$ ✓
$T = 44{,}4\ N$	$m = 3{,}25\ kg$ ✓

(5)

16.5

OPTION 1

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

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

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

OPTION 2

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

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

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

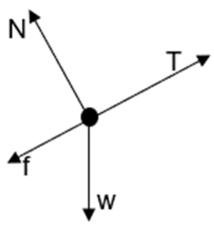
$Maximum\ height = 0{,}59 + 1{,}5$ ✓
$= 2{,}09\ m$ ✓

(5)
[17]

QUESTION 17

17.1 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)

17.2



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)

17.3.1

For block A

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)

17.3.2

For block B

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)

17.4.1 Increase ✓ (1)

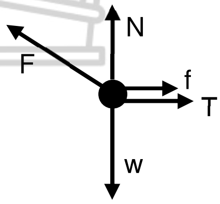
17.4.2 As θ decreases, the normal force increases. ✓
The frictional force is directly proportional to the normal force. ✓ **OR** f α N / f = μN (2)

[16]

QUESTION 18

18.1 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)

18.2



Accepted labels	
w	Fg/40,18 N/mg/weight/gravitational force
T	F_T/tension/F_{string}
f	(kinetic) friction/f_k
N	F_N /Normal/F_{normal}
F	F_{app}/49 N/F_a/F_A

(5)

18.3.1

$F_{net} = 0$
$F sin50° + N + w = 0$
$49 sin50° + N + (4,1)(-9,8) = 0$ ✓
$N = 2,644\ N$

$f_k = \mu N$ ✓
$= (0,35(2,644)$
$= 0,93\ N$ ✓

(3)

18.3.2

For A: Left as positive.
$F_{net} = ma$ ✓
$49 cos50° - T - 0,93$ ✓ $= 4,1a$ ...(1)

For B: Up as positive.
$F_{net} = ma$
$T - (2,3)(9,8)$ ✓ $= 2,3a$ ... (2)

✓

Solve for (1) and (2):
$30,57 - 22,54 = 6,4a$
$a = 1,25\ m \cdot s^{-2}$ ✓

Range: 1,25 m·s^{-2} ~ 1,26 m·s^{-2}

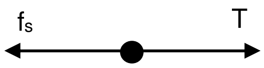
(5)

[15]

QUESTION 19

19.1 The force that opposes the tendency of motion of a stationary object relative/parallel to a surface. ✓✓ (2)

19.2



Acceptable labels
f_s: static friction /f/F_f
T: F_T/F_{string}/tension

(2)

19.3.1

For hanging mass
$F_{net} = ma$
$mg - T = 0$
$T = (4,2)(9,8)$ ✓
$= 41,16\ N$

For crate
$F_{net} = ma$ ✓
$T - f_s^{max} = ma = 0$
$T = f_s^{max} = \mu_s N$
$41,16 = \mu_s (8,5)(9,8)$ ✓
$\mu_s = 0,49$ ✓

(4)

19.3.2

For hanging mass
$F_{net} = ma$
$mg - T = ma$
$(7,4)(9,8) - T$ ✓ $= 7,4a$ ...(1)

For crate
$F_{net} = ma$
$T - f_k = ma$
$T - \mu_k N = ma$
$T - (0,4)(8,5)(9,8)$✓ $= 8,5a$ ...(2)

✓

Solve for (1) and (2)
$72,52 - 33,32 = 15,9a$ ✓
$a = 2,47\ m \cdot s^{-2}$ ✓ $(Value\ of\ Y)$

(5)

19.4 INCREASES ✓; $f_s^{max}\ \alpha\ N$ **OR** $f_s^{max}\ \alpha\ m$ **OR** $f_s^{max}\ \alpha\ \mu_s N$ **OR** The normal force acting on the crate increases. **OR** Increase in mass/weight of crate increases the normal force. ✓ (2)

[15]

VERTICAL MOTION

QUESTION 1

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

1.2

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)

1.3 **Upward positive**

$\Delta y = v_i\Delta t + \frac{1}{2} a\Delta t^2$
$\Delta y_{last} = \Delta y_{(6,12)} - \Delta y_{(5,12)}$ } ✓

$= \{30(6,12) + \frac{1}{2}(-9,8)(6,12)^2\}$ ✓ $- \{30(5,12) + \frac{1}{2}(-9,8)(5,12)^2\}$ ✓

$= -25,076$

Distance = $|\Delta y|$ = 25,08 m ✓

Downward positive

$\Delta y = v_i\Delta t + \frac{1}{2} a\Delta t^2$
$\Delta y_{last} = \Delta y_{(6,12)} - \Delta y_{(5,12)}$ } ✓

$= \{-30(6,12) + \frac{1}{2}(9,8)(6,12)^2\}$ ✓ $- \{-30(5,12) + \frac{1}{2}(9,8)(5,12)^2\}$ ✓

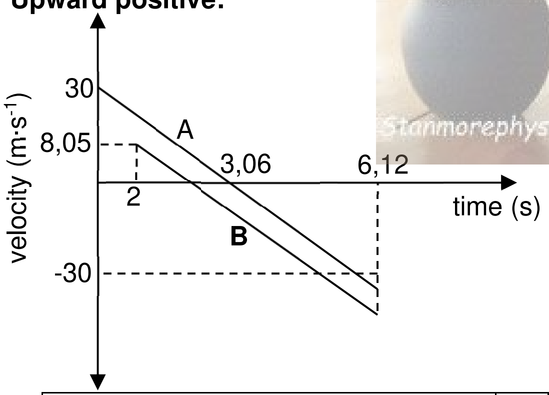
$= 25,076$

Distance = $|\Delta y|$ = 25,08 m ✓ (4)

1.4

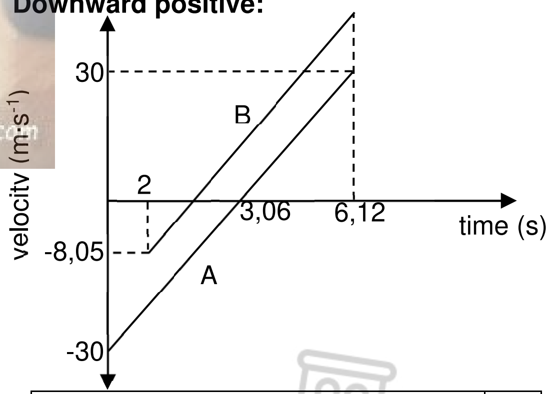
Upward positive	**Downward positive**
$\Delta y = v_i\Delta t + \frac{1}{2} a\Delta t^2$ ✓ -50✓ $= [v_i(4,12)] + [\frac{1}{2}(-9,8)(4,12)^2]$ ✓ $v_i = 8,05\ m\cdot s^{-1}$ speed = $8,05\ m\cdot s^{-1}$ ✓	$\Delta y = v_i\Delta t + \frac{1}{2} a\Delta t^2$ ✓ 50✓ $= v_i(4,12) + [\frac{1}{2}(9,8)(4,12)^2]$ ✓ $v_i = -8,05\ m\cdot s^{-1}$ speed = $8,05\ m\cdot s^{-1}$ ✓

1.5 **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 2

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

2.2

OPTION 1: Upwards positive $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $= 0^2 + (2)(-9,8)$ ✓ (-20) ✓ $v_f = 19,80\ m\cdot s^{-1}$ ✓	**OPTION 1: Downwards positive** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $= 0^2 + (2)(9,8)$ ✓ (20) ✓ $v_f = 19,80\ m\cdot s^{-1}$ ✓
OPTION 2: Upwards positive $\Delta y = v_i\Delta t + ½ a\Delta t^2$ $-20 = 0 + ½ (-9,8) \Delta t^2$✓ ✓either one $\Delta t = 2,02$ s $v_f = v_i + a\Delta t$ $= 0 + (-9,8)(2,02)$ ✓ $= -19,80\ m\cdot s^{-1}$ ∴ $v_f = 19,80\ m\cdot s^{-1}$ ✓	**OPTION 2: Downwards positive** $\Delta y = v_i\Delta t + ½ a\Delta t^2$ $20 = 0 + ½ (9,8) \Delta t^2$✓ ✓either one $\Delta t = 2,02$ s $v_f = v_i + a\Delta t$ $= 0 + (9,8)(2,02)$ ✓ $= 19,80\ m\cdot s^{-1}$ ✓

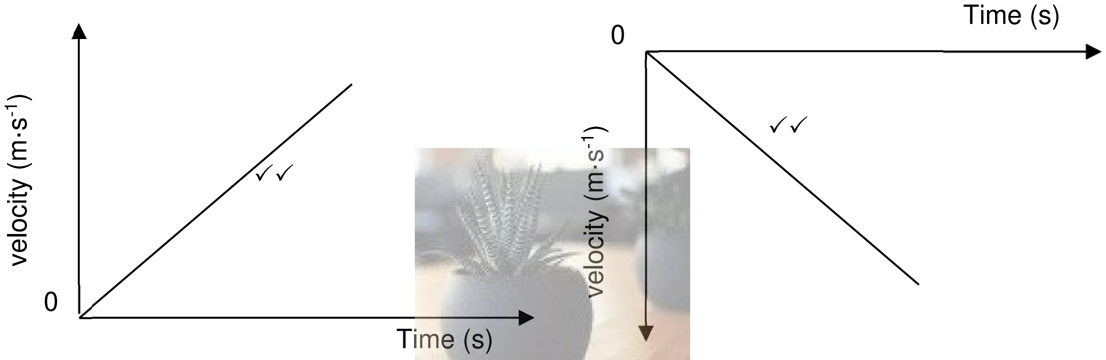
(4)

2.3

OPTION 1: Upwards positive $v_f = v_i + a\Delta t$ ✓ $-19,80 = 0 + (-9,8)\Delta t$ ✓ ∴ $\Delta t = 2,02$ s ✓	**OPTION 1: Downwards positive** $v_f = v_i + a\Delta t$ ✓ $19,80 = 0 + (9,8)\Delta t$ ✓ ∴ $\Delta t = 2,02$ s ✓
OPTION 2: Upwards positive: $\Delta y = v_i\Delta t + ½ a\Delta t^2$✓ $-20 = 0 + ½ (-9,8) \Delta t^2$✓ ∴ $\Delta t = 2,02$ s ✓	**OPTION 2: Downwards positive:** $\Delta y = v_i\Delta t + ½ a\Delta t^2$✓ $20 = 0 + ½ (9,8) \Delta t^2$✓ ∴ $\Delta t = 2,02$ s ✓

(3)

2.4 **Downward positive** **Upward positive**



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

(2)
[11]

QUESTION 3

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

3.2.1

OPTION 1 **Upwards as positive** $\Delta y = v_i\Delta t + ½a\Delta t^2$✓ $= (10)(3) + ½(-9,8)(3^2)$ ✓ $= -14,10$ Height of building = 14,10 m ✓	**Downwards as positive** $\Delta y = v_i\Delta t + ½ a\Delta t^2$✓ $= (-10)(3) + ½ (9,8)(3^2)$ ✓ $= 14,10$ Height of building = 14,10 m ✓
OPTION 2 **Upward as positive** For maximum height: $v_f = v_i + a\Delta t$ $0 = 10 + (-9,8)\Delta t$ ∴ $\Delta t = 1,02$ s Time taken from point A to ground: $3 - 2(1,02) = 0,96$ s $\Delta y = v_i\Delta t + ½ a\Delta t^2$✓ $= (-10)(0,96) + ½ (-9,8)(0,96)^2$✓ $= -14,1184$ ∴ Height = 14,12 m ✓	**Downwards as positive** For maximum height: $v_f = v_i + a\Delta t$ $0 = -10 + (9,8)\Delta t$ ∴ $\Delta t = 1,02$ s Time taken from point A to ground: $3 - 2(1,02) = 0,96$ s $\Delta y = v_i\Delta t + ½ a\Delta t^2$✓ $= (10)(0,96) + ½ (9,8)(0,96)^2$ ✓ $= 14,1184$ ∴ Height = 14,12 m ✓

(3)

3.2.2

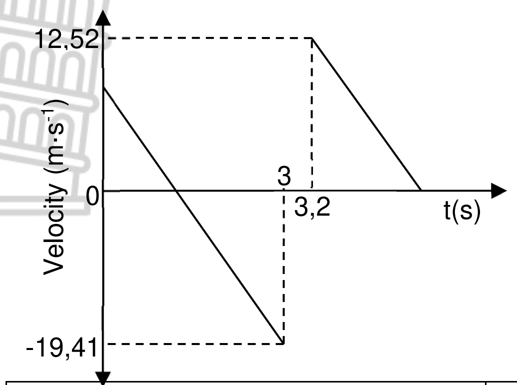
Upwards as positive: $v_f = v_i + a\Delta t$ ✓ $= (10) + (-9,8)(3)$ ✓ $= -19,41$ Speed = $19,41\ m\cdot s^{-1}$ ✓	**Downwards as positive:** $v_f = v_i + a\Delta t$ ✓ $= (-10) + (9,8)(3)$ ✓ $= 19,41$ Speed = $19,41\ m\cdot s^{-1}$ ✓

3.2.3

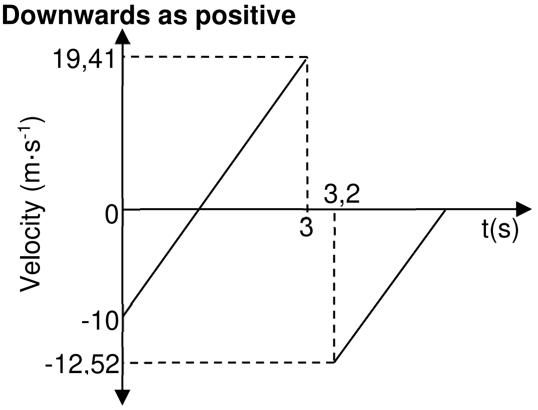
Upwards as positive:	Downwards as positive:
$v_f^2 = v_i^2 + 2a\Delta y$ ✓ $0 = v_i^2 + (2)(-9,8)(8)$ ✓ ∴ v_i = 12,52 m·s⁻¹ Speed = 12,52 m·s⁻¹ ✓	$v_f^2 = v_i^2 + 2a\Delta y$ ✓ $0 = v_i^2 + (2)(9,8)(-8)$ ∴ v_i = -12,52 Speed = 12,52 m·s⁻¹ ✓

(3)

3.3 **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 4

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

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

4.3

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

(4)

4.4

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

(6)
[14]

QUESTION 5

5.1

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

(3)

5.2

OPTION 1

Upwards positive:
$v_f = v_i + a\Delta t$ ✓ ∴ -3v = -v ✓ + (-9,8)(1,22) ✓
v = 5,98 m·s⁻¹ ✓ (5,978 to 6,03 m·s⁻¹)

Downwards positive:
$v_f = v_i + a\Delta t$ ✓ ∴ 3v = v ✓ + (9,8)(1,22) ✓
v = 5,98 m·s⁻¹ ✓ (5,978 to 6,03 m·s⁻¹)

OPTION 2

Upwards 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 ✓

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)

5.3

OPTION 1

Upwards positive:
$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓
= (-5,98)(2,44) + ½(-9,8)(2,44)²✓ = - 43,764
∴h = 43,76 m✓ (43,764 to 44,08 m)

Downwards positive:
$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓
= (5,98)(2,44) + ½(9,8)(2,44)² ✓ = 43,764
∴h = 43,76 m✓(43,764 to 44,08)

OPTION 2

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

Downwards positive:
$v_f = v_i + a\Delta t$
v_f = 5,98 + 9,8(2,44) = 29,892 m·s⁻¹
$v_f^2 = v_i^2 + 2a\Delta y$ ✓
(29,892)² = (5,98)² + 2(9,8)Δy ✓
Δy = 43,76 m
∴ h = 43,76 m✓(43,764 to 44,08)

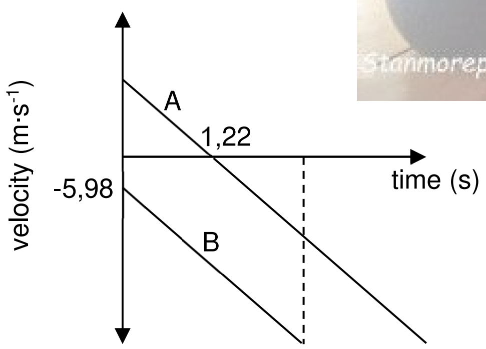
OPTION 3

Upwards positive:
For A: $v_f = v_i + a\Delta t$
-12 = 12 + (-9,8)Δt ∴ Δt = 2,45 s
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 ✓
= - 44,06 m ∴h = 44,06 m ✓

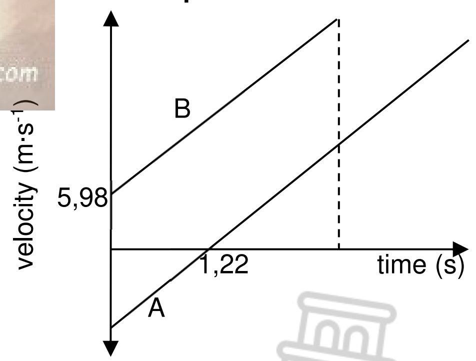
Downwards positive:
For A: $v_f = v_i + a\Delta t$ ∴ 12 = -12 + (9,8)Δt
∴ Δt = 2,45 s
For B: $\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓
= (5,98)(2,45) + ½ (9,8)(2,45)² ✓
= 44,06 m ∴ h = 44,06 m ✓

(3)

5.4 **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 6

6.1 10 m·s⁻¹ ✓ (1)

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

6.3

OPTION 1 $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= (10)(2) + \frac{1}{2}(9,8)(2^2)$ ✓ $= 39,6$ m Height/*Hoogte*= 39,6 m ✓	$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= (-10)(2) + \frac{1}{2}(-9,8)(2^2)$ ✓ $= -39,6$ m Height/*Hoogte* = 39,6 m ✓
OPTION 2/*OPSIE 2* $\Delta x = \frac{(v_i + v_f)}{2}\Delta t$ ✓ $\Delta x = \left(\frac{10 + 29,6}{2}\right)(2)$ ✓ $\Delta x = 39,6\ m$ ✓	**OPTION 3/*OPSIE 3*** $v_f^2 = v_i^2 + 2a\Delta x$ ✓ $(29,6)^2 = (10)^2 + 2(9,8)a\Delta x$ ✓ $\Delta x = 39,6\ m$ ✓

(3)

6.4

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

(4)

6.5.1 0,2 s ✓ (1)

6.5.2 4,955 s ✓✓ (2)

6.5.3 - 27 $m\cdot s^{-1}$ ✓ (1)

6.6 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 7

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

7.2

OPTION 1 **UPWARDS AS POSITIVE** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= \underline{(0)(1) + \frac{1}{2}(-9,8)(1^2)}$ ✓ $= -4,9$ m Height = $2\Delta y = (2)(4,9)$ = 9,8 m ✓	**DOWNWARDS AS POSITIVE** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= \underline{(0)(1) + \frac{1}{2}(9,8)(1^2)}$ ✓ $= 4,9$ m Height = $2\Delta y = (2)(4,9)$ = 9,8 m ✓
OPTION 2 **UPWARD POSITIVE** $v_f = v_i + a\Delta t = 0 + (-9,8)(1) = -9,8\ m\cdot s^{-1}$ $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $\underline{(-9,8)^2 = 0 + (2)(-9,8)\Delta y}$ ✓ $\Delta y = -4,9$ m Height/*hoogte* = $2\Delta y = (2)(4,9)$ = 9,8 m ✓	**DOWNWARD POSITIVE** $v_f = v_i + a\Delta t = 0 + (9,8)(1) = 9,8\ m\cdot s^{-1}$ $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $\underline{(9,8)^2 = 0 + (2)(9,8)\Delta y}$ ✓ $\Delta y = 4,9$ m Height/*hoogte* = $2\Delta y = (2)(4,9)$ = 9,8 m ✓

(3)

7.3

UPWARDS AS POSITIVE $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $= \underline{0 + (2)(-9,8)(-9,8)}$ ✓ $v_f = 13,86\ m\cdot s^{-1}$ ✓	**DOWNWARDS AS POSITIVE** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $= \underline{0 + (2)(9,8)(9,8)}$ ✓ $v_f = 13,86\ m\cdot s^{-1}$ ✓
OR **FROM POINT B** **UPWARDS AS POSITIVE** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $= \underline{(-9,8)^2 + (2)(-9,8)(-4,9)}$ ✓ $v_f = -13,86\ m\cdot s^{-1}$ Magnitude = $13,86 m\cdot s^{-1}$ ✓	**OR** **FROM POINT B** **DOWNWARDS AS POSITIVE** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $= \underline{(9,8)^2 + (2)(9,8)(4,9)}$ ✓ $v_f = 13,86\ m\cdot s^{-1}$ ✓

(3)

7.4

UPWARDS AS POSITIVE $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $0 = v_i^2 \underline{+ (2)(-9,8)(4,9)}$ ✓ ∴ $v_i = 9,8\ m\cdot s^{-1}$ $F_{net}\Delta t = m\Delta v$ $F_{net}\Delta t = m(v_f - v_i)$ } ✓ 1 mark for any $\underline{F_{net}(0,2)}$ ✓ = $\underline{0,4[9,8 - (-13,86)]}$ ✓ $F_{net} = 47,32$ N ✓	**DOWNWARDS AS POSITIVE** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $0 = v_i^2 \underline{+ (2)(9,8)(-4,9)}$ ✓ ∴ $v_i = -9,8\ m\cdot s^{-1}$ $F_{net}\Delta t = m\Delta v$ $F_{net}\Delta t = m(v_f - v_i)$ } ✓ 1 mark for any $\underline{F_{net}(0,2)}$ ✓ = $\underline{0,4[-9,8 - (13,86)]}$ ✓ $F_{net} = -47,32$ N ∴ $F_{net} = 47,32$ N ✓

(6)

[14]

QUESTION 8

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

8.2

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** $F_{net}\Delta t = m(v_f - v_i)$ ✓ $mg\Delta t = m(v_f - v_i)$ $(-9,8)\Delta t = 0 - 7,5$ ✓ ∴ $\Delta t = 0,76531$ s (0,77 s) ✓	**Downward positive** $F_{net}\Delta t = m(v_f - v_i)$ ✓ $mg\Delta t = m(v_f - v_i)$ $(9,8)\Delta t = 0 -(- 7,5)$ ✓ ∴ $\Delta t = 0,76531$ s (0,77 s) ✓

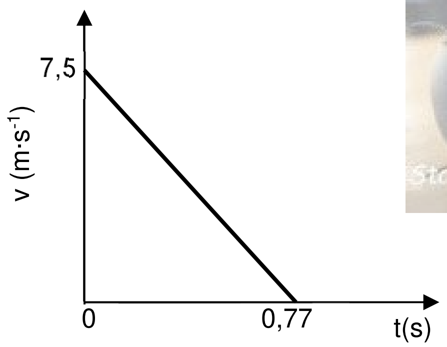
(3)

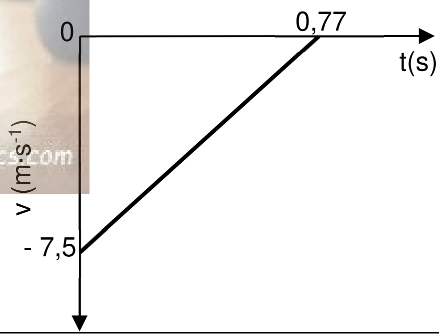
8.3

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** $\Delta y = v_i\Delta t + ½ a\Delta t^2$✓ $\Delta y = (7,5)(0,77)$ ✓ + ½ $(-9,8)(0,77)^2$✓ $\Delta y = 2,87$ 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** $\Delta y = v_i\Delta t + ½ a\Delta t^2$✓ $\Delta y = (-7,5)(0,77)$ ✓ + ½ $(9,8)(0,77)^2$✓ $\Delta y = -2,87$ m (2,869 m)✓ It is higher than height needed to reach point **T** (2,1 m) ✓ therefore ball will pass point **T**. ✓

(6)

8.4





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

(2)
[13]

QUESTION 9

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

9.2.1

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

(3)

9.2.2

OPTION 1/ **UPWARDS AS POSITIVE:** $\Delta y = v_i\Delta t + ½a\Delta t^2$ ✓ = $\underline{14,99 (1,53) + ½ (- 9,8)(1,53)^2}$✓ = 11,47 m✓(11,46-11,48) Maximum height is 11,47 m	**DOWNWARDS AS POSITIVE:** $\Delta y = v_i\Delta t + ½a\Delta t^2$ ✓ = $\underline{-14,99 (1,53) + ½ (9,8)(1,53)^2}$ ✓ = -11,47 m (11,46-11,48) Maximum height is 11,47 m ✓
OPTION 2 **UPWARDS AS POSITIVE:** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $\underline{0 = (14,99)^2 + 2(-9,8)(\Delta y)}$ ✓ Δy= 11,47 m·✓(11,46-11,48) Maximum height reached is 11,47 m	**DOWNWARDS AS POSITIVE:** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $\underline{0 = (-14,99)^2 + 2(9,8)(\Delta y)}$ ✓ Δy= -11,47 m·(11,46-11,48) Maximum height reached is 11,47 m ✓

(3)

9.3

OPTION 1 **UPWARDS AS POSITIVE:** $\Delta y = v_i\Delta t + ½a\Delta t^2$ ✓ = (14,99) (4) + ½ (- 9,8)(4)²✓ = -18,4 m Position is 18,4 m downwards (below the edge of the roof) ✓	**DOWNWARDS AS POSITIVE:** $\Delta y = v_i\Delta t + ½a\Delta t^2$ ✓ = (-14,99) (4) + ½ (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·s⁻¹ $v_f^2 = v_i^2 + 2a\Delta y$✓ $\underline{(-24,2)^2 = (14,99)^2 + 2(-9,8)(\Delta y)}$✓ Δy= - 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·s⁻¹ $v_f^2 = v_i^2 + 2a\Delta y$✓ $(24,2)^2 = (-14,99)^2 + 2(9,8)(\Delta y)$✓ Δy= 18,4 m· Ball is 18,4 m downwards (below the edge of the roof) ✓

(3)

9.4 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 10

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

10.2

OPTION 1/ **UPWARDS AS POSITIVE:** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $\underline{0 = (10)^2 + (2)(- 9,8)\Delta y}$ ✓ Δy = 5,10 m (5,102) Height = $\underline{40 +}$ 5,10 ✓ = 45,10 m ✓	**DOWNWARDS AS POSITIVE:** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $\underline{0 = (-10)^2 + (2)(9,8)\Delta y}$ ✓ Δy = - 5,10 m (5,102) Height = $\underline{40 +}$ 5,10 ✓ = 45,10 m ✓
OPTION 2 **UPWARDS AS POSITIVE:** $\Delta y = v_i\Delta t + ½ a\Delta t^2$ 0 = (10) Δt + ½(-9,8)Δt^2 Δt = 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 = $\underline{40 +}$ 5,10 ✓ = 45,10 m ✓	**DOWNWARDS AS POSITIVE:** $\Delta y = v_i\Delta t + ½ a\Delta t^2$ 0 = (-10) Δt + ½(9,8)Δt^2 Δt = 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 = $\underline{40 +}$ 5,10 ✓ = 45,10 m ✓

(4)

10.3 9,8 m·s⁻² ✓ downwards ✓ (2)

10.4

OPTION 1/ **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) ✓
OPTION 2 **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)

10.5.1 d ✓ (1)
10.5.2 a ✓ (1)
10.5.3 f ✓ (1)
10.5.4 c ✓ (1)

[18]

QUESTION 11

11.1 (Motion of an object) under the influence of gravity (weight) only. ✓✓ (2)

11.2.1 $\Delta t = 0,67 – 0,64 = 0,03$ s ✓✓ (2)

11.2.2

OPTION 1 $\Delta t = \frac{1,90 - 0,67}{2}$ ✓ $= 0,62\ s$ ✓ $(0,615\ s)$	**OPTION 2** $\Delta x = v_i\Delta t + ½\ a\Delta t^2$ $(-1,8) = 0 + ½\ (-9,8)\Delta t^2$ ✓ $\Delta t = 0,61$ s ✓ (0,606 s)
OPTION 3 $\Delta t = \frac{1,90 + 0,67}{2} = 1,285\ s$ $\Delta t = 1,285 – 0,67$ ✓ $= 0,62$ s ✓ (0,615 s)	***OPTION 4*** $v_f^2 = v_i^2 + 2a\Delta x$ $0 = v_i^2 + 2(-9,8)(1,8)$ $v_i = 5,94\ m\cdot s^{-1}$ $v_f = v_i + a\Delta t$ $0 = 5,94 + (-9,8)\Delta t$ ✓ $\Delta t = 0,61$ s ✓

(2)

11.2.3

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

OPTION 3

Motion from top to bottom

Downwards positive

$v_f^2 = v_i^2 + 2a\Delta y$ ✓

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

$v_f = 5,94\ m\cdot s^{-1}$ ✓

initial velocity =5,94 $m\cdot s^{-1}$

Upwards positive

$v_f^2 = v_i^2 + 2a\Delta y$ ✓

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

$v_f = 5,94\ m\cdot s^{-1}$ ✓

initial velocity =5,94 $m\cdot s^{-1}$

Motion from bottom to top

Downwards positive

$v_f^2 = v_i^2 + 2a\Delta y$ ✓

$\underline{0^2 = v_i^2 + 2(9,8)(-1,8)}$ ✓

$v_i = 5,94\ m\cdot s^{-1}$ ✓

Upwards positive

$v_f^2 = v_i^2 + 2a\Delta y$ ✓

$\underline{0 = v_i^2 + 2(-9,8)(1,8)}$ ✓

$v_i = 5,94\ m\cdot s^{-1}$ ✓

OPTION 4

Upwards positive

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

$\underline{0 = v_i(1,23) + \frac{1}{2}(-9,8)(1,23)^2}$ ✓

$v_i = 6,03\ m\cdot s^{-1}$ ✓

Downwards positive

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

$\underline{0 = v_i(1,23) + \frac{1}{2}(9,8)(1,23)^2}$ ✓

$v_i = -6,03\ m\cdot s^{-1}$

speed = 6,03 $m\cdot s^{-1}$ ✓

OPTION 5

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

$$1,8 = \left(\frac{0 + v_i}{2}\right)(0,62) \ ✓$$

$$v_i = 5,81\ m\cdot s^{-1} \ ✓$$

OPTION 6

$F_{net}\Delta t = m\Delta v$
$F_{net}\Delta t = m(v_f - v_i)$ } ✓

$\underline{m(9,8)(0,62) = m(0 - v_i)}$ ✓

$v_i = 5,94\ m\cdot s^{-1}$ ✓

OPTION 7

$(E_p + E_k)_{floor} = (E_p + E_k)_{top}$ ✓

$(mgh + \frac{1}{2}mv^2)_{floor} = (mgh + \frac{1}{2}mv^2)_{top}$

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

$v = 5,94\ m\cdot s^{-1}$ ✓

(3)

11.2.4

Calculate initial velocity:	**Calculate time Δt**
<u>OPTION 1</u> Downwards positive $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $0 = v_i^2 + 2(9,8)(-1,2)$ ✓ $v_i = -4,85\ m \cdot s^{-1}$ Upwards positive $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $0 = v_i^2 + 2(-9,8)(1,2)$ ✓ $v_i = 4,85\ m \cdot s^{-1}$	<u>Upwards positive</u> $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $1,2 = (4,85)\Delta t + \frac{1}{2}(-9,8)\Delta t^2$ ✓ $\Delta t = 0,4898\ s$ / $0,5\ s$ $t = 1,97 + 2(0,4898)$ ✓ $= 2,95\ s$ / $2,97\ s$ ✓ **OR** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $0 = (4,85)\Delta t + \frac{1}{2}(-9,8)\Delta t^2$ ✓ $\Delta t = 0,9898\ s$ (or $\Delta t = 0$) $t = 1,97 + 0,9898$ ✓ $= 2,96\ s$ ✓
<u>OPTION 2</u> $(E_{mech})_{top} = (E_{mech})_{bot}$ $(E_p + E_k)_{top} = (E_p + E_k)_{Bot}$ } ✓Any one/ $(mgh + \frac{1}{2}mv^2)_{top} = (mgh + \frac{1}{2}mv^2)_{Bot}$ $(9,8)(1,2) + 0 = 0 + (\frac{1}{2})v^2$ ✓ $v_i = 4,85\ m \cdot s^{-1}$ upwards	<u>Downwards positive</u> $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $1,2 = (-4,85)\Delta t + \frac{1}{2}(9,8)\Delta t^2$ ✓ $\Delta t = 0,4898\ s$ / $0,5\ s$ $t = 1,97 + 2(0,4898)$ ✓ $= 2,95\ s$ / $2,97\ s$ ✓
<u>OPTION 3</u> $W_{nc} = \Delta E_p + \Delta E_k$ $0 = (0 - mgh) + \frac{1}{2}m(v_f^2 - v_i^2)$ } ✓Any one/ $0 = -(9,8)(1,2) + \frac{1}{2}v_i^2$ ✓ $v_i = 4,85\ m \cdot s^{-1}$ upwards	**OR** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $0 = (4,85)\Delta t + \frac{1}{2}(9,8)\Delta t^2$ ✓ $\Delta t = 0,9898\ s$ (or $\Delta t = 0$) $t = 1,97 + 0,9898$ ✓ $= 2,96\ s$ ✓
<u>OPTION 4</u> $W_{net} = \Delta E_k$ $w\Delta x\cos180° = \frac{1}{2}m(v_f^2 - v_i^2)$ } ✓Any one/ $(9,8)(1,2)\cos180° = \frac{1}{2}v_i^2$ ✓ $v_i = -4,85\ m \cdot s^{-1}$	**OR** $v_f = v_i + a\Delta t$ ✓ $-4,85 = 4,85 + (-9,8)\Delta t$ ✓ $\Delta t = 0,9898\ s$ $\Delta t = 1,97 + 0,9898$ ✓ $= 2,96\ s$ ✓ **OR** <u>Upwards positive</u> $v_f = v_i + a\Delta t$ ✓ $0 = 4,85 + (-9,8)\Delta t$ ✓ $\Delta t = 0,4949\ s$ $\Delta t = 1,97 + (2)(0,4949)$ ✓ $= 2,96\ s$ ✓ **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
$\Delta y = v_i\Delta t + ½ a\Delta t^2$ ✓
$1,2$ ✓ $= 0 + ½(9,8)\Delta t^2$ ✓
$\Delta t = 0,49$ s
$t = 1,97 +$ ✓ $2(0,49)$ ✓
$= 2,96$ s ✓
Upwards positive
$\Delta y = v_i\Delta t + ½ a\Delta t^2$ ✓
$-1,2$ ✓ $= 0 + ½(-9,8)\Delta t^2$ ✓
$\Delta t = 0,49$ s
$t = 1,97 +$ ✓ $2(0,49)$ ✓
$= 2,96$ s ✓

(6)
[15]

QUESTION 12

12.1 Weight / gravitational force ✓ (1)
12.2 9,8 m·s^{-2} ✓ downward ✓ (2)
12.3 3 m (1)
12.4.1
UPWARDS AS POSITIVE
$v_f = v_i + a\Delta t$ ✓
$0 = v_i + (-9,8)(1,02)$ ✓
$v_i = 10$ m·s^{-1} ✓ (9,996)
(3)

12.4.2
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)

12.5
UPWARDS AS POSITIVE
$v_f = v_i + a\Delta t$ ✓
$0 = v_i + (-9,8)(1,1)$ ✓
$v_i = 10,78$ m·s^{-1}

$v_f^2 = v_i^2 + 2a\Delta y$
$= (-10)^2 + 2(-9,8)(-3)$
$v_f = 12,60$ m·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 13

13.1 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·s^{-2} / is zero.
- It has constant velocity / no acceleration.

(2)

13.2.1

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
$W_{net} = \Delta E_k$ ✓
$F_{net}\Delta y\cos\theta = \frac{1}{2}m(v_f^2 - v_i^2)$
$m(9,8)(200)(\cos 0°) = \frac{1}{2}m(62,68^2 - v_i^2)$ ✓
$v_i = 2,96\ m\cdot s^{-1}$
$Speed = 2,96\ m\cdot s^{-1}$ ✓

(3)

13.2.2

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)

13.2.3

UPWARDS AS POSITIVE

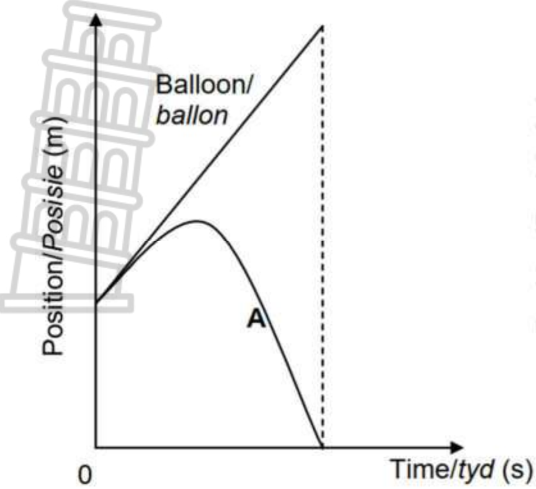
Stone B
$\Delta y = v_i\Delta t + \frac{1}{2}\Delta t^2$ ✓
$= (2,96)(6,7 - 5) + \frac{1}{2}(-9,8)(6,7 - 5)^2$ ✓✓
$= -9,13\ m$
Distance = 9,13 m

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 ✓

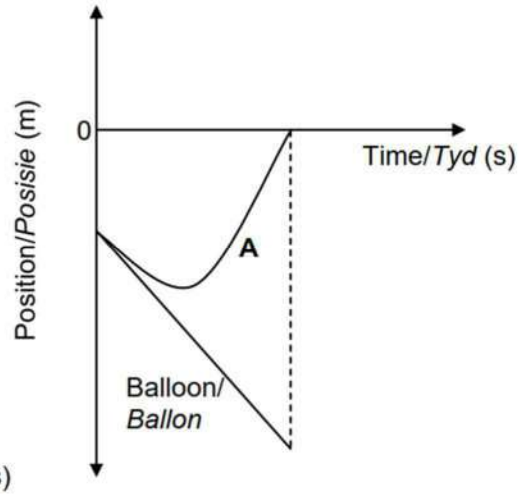
(6)

13.3

UPWARDS POSITIVE



DOWNWARDS POSITIVE



(4)
[18]

QUESTION 14

14.1 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)

14.2.1

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

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

OPTION 3
UPWARDS POSITIVE
$\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓
$\Delta y = \left(\frac{15 + 0}{2}\right)\Delta t$
$\Delta y = 7{,}5\Delta t$

$v_f^2 = v_i^2 + 2a\Delta y$
$0 = 15^2 + 2(-9{,}8)(7{,}5\Delta t)$ ✓
$\Delta t = 1{,}53\ s$ ✓

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)

14.2.2

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
$v_f^2 = v_i^2 + 2a\Delta y$ ✓
$0 = 15^2 + 2(-9{,}8)\Delta y$ ✓
$\Delta y = 11{,}48\ m$
$Height = 11{,}48 + 30$ ✓
$= 41{,}48\ m$ ✓

(4)

14.3 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.

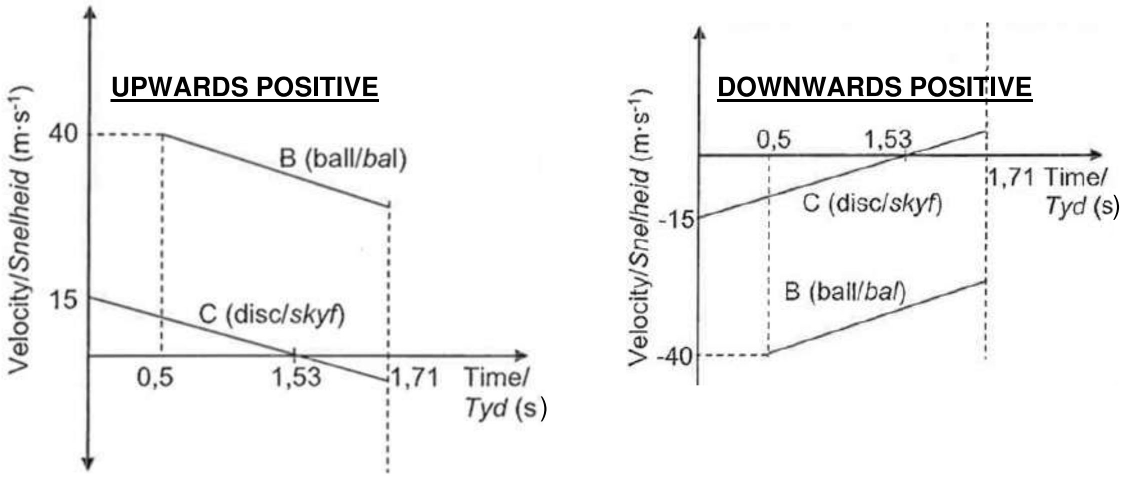
$\Delta y_C = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓
$= (15)\Delta t + \frac{1}{2}(-9{,}8)\Delta t^2$ ✓
$= -4{,}9\Delta t^2 + 15\Delta t$

$\Delta y_B = v_i\Delta t + \frac{1}{2}a\Delta t^2$
$= (40)(\Delta t - 0{,}5$✓$) + \frac{1}{2}(-9{,}8)(\Delta t - 0{,}5)^2$✓
$= -4{,}9\Delta t^2 + 44{,}9\Delta t - 21{,}225$

$\Delta y_C + 30 = \Delta y_B$
$-4{,}9\Delta t^2 + 15\Delta t + 30 = -4{,}9\Delta t^2 + 44{,}9\Delta t - 21{,}225$ ✓
$\Delta t = 1{,}71\ s$ ✓

(6)

14.4

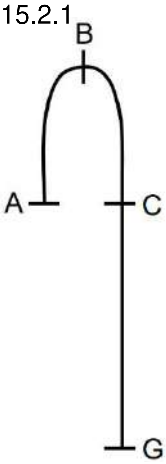


(5)
[20]

QUESTION 15

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

15.2.1



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
$v_f = v_i + a\Delta t$ ✓
$-12 = 12 + (-9{,}8)\Delta t$ ✓
$\Delta t = 2{,}449\ s$
$\Delta t_{up} = 1{,}22\ s$ ✓

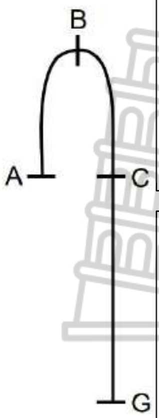
DOWNWARD AS POSITIVE
$v_f = v_i + a\Delta t$ ✓
$12 = -12 + (+9{,}8)\Delta t$ ✓
$\Delta t = 2{,}449\ s$
$\Delta t_{up} = 1{,}22\ s$ ✓

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
$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓
$0 = -12\Delta t + \frac{1}{2}(+9{,}8)\Delta t^2$ ✓
$\Delta t = 2{,}449\ s$
$\Delta t_{up} = 1{,}22\ s$ ✓

(3)

15.2.2



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

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

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

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

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

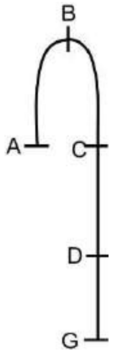
$-25 = \left(\frac{12 + v_f}{2}\right)(3{,}793)$ ✓

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

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

(4)

15.2.3



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

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

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

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

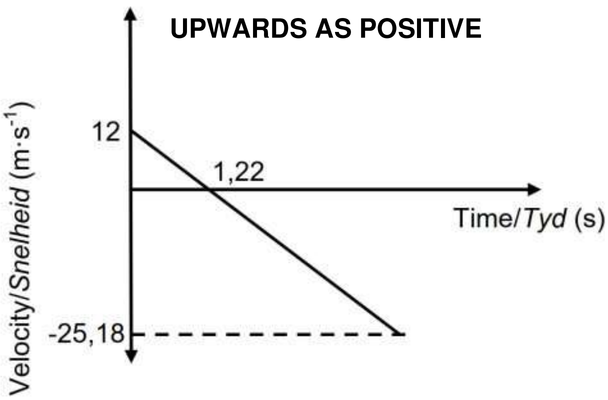
D to G

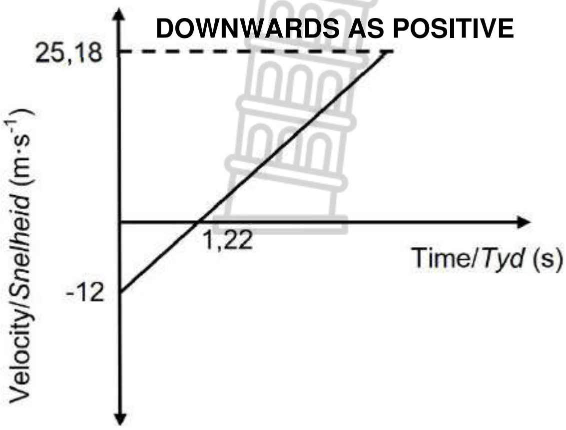
$\Delta t_{door-ground} = 3{,}79 - 3{,}72$

$= 0{,}07\ s$ ✓

(4)

15.3





(3)

[16]

QUESTION 16

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

16.2.1

<u>OPTION 1</u>

UPWARD AS POSITIVE

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

$-15{,}2 = (0)\Delta t + \frac{1}{2}(-9{,}8)\Delta t^2$ ✓

$\Delta t = 1{,}76\ s$ ✓

DOWNWARD AS POSITIVE

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

$15{,}2 = (0)\Delta t + \frac{1}{2}(+9{,}8)\Delta t^2$ ✓

$\Delta t = 1{,}76\ s$ ✓

<u>OPTION 2</u>

UPWARD AS POSITIVE

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

$= 0^2 + 2(-9{,}8)(-15{,}2)$

$v_f = -17{,}26\ m\cdot s^{-1}$

$v_f = v_i + a\Delta t$ ✓

$-17{,}26 = 0 + (-9{,}8)\Delta t$ ✓

$\Delta t = 1{,}76\ s$ ✓

DOWNWARD AS POSITIVE

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

$= 0^2 + 2(+9{,}8)(+15{,}2)$

$v_f = 17{,}26\ m\cdot s^{-1}$

$v_f = v_i + a\Delta t$ ✓

$17{,}26 = 0 + (+9{,}8)\Delta t$ ✓

$\Delta t = 1{,}76\ s$ ✓

<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

$v_f = v_i + a\Delta t$ ✓

$-17{,}26 = 0 + (-9{,}8)\Delta t$ ✓

$\Delta t = 1{,}76\ s$ ✓

OR

DOWNWARD AS POSITIVE

$v_f = v_i + a\Delta t$ ✓

$17{,}26 = 0 + (+9{,}8)\Delta t$ ✓

$\Delta t = 1{,}76\ s$ ✓

(3)

16.2.2

<u>OPTION 1</u>

UPWARD AS POSITIVE

<u>Δt for **A** for 3,2 m</u>:

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

$-3{,}2 = (0)\Delta t_A + \frac{1}{2}(-9{,}8)\Delta t_A^2$ ✓

$\Delta t_A = 0{,}81\ s$

<u>Δt for **B**</u>:

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

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

$0 = v_i(0{,}95) + \frac{1}{2}(-9{,}8)(0{,}95^2)$ ✓

$v_i = 4{,}66\ m\cdot s^{-1}$

$\therefore Magnitude\ of\ v_i = 4{,}66\ m\cdot s^{-1}$ ✓

<u>OPTION 2</u>

DOWNWARD AS POSITIVE

<u>Δt for **A** for 3,2 m</u>:

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

$3{,}2 = 0\Delta t_A + \frac{1}{2}(+9{,}8)\Delta t_A^2$ ✓

$\Delta t_A = 0{,}81\ s$

<u>Δt for **B**</u>:

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

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

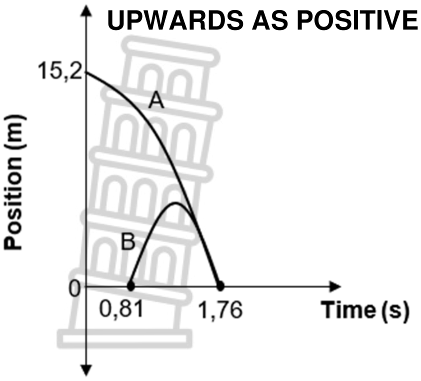
$0 = v_i(0{,}95) + \frac{1}{2}(+9{,}8)(0{,}95^2)$ ✓

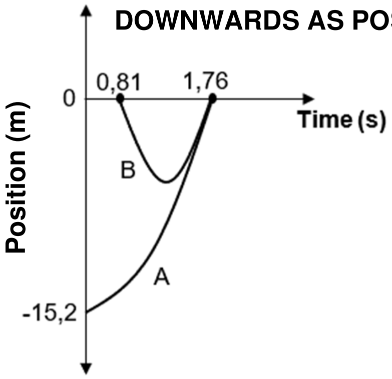
$v_i = -4{,}66\ m\cdot s^{-1}$

$\therefore Magnitude\ of\ v_i = 4{,}66\ m\cdot s^{-1}$ ✓

(5)

16.3





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 17

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

17.2

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)

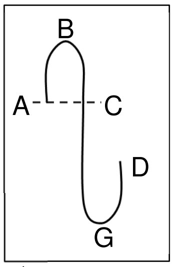
17.3.1

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

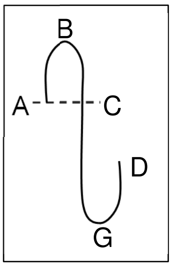
DOWNWARDS AS POSITIVE: B-G

$v_f^2 = v_i^2 + 2a\Delta y$ ✓

$v_f^2 = 0^2 + 2(+9{,}8)(+21{,}19)$ ✓

$= 415{,}324$

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



OR

DOWNWARDS AS POSITIVE: A-G

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

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

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

$v_f = v_i + a\Delta t$

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

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

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

OR

DOWNWARDS AS POSITIVE: C-G

$v_f^2 = v_i^2 + 2a\Delta y$ ✓

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

$= 415{,}3135$

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

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)

17.3.2

UPWARDS AS POSITIVE: G-D

$v_f = v_i + a\Delta t$ ✓

$0 = 11{,}92 + (-9{,}8)\Delta t$ ✓

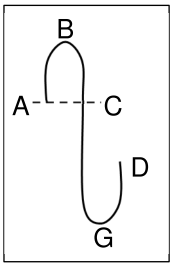
$\Delta t = 1{,}22\ s$ ✓

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)

17.4.1 11,92 ($m \cdot s^{-1}$) ✓ (1)

17.4.2 10,74 ($m \cdot s^{-1}$) ✓ (1)

17.4.3 1,22 (s) ✓ (1)

[16]

QUESTION 18

18.1 Motion during which the only force acting is gravitational force. (2 or 0)

OR

Motion under the influence of gravitational force only. ✓✓ (2 or 0) (2)

18.2 No ✓ (1)

18.3.1

OPTION 1

DOWN AS POSITIVE

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

$15 = 3{,}4\Delta t + \frac{1}{2}(9{,}8)\Delta t^2$ ✓

$\Delta t = 1{,}44\ s$ ✓

UP AS POSITIVE

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

$-15 = -3{,}4\Delta t + \frac{1}{2}(-9{,}8)\Delta t^2$ ✓

$\Delta t = 1{,}44\ s$ ✓

OPTION 2

DOWN AS POSITIVE

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

$= 3{,}4^2 + 2(9{,}8)(15)$

$v_f = 17{,}48\ m \cdot s^{-1}$

$v_f = v_i + a\Delta t$ ✓

$17{,}48 = 3{,}4 + 9{,}8\Delta t$ ✓

$\Delta t = 1{,}44\ s$ ✓

UP AS POSITIVE

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

$= (-3{,}4)^2 + 2(-9{,}8)(-15)$

$v_f = -17{,}48\ m \cdot s^{-1}$

$v_f = v_i + a\Delta t$ ✓

$-17{,}48 = -3{,}4 + (-9{,}8)\Delta t$ ✓

$\Delta t = 1{,}44\ s$ ✓

(3)

18.3.2

DOWN AS POSITIVE

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

$= (3{,}4)(1{,}44) + \frac{1}{2}(0)(1{,}44)^2$ ✓

$= 4{,}896\ m$

$Height = 15 - 4{,}896$ ✓

$= 10{,}10\ m$ ✓

UP AS POSITIVE

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

$= (-3{,}4)(1{,}44) + \frac{1}{2}(0)(1{,}44)^2$ ✓

$= -4{,}896\ m$

$Height = 15 - 4{,}896$ ✓

$= 10{,}10\ m$ ✓

(4)

18.4

OPTION 1

UP AS POSITIVE

$v_f = v_i + a\Delta t$ ✓

$0 = 7{,}2 + (-9{,}8)\Delta t$ ✓

$\Delta t = 0{,}735\ s$

$t_3 = 1{,}44 + 0{,}2 + 0{,}735$ ✓

$= 2{,}38\ s$ ✓

DOWN AS POSITIVE

$v_f = v_i + a\Delta t$ ✓

$0 = -7{,}2 + (+9{,}8)\Delta t$ ✓

$\Delta t = 0{,}735\ s$

$t_3 = 1{,}44 + 0{,}2 + 0{,}735$ ✓

$= 2{,}38\ s$ ✓

OPTION 2

UP AS POSITIVE

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

$0 = 7{,}2^2 + 2(-9{,}8)\Delta y$

$\Delta y = 2{,}645\ s$

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

$2{,}645 = \left(\frac{7{,}2 + 0}{2}\right)\Delta t$ ✓

$\Delta t = 0{,}735$

$t_3 = As\ option\ 1$ ✓✓

DOWN AS POSITIVE

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

$0 = (-7{,}2)^2 + 2(+9{,}8)\Delta y$

$\Delta y = -2{,}645\ s$

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

$-2{,}645 = \left(\frac{-7{,}2 + 0}{2}\right)\Delta t$ ✓

$\Delta t = 0{,}735$

$t_3 = As\ option\ 1$ ✓✓

(4)

[14]

QUESTION 19

19.1.1

OPTION 1: Down positive

Ball A

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

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

Ball B

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

$= 5{,}4(t-2) + \frac{1}{2}(9{,}8)(t-2)^2$ ✓ ...(2)

Solve for (1) and (2):

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

$t = 4\ s$ ✓

OPTION 2: Up positive

Ball A

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

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

Ball B

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

$= -5{,}4(t-2) + \frac{1}{2}(-9{,}8)(t-2)^2$ ✓ ...(2)

Solve for (1) and (2):

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

$t = 4\ s$ ✓

(5)

19.1.2

OPTION 1: Down positive

Ball A

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

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

$= 30,4\ m$

$Z = 30,4\ m$ ✓

Ball B

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

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

$= 30,4\ m$

$Z = 30,4\ m$ ✓

OPTION 2: Up positive

Ball A

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

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

$= -30,4\ m$

$Z = 30,4\ m$ ✓

Ball B

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

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

$= -30,4\ m$

$Z = 30,4\ m$ ✓

(3)

19.1.3

OPTION 1: Down positive

Ball A

$v_f^2 = v_i^2 + 2a\Delta y$ ✓

$0^2 = (-12)^2 + 2(9,8)\Delta y$ ✓

$\Delta y = -7,347\ m$

$Y = 7,347 + 30,4$ ✓

$= 37,75\ m$ ✓

OPTION 2: Up positive

Ball A

$v_f^2 = v_i^2 + 2a\Delta y$ ✓

$0^2 = (12)^2 + 2(-9,8)\Delta y$ ✓

$\Delta y = 7,347\ m$

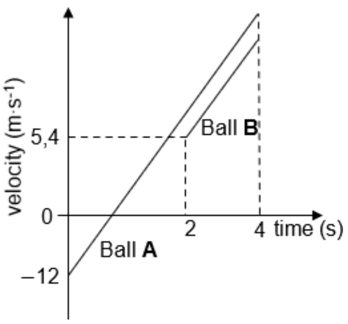
$Y = 7,347 + 30,4$ ✓

$= 37,75\ m$ ✓

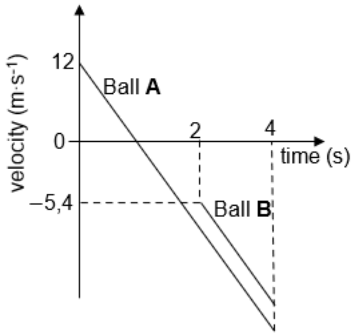
(4)

19.2

Down as positive



Up as positive



Marking criteria:
Correct initial velocities of both balls **A** and **B** with correct shape (straight lines with both positive / both negative slopes). ✓
Correct initial times for balls **A** and **B** with **B** starts after the intercept of **A**. ✓
Both graphs end at 4 s. ✓
Graphs parallel to each other and **B** to the right of **A**. ✓

(4)
[16]

MOMENTUM AND IMPULSE

QUESTION 1

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

1.2.1

OPTION 1	OPTION 2
$\sum p_i = \sum p_f$ $m_1 v_{1i} + m_2v_{2i} = m_1 v_{1f} + m_2v_{2f}$ $m_1 v_{1i} + m_2v_{2i} = (m_1 + m_2)v_f$ } ✓ any one $(5)(4) + (3)(0)$ ✓ $= (5 + 3)v_f$ ✓ ∴ $v = 2,5$ m·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·s^{-1} ✓

(4)

1.2.2

OPTION 1 $F_{net}\Delta t = \Delta p = (p_f - p_i) = (mv_f - mv_i)$ ✓ ∴ $F_{net}(0,3)$ ✓ $= 8 [(0 - (2,5)]$ ✓
∴ $F_{net} = - 66,67$ N ∴ $F_{net} = 66,67$ 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 ∴ $F_{net} = 66,67$ N ✓	$v_f = v_i + a\Delta t$ ∴ $0 = 2,5 + a(0,3)$ ✓ ∴ $a = - 8,333$ m·s^{-2} $F_{net} = ma$ ✓ $= 8 (-8,333)$ ✓ $= - 66,67$ N ∴ $F_{net} = 66,67$ N ✓

(4)
[10]

QUESTION 2

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

2.2.1

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

(3)

2.2.2

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 $30\,000 + (900)(-15)$ ✓ $= 14\,000 + 900v_B$ ✓ ∴ $v_B = 2,78$ m·s^{-1} ✓ east ✓	$\Delta p_A = -\Delta p_B$ $p_f - p_i = -(mv_f - mv_i)$ } ✓ for any $14\,000 - 30\,000$ ✓ $= 900v_f - 900(-15)$ ✓ $v_f = 2,78$ m·s^{-1} ✓ east

2.2.3

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 ✓	$F_{net}\Delta t = \Delta p$ ✓ $F_{net}(0,1)$ ✓ $= 14\,000 - 30\,000$ ✓ $F_{net} = - 160\,000$ N $F_{net} = 160\,000$ N ✓

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

(4)
[13]

QUESTION 3

3.1

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

(3)

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

3.3 $\sum p_i = \sum p_f$
$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$ } ✓ Any one
$(3,5)(0,5)$ ✓ $= (3,5 + 6)v_f$ ✓
$v_f = v_{6kg} = 0,184$ m·s^{-1}

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

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

(6)
[11]

QUESTION 4

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

4.2.1 $p = mv$ ✓ $= (0,03)(700)$ ✓ $= 21$ kg·m·s^{-1} ✓ (3)

4.2.2 **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}

$F_{ave\ gun\ on\ bullet} = \frac{4620 - 0}{60}$ ✓ = 77,00 N ✓

∴ average force of bullet on gun = 77,01 N / 77,78 N to the west ✓ (5)

4.3 77 N / 77,78 N ✓ to the east ✓ (2)

[12]

QUESTION 5

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

5.2 $\Sigma p_i = \Sigma p_f$
$m_B v_{Bi} + m_b v_{bi} = m_B v_{Bf} + m_b v_{bf}$
$\Delta p_{bullet} = -\Delta p_{block}$
} ✓ Any one

(0,015)(400) ✓ + 0 = (0,015)v_{Bf} + 2(0,7) ✓ ∴ V_{Bf} = 306,67 m·s^{-1}✓ (4)

5.3 **OPTION 1**

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

For bullet:

Δp = (0,015)(306,666 – 400) ✓
= -1,4 kg·m·s^{-1}
F_{net}(0,002) = -1,4 ∴ 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)Δxcos180° = ½(0,015)(306,67²–400²)✓
∴Δx = 0,71 m ✓

For block:

Δp = (2)(0,7 - 0) ✓
= 1,4 kg·m·s^{-1}
F_{net}(0,002) = 1,4 ∴ F_{net} = 700 N

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

$\Delta x = v_i\Delta t + \frac{1}{2} a\Delta t^2$
= (400)(0,002)✓ + ½(-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)Δx ✓
Δx = 0,71 m (0,70667 m) ✓

OPTION 2

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

$v_f^2 = v_i^2 + 2a\Delta x$ ∴ (306,666)² ✓= 400² + 2(-4667) Δx ✓ ∴ Δx = 0,71 m (0,706 m) ✓ (5)

[11]

QUESTION 6

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

6.2 $\Sigma p_i = \Sigma p_f$
$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$
} ✓ any one

For the system cat-skate board **A**

(3,5)(0) + (2,6)(0) ✓ = (3,5)$v_{skateboard}$ + (2,6)(3) ✓ ∴ $v_{skateboard}$ = 2,23 m·s^{-1} ✓ to the left ✓ (5)

6.3

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

(3)

[10]

QUESTION 7

7.1 $E_{(mech\ top)} = E_{(mech\ bottom)}$
$(E_p + E_k)_{top/bo} = (E_p + E_k)_{bottom}$
$(mgh + ½\ mv^2)_{top} = (mgh + ½\ mv^2)_{bottom}$ } ✓ for any
$\underline{(1,5)(9,8)(2) + 0}$ ✓ = $\underline{0 + ½\ (1,5)v^2}$ ✓ ∴ v = 6,26 m·s^{-1} ✓ (4)

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

7.3 $\Sigma p_i = \Sigma p_f$
$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$
$m_1v_{1i} + m_2v_{2i} = (m_1 + m_2)v$ } ✓ for any
$\underline{(1,5)(6,26) + 0}$ ✓ = $\underline{(1,5 + 2)v_f}$ ✓ ∴ v_f = 2,68 m·s^{-1} ✓ (4)

7.4

OPTION 1	OPTION 2
$\Delta x = v\Delta t$ ✓ = (2,68)(3) ✓ = 8,04 m ✓	$\Delta x = v_i\Delta t + ½\ a\Delta t^2$ ✓ = (2,68)(3) + ½ (0)(3)^2 ✓ = 8,04 m ✓ (Range 8,04 – 8,05)

(3)
[13]

QUESTION 8

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

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

NOTE: For QUESTIONS 8.3 and 8.4 motion to the right has been taken as positive.

8.3

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 $\underline{\{(m + 2)(0)\} + \{8(0)\}}$ ✓ = {(m + 2)(-0,6)} ✓ + (8)(4) ✓ ∴ 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) ✓ } ✓ ∴ m_2 = 53,33 kg ∴ 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)

8.4 Impulse = $\Delta p = m(v_f – v_i)$ ✓ = $\underline{(51,33 + 2)(-0,6 – 0)}$ ✓ = -32 N·s/kg·m·s^{-1}
Magnitude of impulse is 32 N·s /32 kg·m·s^{-1} ✓
OR
Impulse = $\Delta p_{parcel} = m(v_f – v_i)$ ✓ = (8)(4 – 0) ✓ = 32 kg m·s^{-1} ∴Δp_{girl} = 32 kg m·s^{-1} ✓ (3)

8.5 32 kg·m·s^{-1} ✓ to the right/opposite direction ✓ (2)
[14]

QUESTION 9

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

9.2 **OPTION 1**
$\sum p_i = \sum p_f$
$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$
$m_1v_{1i} + m_2v_{2i} = (m_1 + m_2)v_f$ } ✓Any one
{0,45(9) + 0,20(0)} ✓ = (0,45 + 0,20)v ✓ ∴ v = 6,23 m·s^{-1} ✓
OR
$\Delta p_{ball} = -\Delta p_{cont}$ ✓ ∴ 0,45(v – 9) ✓ = - 0,2(v – 0) ✓ ∴ v = 6,23 m·s^{-1} ✓ (4)

9.3 K = ½ mv^2✓
Total kinetic energy before collision: $\underline{½\ (0,45)(9)^2 + 0}$ ✓= 18,225 J
Total kinetic energy after collision: $\underline{½\ (0,45 + 0,20)(6,23)^2}$✓ = 12,614 J
$\sum K_{before} \neq \sum K_{after}$ ∴ Collision is inelastic. ✓✓ (5)
[11]

QUESTION 10

10.1 Isolated system is a system on which the resultant/net external force is zero.✓✓ (2)

10.2.1 p = mv ✓
24 = m (480) ✓
m = 0,05 kg ✓ (3)

10.2.2

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

(5)
[10]

QUESTION 11

11.1 (Linear) momentum (of an object) is the product of mass and velocity. ✓✓ (2)

11.2.1

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 (0,16)(10) + (0,2)(-15) ✓= (0,16)(-5) +(0,2)v_{Qf} ✓ v_{Qf} = -3 m·s^{-1} v_{Qf} = 3 m·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 (0,16)(-10) + (0,2)(15) ✓= (0,16)(5) +(0,2)Q_{Nf} ✓ v_{Qf} = 3 m·s^{-1} ✓ west ✓
OPTION 3 $\Delta p_p = -\Delta p_Q$ ✓ (0,16)(-5 – 10) ✓= -(0,2)(v – (-15))✓ v = -3 m·s^{-1} = 3 m·s^{-1} ✓west ✓ **IF**: $\Delta p_p = \Delta p_Q$: $\frac{0}{5}$

(5)

11.2.2

For ball P	For ball Q
West as negative Impulse = Δp $F_{net}\Delta t = \Delta p$ } ✓Any one $\Delta p = m(v_{Pf} - v_{Pi})$ = 0,16(-5 – 10) ✓ = - 2,4 ∴ 2,4 N·s ✓ (2,4 kg·m·s^{-1}) **OR** West as positive Impulse = Δp $F_{net}\Delta t = \Delta p$ $= m(v_{Pf} - v_{Pi})$ } ✓Any one = 0,16(5 – (-10)) ✓ = 2,4 N·s ✓	West as negative Impulse = Δp $F_{net}\Delta t = \Delta p$ $= m(v_{Qf} - v_{Qi})$ } ✓Any one = 0,2[-3 – (-15)] ✓ = 2,4 N·s ✓ (2,4 kg·m·s^{-1}) **OR** West as positive Impulse = Δp $F_{net}\Delta t = \Delta p$ $= m(v_{Qf} - v_{Qi})$ } ✓Any one = 0,16(3 – (15)) ✓ = - 2,4 N·s ∴ 2,4 N·s ✓ (2,4 kg·m·s^{-1})

(3)
[10]

QUESTION 12

12.1 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)

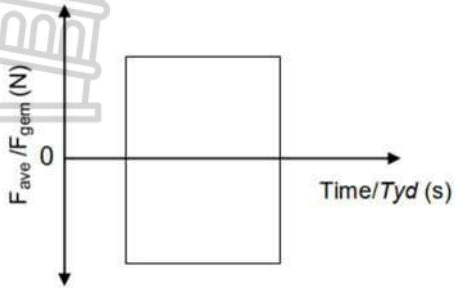
12.2

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)

12.3 Impulse (1)

12.4



(2)
[10]

QUESTION 13

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

13.2

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)

13.3

<u>OPTION 1</u>
EAST + for Y
$F_{net}\Delta t = \Delta p$ ✓
$F_{net}(0,1) = 2(6 - (-4))$ ✓
$F_{net} = 200\ N$
Magnitude of F_{net} = 200 N ✓

<u>OPTION 2</u>
EAST + for X
$F_{net}\Delta t = \Delta p$ ✓
$F_{net}(0,1) = 10(0 - 2)$ ✓
$F_{net} = -200\ N$
Magnitude of F_{net} = 200 N ✓

(3)
[10]

QUESTION 14

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

14.2.1 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**
$Impulse_{rocket} = -Impulse_{toy\ cart}$ ✓✓ (2)

14.2.2

<u>OPTION 1</u>
RIGHT AS POSITIVE
$\Sigma p_i = \Sigma p_f$ ✓
$(20 + m_{rocket})2,5$ ✓ $= (20)(0,6)$ ✓ $+ m_{rocket}(30)$ ✓
$m_{rocket} = 1,38\ kg$ ✓

<u>OPTION 2</u>
RIGHT AS POSITIVE
$\Delta p_{cart} = -\Delta p_{rocket}$ ✓
(20)✓$(0,6 - 2,5)$ ✓ $= -m_{rocket}(30 - 2,5)$ ✓
$m_{rocket} = 1,38\ kg$ ✓

(5)
[9]

QUESTION 15

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

15.2.1

OPTION 1

EAST AS POSITIVE

$\Sigma p_i = \Sigma p_f$ ✓

$m_x v_{ix} + m_y v_{iy} = m_x v_{fx} + m_y v_{fy}$

$(1{,}2)(8)$✓ $+ (0{,}5)(0) = (1{,}2)(4) + (0{,}5)v_{fy}$ ✓

$v_{fy} = 9{,}6\ m \cdot s^{-1}$ ✓

WEST AS POSITIVE

$\Sigma p_i = \Sigma p_f$ ✓

$m_x v_{ix} + m_y v_{iy} = m_x v_{fx} + m_y v_{fy}$

$(1{,}2)(-8)$✓ $+ (0{,}5)(0) = (1{,}2)(-4) + (0{,}5)v_{fy}$ ✓

$v_{fy} = -9{,}6\ m \cdot s^{-1}$

$\therefore v_{fy} = 9{,}6\ m \cdot s^{-1}$ ✓

OPTION 2

EAST AS POSITIVE

$\Delta p_x = -\Delta p_y$ ✓

$m_x(v_{fx} - v_{ix}) = -m_y(v_{fy} - v_{iy})$

$(1{,}2)(4-8)$✓ $= -(0{,}5)(v_{fy} - 0)$ ✓

$v_{fy} = 9{,}6\ m \cdot s^{-1}$ ✓

WEST AS POSITIVE

$\Delta p_x = -\Delta p_y$ ✓

$m_x(v_{fx} - v_{ix}) = -m_y(v_{fy} - v_{iy})$

$(1{,}2)(-4-(-8))$✓ $= -(0{,}5)(v_{fy} - 0)$ ✓

$v_{fy} = -9{,}6\ m \cdot s^{-1}$

$\therefore v_{fy} = -9{,}6\ m \cdot s^{-1}$ ✓

(4)

15.2.2

OPTION 1

FOR Y: EAST AS POSITIVE

$F_{net}\Delta t = \Delta p$ ✓

$F_{net}\Delta t = m_x(v_f - v_i)$

$F_{net}(0{,}1) = (0{,}5)(9{,}6 - 0)$ ✓

$F_{net\ on\ Y} = +48\ N$ ✓

$\therefore Magnitude\ of\ F_{net\ on\ Y} = 48\ N$ ✓

FOR Y: WEST AS POSITIVE

$F_{net}\Delta t = \Delta p$ ✓

$F_{net}\Delta t = m_x(v_f - v_i)$

$F_{net}(0{,}1) = (0{,}5)(-9{,}6 - 0)$ ✓

$F_{net\ on\ Y} = -48\ N$

$\therefore Magnitude\ of\ F_{net\ on\ Y} = 48\ N$ ✓

OPTION 2

FOR X: EAST AS POSITIVE

$F_{net}\Delta t = \Delta p$ ✓

$F_{net}\Delta t = m_x(v_f - v_i)$

$F_{net}(0{,}1) = (1{,}2)(4 - (+8))$ ✓

$F_{net\ on\ X} = -48\ N$

$F_{net\ on\ Y} = +48\ N$ ✓

$\therefore Magnitude\ of\ F_{net\ on\ Y} = 48\ N$ ✓

FOR X: WEST AS POSITIVE

$F_{net}\Delta t = \Delta p$ ✓

$F_{net}\Delta t = m_x(v_f - v_i)$

$F_{net}(0{,}1) = (1{,}2)(-4 - (-8))$ ✓

$F_{net\ on\ X} = +48\ N$

$F_{net\ on\ Y} = -48\ N$

$\therefore Magnitude\ of\ F_{net\ on\ Y} = 48\ N$ ✓

(3)

15.3

Inelastic ✓

Once for: $E_k = \frac{1}{2}mv^2$ ✓

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

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

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

(5)
[14]

QUESTION 16

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

16.2.1

OPTION 1

RIGHT AS POSITIVE

$\Sigma p_i = \Sigma p_f$ ✓

$m_A v_{Ai} + m_B v_{Bi} = (m_{A+B})v_f$

$(7{,}2)(0{,}4) + (5{,}3)(0) = 12{,}5 v_f$ ✓

$v_f = 0{,}2304\ m \cdot s^{-1}$

$\therefore Magnitude\ of\ v_f = 0{,}2304\ m \cdot s^{-1}$ ✓

LEFT AS POSITIVE

$\Sigma p_i = \Sigma p_f$ ✓

$m_A v_{Ai} + m_B v_{Bi} = (m_{A+B})v_f$

$(7{,}2)(-0{,}4) + (5{,}3)(0) = 12{,}5 v_f$ ✓

$v_f = -0{,}2304\ m \cdot s^{-1}$

$\therefore Magnitude\ of\ v_f = 0{,}2304\ m \cdot s^{-1}$ ✓

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)

16.2.2

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 17

17.1 591 N to the right ✓ (1)

17.2

OPTION 1

RIGHT AS POSITIVE

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

LEFT AS POSITIVE

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

OPTION 2

RIGHT AS POSITIVE

$F_{net} = ma$
$-591 = (0{,}03)a$ ✓
$a = -19\ 700\ m \cdot s^{-2}$

$v_f = v_i + a\Delta t$ ✓
$0 = v_i + (-19\ 700)(0{,}02)$ ✓
$v_i = 394\ m \cdot s^{-1}$
$Magnitude\ of\ velocity = 394\ m \cdot s^{-1}$ ✓

LEFT AS POSITIVE

$F_{net} = ma$
$+591 = (0{,}03)a$ ✓
$a = +19\ 700\ m \cdot s^{-2}$

$v_f = v_i + a\Delta t$ ✓
$0 = v_i + (+19\ 700)(0{,}02)$ ✓
$v_i = -394\ m \cdot s^{-1}$
$Magnitude\ of\ velocity = 394\ m \cdot s^{-1}$ ✓

(4)

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

17.4

RIGHT AS POSITIVE

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

LEFT AS POSITIVE

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

(4)
[11]

QUESTION 18

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

18.2

<u>OPTION 1</u>

RIGHT AS POSITIVE

$\Sigma p_f = \Sigma p_i$ ✓

$2{,}6v_f + (3{,}2)(-0{,}4)$ ✓ $= 0$ ✓

$v_f = 0{,}492\ m\cdot s^{-1}$

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

$= (0{,}492)(1{,}3) + \frac{1}{2}(0)(0{,}492^2)$ ✓

$= 0{,}64\ m$

$Distance = 0{,}64\ m$ ✓

OR

$\bar{v} = \frac{\Delta x}{\Delta t}$

$0{,}492 = \frac{\Delta x}{1{,}3}$ ✓

$\Delta x = 0{,}64\ m$

$Distance = 0{,}64\ m$ ✓

Other equations of motion may also be used.

LEFT AS POSITIVE

$\Sigma p_f = \Sigma p_i$ ✓

$2{,}6v_f + (3{,}2)(0{,}4)$ ✓ $= 0$ ✓

$v_f = -0{,}492\ m\cdot s^{-1}$

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

$= (-0{,}492)(1{,}3) + \frac{1}{2}(0)(-0{,}492)^2$ ✓

$= -0{,}64\ m$

$Distance = 0{,}64\ m$ ✓

OR

$\bar{v} = \frac{\Delta x}{\Delta t}$

$-0{,}492 = \frac{\Delta x}{1{,}3}$ ✓

$\Delta x = -0{,}64\ m$

$Distance = 0{,}64\ m$ ✓

Other equations of motion may also be used.

<u>OPTION 2</u>

RIGHT AS POSITIVE

$\Delta p_A = -\Delta p_B$ ✓

$3{,}2(-0{,}4 - 0)$✓ $= -2{,}6(v_f - 0)$ ✓

$v_f = 0{,}492\ m\cdot s^{-1}$

Δx: As for option 1. ✓✓

LEFT AS POSITIVE

$\Delta p_A = -\Delta p_B$ ✓

$3{,}2(0{,}4 - 0)$✓ $= -2{,}6(v_f - 0)$ ✓

$v_f = -0{,}492\ m\cdot s^{-1}$

Δx: As for option 1. ✓✓

(5)

18.3

<u>OPTION 1</u>

RIGHT AS POSITIVE

For A

$F_{net}\Delta t = m(v_f - v_i)$✓

$-4{,}2\Delta t = 3{,}2(-0{,}4 - 0)$ ✓

$\Delta t = 0{,}30\ s$ ✓

For B

$F_{net}\Delta t = m(v_f - v_i)$✓

$4{,}2\Delta t = 2{,}6(0{,}492 - 0)$ ✓

$\Delta t = 0{,}30\ s$ ✓

<u>OPTION 2</u>

LEFT AS POSITIVE

For A

$F_{net}\Delta t = m(v_f - v_i)$✓

$4{,}2\Delta t = 3{,}2(0{,}4 - 0)$ ✓

$\Delta t = 0{,}30\ s$ ✓

For B

$F_{net}\Delta t = m(v_f - v_i)$✓

$-4{,}2\Delta t = 2{,}6(-0{,}492 - 0)$ ✓

$\Delta t = 0{,}30\ s$ ✓

(3)

18.4 LESS THAN ✓

Final momentum / change in momentum/impulse remains constant. ✓

If mass/inertia increases, velocity decreases/velocity is inversely proportional to mass. ✓

OR

From $F_{net}\Delta t = m\Delta v$: If $F_{net}\Delta t$ remains constant ✓ and m increase, then Δv decreases and v_C decreases.✓

OR

From $F_{net} = ma$: If F_{net} remains constant ✓ and a is inversely proportional to m, then m increases and a decrease and therefore v_C decreases. ✓ (3)

[13]

QUESTION 19

19.1 The total mechanical energy / sum of gravitational potential energy and kinetic energy, in an isolated system remains constant / is conserved. ✓✓ (2)

19.2

OPTION 1

$(E_p + E_k)_{top} = (E_p + E_k)_{bottom}$ ✓

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

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

$v = 5,42\ m \cdot s^{-1}$ ✓

OPTION 2

$W_{net} = \Delta K$ ✓

$mg\Delta y\cos\theta = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

$(2)(9,8)(1,5)cos180°$ ✓ $= 0 + \frac{1}{2}(2)v_i^2$ ✓

$v_i = 5,42\ m \cdot s^{-1}$ ✓

OPTION 3

$W_{nc} = \Delta K + \Delta U$ ✓

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

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

$v_i = 5,42\ m \cdot s^{-1}$ ✓

(4)

19.3.1

Right positive

$\Delta p_B = m(v_f - v_i)$ ✓

$= 2(5,42 - 0)$ ✓

$= 10,84\ kg \cdot m \cdot s^{-1}$

$\Delta p_B = 10,84\ kg \cdot m \cdot s^{-1}; right$ ✓

Left positive

$\Delta p_B = m(v_f - v_i)$

$= 2(-5,42 - 0)$

$= -10,84\ kg \cdot m \cdot s^{-1}$

$\Delta p_B = 10,84\ kg \cdot m \cdot s^{-1}; right$

(3)

19.3.2 10,84 kg·m·s^{-1}; left ✓ (1)

19.4

Right positive

$\Delta p_A = m(v_f - v_i)$

$-10,84 = 1,5(v_f - 0)$ ✓

$v_f = -7,23\ m \cdot s^{-1}$

$Speed = 7,23\ m \cdot s^{-1}$ ✓

Left positive

$\Delta p_A = m(v_f - v_i)$

$10,84 = 1,5(v_f - 0)$ ✓

$v_f = 7,23\ m \cdot s^{-1}$

$Speed = 7,23\ m \cdot s^{-1}$ ✓

(2)

[12]

WORK, ENERGY AND POWER

QUESTION 1

1.1 $E_k = \frac{1}{2} mv^2$ ✓ $= \frac{1}{2}(2)(4{,}95)^2$ ✓ $= 24{,}50$ J ✓ (3)

1.2 **OPTION 1**

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

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

OPTION 2

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

$-[(5)(9{,}8)(\frac{1}{4}h) - (5)(9{,}8)h]$ ✓ $= 24{,}50$ ✓
∴ $h = 0{,}67$ 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)

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

1.4 **OPTION 1**

$W_{net} = \Delta E_K$ ✓
$W_f + mg\Delta y\cos\theta = \frac{1}{2}m(v_f^2 - v_i^2)$
$W_f + (2)(9{,}8)(0{,}5)\cos180°$ ✓ $= \frac{1}{2}(2)(2^2 - 4{,}95^2)$ ✓
$= -10{,}7$ J ✓

OPTION 2

$W_{nc} = \Delta E_K + \Delta U$
$W_{nc} = \Delta E_K + \Delta E_P$ } ✓
$W_f = \frac{1}{2}(2)(2^2 - 4{,}95^2)$ ✓ $+ (2)(9{,}8)(0{,}5-0)$ ✓
∴ $W_f = -10{,}7$ J ✓ (4)

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QUESTION 2

2.1 $W_{net} = \Delta K$
$W_{net} = \frac{1}{2}(M + m)(v_f^2 - v_i^2)$ } ✓

$W_{fr} = f\Delta x\cos\theta$ ✓ $= \frac{1}{2}(M + m)(v_f^2 - v_i^2)$
$10 \times 2\cos180$ ✓ $= \frac{1}{2}(7{,}02)(0 - v_i^2)$ ✓
$v_{bb} = 2{,}39$ m·s^{-1} ✓ (2,387) m·s^{-1} (5)

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

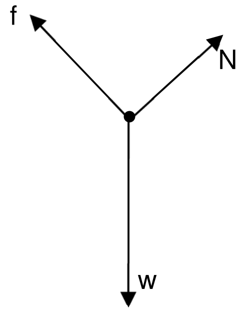
2.3 **POSITIVE MARKING FROM QUESTION 8.1.**

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

[11]

QUESTION 3

3.1



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)

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

3.3 **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
$(50)(25\cos180°)$ ✓ $+ (60)(9{,}8)(25\cos70°)$ ✓ $= \frac{1}{2}(60)(15^2 - v_i^2)$ ✓
$-1\ 250 + 5\ 027{,}696 = 6\ 750 - 30v_i^2$ ∴ $v_i = 9{,}95(4)$ 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
$(50)(25\cos180°)$ ✓ $+ (60)(9{,}8\sin20°)(25\cos0°)$ ✓ $= \frac{1}{2}(60)(15^2 - v_i^2)$ ✓
$-1\ 250 + 5\ 027{,}696 = 6\ 750 - 30v_i^2$ ∴ $v_i = 9{,}95(4)$ 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)(25cos180°) ✓= ½(60)(15² – v_i^2) ✓ + (60)(9,8)(-25sin 20°) ✓

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

3.4 **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

$= \frac{[50(25\cos 180°)]}{2,004}$ ✓ ✓ = - 623,75 W✓

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

$25 = \frac{(9,954+15)}{2}\Delta t$ ✓

Δt = 2,004 s

(4)

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QUESTION 4

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

4.2.1 **OPTION 1**

W = FΔxcosθ✓

$W_{gravity}$ = mgΔycosθ = (1 200)(9,8)(55)cos180° ✓ = - 646 800 J (6,47 x10^5 J)✓

OPTION 2

W = - ΔE_p✓ = -(1200)(9,8)(55 -0) ✓ = -646800 J ✓ (3)

4.2.2 $W_{counterweight}$ = mgΔycosθ = (950)(9,8)(55)cos0° ✓ = 512 050 J ✓ (5,12 x10^5 J) (2)

4.3 **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

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

OPTION 2

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

-117600✓ + 9310✓ + F_{motor} = 0 ∴ 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)

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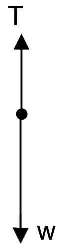
QUESTION 5

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

5.2



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

(2)

5.3

W_w = wΔxcosθ✓ = mgΔxcosθ = (6)(9,8)(1,6)cos0°✓ ∴W = 94,08 J ✓	W_w = - ΔE_P ✓= - mg(h_f – h_i) = - (6)(9,8)(0 – 1,6) ✓ = 94,08 J✓

(3)

5.4

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

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

$W_{net} = ½m(v_f^2 – v_i^2)$ ∴ $\underline{68,992}$✓= $\underline{½(4)(v_f^2 – 0) + ½(6)(v_f^2 – 0)}$✓ ∴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

$\underline{(0,4)(4)(9,8)\ (1,6)\ \cos 180°}$ ✓= [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: $\underline{T(1,6)\cos0° + [(0,4)(9,8)(4)](1,6)\cos180°}$✓ = ½(4)$v^2$ – 0)

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

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

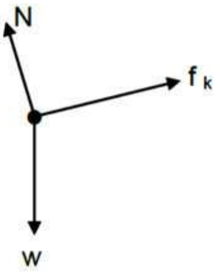
[12]

QUESTION 6

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

6.2 $E_{mech\ P} = E_{mech\ Q}$ **OR** $(E_p + E_k)_{Pe} = (E_p + E_k)_Q$ **OR** $W_{net} = \Delta E_K$ OR $W_{con} = \Delta E_K$ **OR**
$(mgh + ½\ mv^2)_P = (mgh + ½\ mv^2)_Q$ ✓
$\underline{(50)(9,8)3 + 0}$ ✓= $\underline{0 + ½(50)v^2}$✓ ∴ v = 7,67 m·s ✓ (4)

6.3



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

(3)

6.4 $f_k = \mu_k N$ **OR** $f_k = \mu_k mg\cos\theta$ ✓
$f_k = (0,08)(50)(9,8)\cos30°$ ✓= 33,95 N ✓ (3)

6.5 **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)
$\underline{1055,259 = ½\ (50)\ (v_f^2 – 7,668^2)}$ ✓
v_f = 10,05 m·s⁻¹✓ (5)

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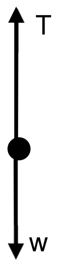
QUESTION 7

7.1



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

(2)

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

7.3 $W = F\Delta x\cos\theta$ / $W_w = mg\Delta x\cos\theta$ } ✓any one
$= \underline{75(9,8)(12)\cos 180°}$✓ $= -8\ 820$ J ✓
OR $W_w = -\Delta E_p$ ✓ $= -(mgh - 0) = -(75)(9,8)(12)$ ✓ $= -8\ 820$ J ✓ (3)

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

7.5
OPTION 1
$W_{net} = \Delta K$
$F_{net}\Delta x\cos\theta = (½ mv_f^2 - ½ mv_i^2)$ } ✓any one
$\underline{(75)(0,65)(12)}$ ✓$\cos 0°$ ✓ $= ½(75)(v_f^2 - 0)$ ✓
$\therefore v_f = 3,95\ m\cdot s^{-1}$ ✓

OPTION 2
$W_{net} = \Delta K$
$W_{nc} = \Delta K + \Delta U$ } ✓any one
$W_T + W_g = \Delta K$
$T - mg = ma$
$T - 75(9,8) = 75(0,65)$✓ $\therefore T = 783,75$ N
$W_T = 783,75\ (12)\cos 0°$✓ $= 9405$ J
$9405 - (8820) = ½\ (75)(v_f^2 - 0)$ ✓ $\therefore v_f = 3,95\ m\cdot s^{-1}$ ✓

$W_{nc} = (½ mv_f^2 - ½ mv_i^2) + (mgh_f - mgh_i)$
9405 ✓$= (½\ (75)v_f^2 - 0)$ ✓$+ (75)(9,8)(12 - 0)$ ✓
$v_f = 3,95\ m\cdot s^{-1}$ ✓
(5)
[13]

QUESTION 8

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

8.2 No ✓ (1)

8.3

OPTION 1	OPTION 2
$P = \frac{W}{\Delta t}$ ✓ $= \frac{4,8 \times 10^6}{(90)}$ ✓ $= 53\ 333,33$ W $= 5,33 \times 10^4$ W (53,33 kW) ✓	$\Delta x = \left(\frac{v_f + v_i}{2}\right)\Delta t$ $= \left(\frac{0 + 25}{2}\right)(90) = 1\ 125$ 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)

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

8.5
OPTION 1
$W_{net} = \Delta K$ ✓ **OR** $W_w + W_f + W_F = ½ mv_f^2 - ½ mv_i^2$ **OR**
$mg\Delta x\cos\theta + W_f + W_F = ½ mv_f^2 - ½ mv_i^2$
$\therefore \underline{(1\ 500)(9,8)200\cos 180°}$✓ $+ \underline{W_f + 4,8 \times 10^6}$ ✓$= \underline{½\ (1\ 500)(25^2 - 0)}$ ✓
$-2\ 940\ 000 + W_f + 4,8 \times 10^6 = 468\ 750$ $\therefore W_f = -1\ 391\ 250$ J $= -1,39 \times 10^6$ J ✓
OR
$W_{net} = \Delta K$✓ OR $W_w + W_f + W_F = ½ mv_f^2 - ½ mv_i^2$ OR $-\Delta E_p + W_f + W_F = ½ mv_f^2 - ½ mv_i^2$
$\therefore \underline{-(1\ 500)(9,8)(200 - 0)}$✓ $+ \underline{W_f + 4,8 \times 10^6}$ ✓$= \underline{½\ (1\ 500)(25^2 - 0)}$ ✓
$-2\ 940\ 000 + W_f + 4,8 \times 10^6 = 468\ 750$ $\therefore W_f = -1\ 391\ 250$ J $= -1,39 \times 10^6$ J ✓ (5)

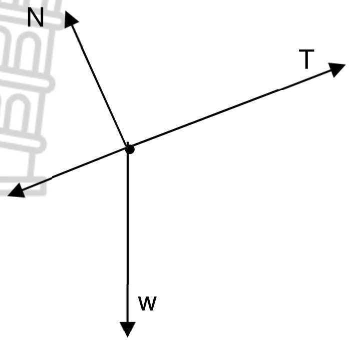
OPTION 2
$W_{nc} = \Delta K + \Delta U$ ✓ **OR** $W_{nc} = ½ mv_f^2 - ½ mv_i^2 + mgh_f - mgh_i = ½ m(v_f^2 - v_i^2) + mg(h_f - h_i)$ **OR**
$W_{nc} = ½ mv_f^2 + mgh_f - ½ mv_i^2 - mgh_i$ **OR** $W_f + W_F = ½ mv_f^2 - ½ mv_i^2 + mgh_f - mgh_i$ ✓
$\therefore \underline{W_f + 4,8 \times 10^6}$ ✓$= \underline{[½\ (1\ 500)(25)^2 + -0]}$ ✓$+ \underline{[(1\ 500)(9,8)(200) - 0]}$✓
$\therefore W_f = -1,39 \times 10^6$ J ($-1,40 \times 10^6$ J)✓
OR
$W_{nc} = \Delta K + \Delta U$ ✓ **OR** $W_{nc} = ½ mv_f^2 - ½ mv_i^2 + mgh_f - mgh_i = ½ m(v_f^2 - v_i^2) + mg(h_f - h_i)$ **OR**
$W_{nc} = ½ mv_f^2 + mgh_f - ½ mv_i^2 - mgh_i$
$\therefore \underline{W_f + 4,8 \times 10^6}$ ✓$= [\underline{½\ (1500)(25)^2}$ ✓$+ \underline{(1500)(9,8)(200)}$ ✓$] - [0 + 0]$ (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 9

9.1 Tension ✓

9.2 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)

9.3



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)

9.4 $W = F\Delta x\cos\theta$ ✓
$W_f = [178,22(4)\cos180^\circ]$ ✓
$= -712,88$ J ✓ (3)

9.5

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
$F_{net} = F_T - [mg\sin\theta + f_k]$
$= \underline{700 - [(70)(9,8\sin30^\circ) + 178,22]}$ ✓
$= 178,78$ N
$W_{net} = \Delta E_K$ ✓
$F_{net}\,.\,\Delta x\cos\theta = \Delta E_K$
$\underline{(178,78)(4)\cos0^\circ}$ ✓ = $\underline{\tfrac{1}{2}70(v_f^2 - 0)}$ ✓ $\therefore$ $v_f = 4,52$ m·s^{-1} ✓ (5)

9.6 $2(-712,88) = -1425,76$ J ✓ (1)

[15]

QUESTION 10

10.1 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)

10.2 Gravitational (force) ✓ (1)

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

10.4 $E_P = mgh$ ✓ = $\underline{(1,8)(9,8)(1,5)}$ ✓ = 26,46 J ✓ (3)

10.5

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

(4)

10.6 (W_{net} =) 0 J / zero ✓ (1)

[13]

QUESTION 11

11.1 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)

11.2

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

(3)

11.3

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

(4)

11.4

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

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

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

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

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

OPTION 3

$F_{net} = ma$ } ✓ Enige een
$F_{engine} + F_{friction} + F_{g//} = 0$

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

$F_{engine} = 907,17$ 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 12

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

12.2

$P = \frac{W}{\Delta t}$ ✓
$= \frac{\Delta mgh}{\Delta t}$
$= \frac{(1\ 250)(9,8)(5,8)}{60}$ ✓
$= 1\ 184,17\ W$ ✓

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)

12.3 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)

12.4 Non-conservate (1)

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

12.6

From R to the wall:	Into the wall
$(E_p + E_k)_R = (E_p + E_k)_{Bottom/Onder}$	$W_{net} = \Delta K$ ✓
$(mgh + ½ mv^2)_R = (mgh + ½ mv^2)_{Bottom/Onder}$	$F_{wall/muur}\ \Delta x\cos\theta = K_f - K_i$
$(1\ 250)(9,8)(5,8) + 0 = 0 + E_k$ ✓	$F_{wall/muur}\ (0,25)(\cos 180°)$ ✓ $= 0 - 71\ 050$ ✓
$E_k = 71\ 050$ J	$F_{wall/muur} = 284\ 200$ N ✓

(5)
[14]

QUESTION 13

13.1 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)

13.2

$(E_p + E_k)_p = (E_p + E_k)_p$ ✓

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

$v_f = 9,90\ m \cdot s^{-1}$ ✓

(3)

13.3

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)

13.4

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 14

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

14.2 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)

14.3

OPTION 1

$W_{net} = \Delta K$ ✓

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

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

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

$\Delta x = 96{,}64\ m$ ✓

OPTION 2

$W_{nc} = \Delta K + \Delta U$ ✓

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

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

$\Delta x = 96{,}64\ m$ ✓

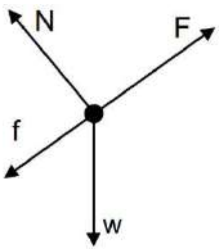
(5)

14.4 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 15

15.1 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)

15.2



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)

15.3

OPTION 1

$W_{nc} = \Delta K + \Delta U$ ✓

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

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

$= 559{,}58\ J$ ✓

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

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

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

(4)

15.4 **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)

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

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

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)

(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 16

16.1 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)

16.2

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)

16.3

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

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

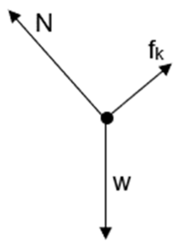
$P_{ave} = F_{ave}\left(\frac{\Delta x}{\Delta t}\right)$ ✓
$= \frac{(96,8)(15,6)}{5,23}$ ✓
$= 288,73\ W$ ✓

OR

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

(3)

16.4



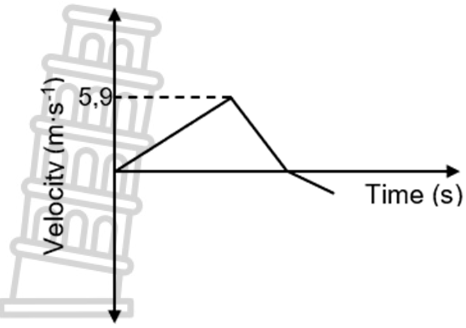
Accepted symbols

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

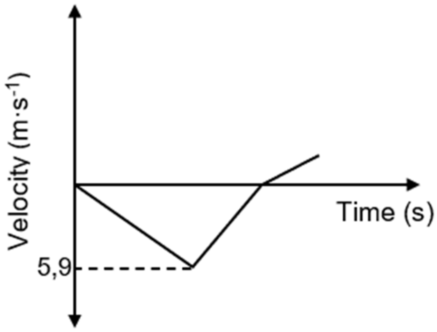
(3)

16.5

UPWARDS AS POSITIVE



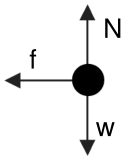
DOWNWARDS AS POSITIVE



(4)
[17]

QUESTION 17

17.1



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

(3)

17.2 Initial kinetic energy ✓ (1)

17.3 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)

17.4

OPTION 1

$W_{net} = \Delta K$ ✓

$f\Delta x\cos180° = K_f - K_i$

$-f(4{,}5)$✓ $= 0 - 18$ ✓

$\boldsymbol{OR}\ -f(3) = 0 - 12$

$\boldsymbol{OR}\ -f(1{,}5) = 0 - 6$

$f = 4\ N$

$f_k = \mu_k N$ ✓

$4 = (0{,}18)(m)(9{,}8)$ ✓

$m = 2{,}27\ kg$ ✓

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]

QUESTION 18

18.1 The total mechanical energy / sum of the gravitational potential energy and kinetic energy in an isolated system is conserved/ remains constant. ✓✓ **OR**
If the sum of the non-conservative forces is zero, then total mechanical energy/sum of the gravitational potential energy and kinetic energy is conserved/remains constant. (2)

18.2

OPTION 1

$(E_p + E_k)_B = (E_p + E_k)_A$ ✓

$\left(mgh + \frac{1}{2}mv^2\right)_B = \left(mgh + \frac{1}{2}mv^2\right)_A$

$0 + \frac{1}{2}(18)v_B^2 = (18)(9{,}8)(3) + 0$ ✓

$v_B = 7{,}67\ m\cdot s^{-1}$ ✓

OPTION 2

$W_{nc} = \Delta K + \Delta U$ ✓

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

$0 = \frac{1}{2}(18)v_f^2 - 0 + 0 - (18)(9{,}8)(3)$ ✓

$v_f = 7{,}67\ m\cdot s^{-1}$ ✓

OPTION 3
$W_{net} = \Delta K$ ✓
$mg\Delta y cos\theta = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$
$(18)(9{,}8)(3)(cos0°) = \frac{1}{2}(18)v_f^2 - 0$ ✓
$v_f = 7{,}67\ m \cdot s^{-1}$ ✓

(3)

18.3 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)

18.4

OPTION 1	**OPTION 2**
$W_{net} = \Delta K$ ✓	$W_{nc} = \Delta K + \Delta U$ ✓
$f\Delta x cos\theta = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$	$f\Delta x cos\theta = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 + mg\Delta h$
$(40{,}6)(\Delta x)(cos180°)$ ✓ $= 0 - \frac{1}{2}(18)(7{,}67^2)$ ✓	$(40{,}6)(\Delta x)(cos180°)$ ✓ $= 0 - \frac{1}{2}(18)v_f^2 + 0$ ✓
$\Delta x = 13{,}04\ m$ ✓ (Range: 13,03 ~ 13,04 m)	$\Delta x = 13{,}04\ m$ ✓ (Range: 13,03 ~ 13,04 m)

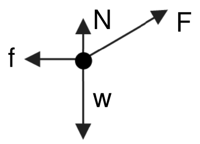
(4)

18.5 Smaller than ✓
Total mechanical energy / Gravitational potential energy (at **A**) is less. ✓
Velocity(speed) / Kinetic energy at **B** is less. / ΔE_k will be less from **B** to **C**. ✓ (3)
[14]

QUESTION 19

19.1 The work done on an object by a constant force *F* is $F\Delta x cos\theta$, where *F* is the magnitude of the force, Δx the magnitude of the displacement and θ the angle between the force and the displacement. ✓✓
OR
The work done on an object is the product of the force and the displacement of the object in the direction of the displacement. (2)

19.2



Accepted labels

w	F_w/F_g/mg/58,8 N/ gravitational force /weight
f	F_f/f_k/ (kinetic) friction
N	F_N/ Normal force
F	F_A/ Applied force

(4)

19.3

OPTION 1
$W_{net} = \Delta K$ ✓
$W_F + W_f = \Delta K$
$F\Delta x cos\Theta + f\Delta x cos\Theta = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$
$F(1{,}5)cos30° + (10)(1{,}5)cos180°$ ✓ $= \frac{1}{2}(6)(2^2) - \frac{1}{2}(6)(0^2)$ ✓
$F = 20{,}78\ N$ ✓

OPTION 2
$W_{nc} = \Delta K + \Delta U$ ✓
$W_F + W_f = \Delta K + \Delta U$
$F\Delta x cos\Theta + f\Delta x cos\Theta = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 + mgh_f - mgh_i$
$F(1{,}5)cos30° + (10)(1{,}5)cos180°$ ✓ $= \frac{1}{2}(6)(2^2) - \frac{1}{2}(6)(0^2) + 0 - 0$ ✓
$F = 20{,}78\ N$ ✓

(4)

19.4 Remains the same. ✓✓ (2)
[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 $v = f\lambda$ ✓ ∴ $340 = f(0{,}28)$ ✓ ∴ $f_s = 1\ 214{,}29$ Hz ✓ (3)

1.1.3 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ **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** $f_L = \left(\frac{340}{340 - 30}\right) \times \frac{340}{0{,}28}$ ∴ $f_L = 1\ 331{,}80$ Hz ✓ (5)

1.1.4 Decreases ✓ (1)

1.2 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 2

2.1 Speed ✓ (1)

2.2 3 $m \cdot s^{-1}$ ✓ (1)

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

2.3.2 345 $m \cdot s^{-1}$ ✓ (1)

2.3.3 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓ $= \left(\frac{345 + 0}{345 - 57{,}5}\right) \left(\frac{1000}{1}\right) = 1\ 200$ Hz ✓ ✓ ✓ (4)

2.3.4 295 ✓ (K) (1)

2.4.1 Diagram 3 ✓ (1)

2.4.2 1 ✓ The source is stationary. ✓ (2)

[13]

QUESTION 3

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

3.1.2 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ **OR** $f_L = \frac{v}{v - v_s} f_s$ ✓

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

3.2 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 4

4.1.1 Doppler effect ✓ (1)

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

4.1.3 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ **OR** $f_L = \frac{v}{v - v_s} f_s$ **OR** $f_L = \frac{v}{v + v_s} f_s$ ✓

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

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

4.1.4 (a) Increase ✓ (1)

(b) Decrease ✓ (1)

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

4.2.2 Decrease ✓ (1)

[13]

QUESTION 5

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

5.2.1 170 Hz ✓ (1)

5.2.2 130 Hz ✓ (1)

5.3 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓

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

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

$v_s = 45{,}33\ m\cdot s^{-1}$ ✓ (45,33 – 45,45 m·s⁻¹) (6)

[10]

QUESTION 6

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

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

6.3

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

FOR A:

$690 = \frac{340}{340 - v_s} f_s$ ✓ ✓ (1)

FOR B:

$610 = \frac{340}{340 + v_s} f_s$ ✓ ✓ (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)

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

[11]

QUESTION 7

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

7.2

OPTION 1

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

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

7.3 Greater than ✓ (1)

[10]

QUESTION 8

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

8.2 Away from ✓ Observed frequency lower ✓ (2)

8.3 $v = f\lambda$ ✓ ∴ $340 = f\ (0{,}34)$ ✓ ∴ $f = 1\ 000$ Hz ✓ (3)

8.4

OPTION 1

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

$950 = \frac{340 - v_L}{340 + 0}\ 1\ 000$ ✓ ✓ ✓ ∴ $v_L = 17\ m\cdot s^{-1}$

Distance $x = v\Delta t = (17)(10)$ ✓ = 170 m ✓

OPTION 2

$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓ **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 9

9.1.1 $\Delta x = v_i\Delta t + \frac{1}{2} a\Delta t^2$ **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)

9.1.2 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)

9.1.3 Car/source (just) passes observer. ✓✓ (2)

9.1.4 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓ **OR** $f_L = \frac{v}{v - v_s} f_s$

932 ✓ $= \frac{340}{340-30}$ ✓ f_s ∴ f_s = 849,76 Hz ✓ (4)

9.2 **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 10

10.1 Doppler effect ✓ (1)

10.2 P registers a shorter period/higher frequency./Q registers a longer period/lower frequency. ✓ (1)

10.3 $f = \frac{1}{T}$ ✓ $= \frac{1}{17 \times 10^{-4}}$ ✓ $= 5{,}88 \times 10^{2} = 588{,}24$ Hz ✓ (3)

10.4 $f = \frac{1}{18 \times 10^{-4}}$ ✓ $= 5{,}56 \times 10^{2} = 555{,}56$ Hz

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

$555{,}56$ ✓ $= \frac{340}{340+v}$ ✓ $588{,}24$ ✓ ∴ v = 20 m·s^{-1} ✓ (6)

[11]

QUESTION 11

11.1 The <u>change in frequency</u>✓ <u>(or pitch)</u> (of the sound) detected by a listener because <u>the source and the listener have different velocities relative to the medium of propagation</u>. ✓ **OR**
<u>An (apparent) change in (observed/detected) frequency (pitch)</u>, as a result of the <u>relative motion</u> between <u>a source and an observer</u> (listener). (2)

11.2 Towards (1)

11.3

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

$3\ 148$ ✓ $= \frac{340 + 0}{340 - v_s} f_s$ ✓

$2\ 073$ ✓ $= \frac{340 - 0}{340 + v_s} f_s$ ✓

Solve for v_s: ∴ v_s = 70 m·s^{-1} ✓ (6)

11.4

OPTION 1	**OPTION 2**	**OPTION 3**
$\Delta t = \frac{\Delta x}{v}$ $\Delta t = \frac{350}{70}$ ✓ $\Delta t = 5\ s$ ✓	$\Delta x = v_i\Delta t + \frac{1}{2} a\Delta t^2$ <u>$350 = 70\Delta t + 0$</u> ✓ Δt = 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 12

12.1 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)

12.2.1 700 Hz ✓
Learner's speed is zero. / No relative motion between source and listener. / Listener and source are stationary. ✓ (2)

12.2.2 Away ✓ The observed frequency is smaller than the source frequency. ✓ (2)

12.2.3

$f_L = \frac{v \pm v_L}{v \pm v_S} f_S$ ✓ $679{,}1$ ✓ $= \frac{v - 10}{v}$ ✓(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 13

13.1
$v = \lambda f$ ✓
$340 = 680\lambda$ ✓
$\lambda = 0{,}5\ m$ ✓
(3)

13.2 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)

13.3.1 Decreased ✓ (1)

13.3.2 Increased ✓ (1)

13.4

$$f_L = \frac{v}{\lambda_L}$$
$$= \frac{340}{0{,}5 - 0{,}05} \checkmark$$
$$= 755{,}56\ Hz$$
$$f_L = \frac{v \pm v_L}{v \pm v_S} f_S \checkmark$$
$$755{,}56 = \left[\frac{340 + 0}{340 - v_S}\right](680) \checkmark\checkmark$$
$$v_S = 34\ m \cdot s^{-1} \checkmark$$

(5)
[12]

QUESTION 14

14.1 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)

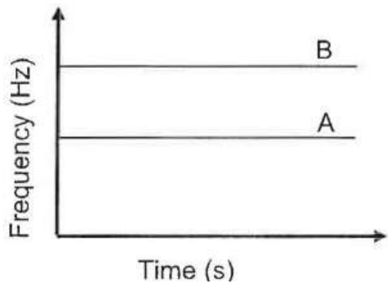
14.2
$v = \lambda f$ ✓
$340 = \lambda(880)$ ✓
$\lambda = 0{,}386\ m$ ✓
(3)

14.3

$$f_L = \left(\frac{v \pm v_L}{v \pm v_S}\right) f_S \checkmark$$
$$= \left(\frac{340 + 10}{340}\right) \checkmark (880) \checkmark$$
$$= 905{,}882\ Hz \checkmark$$

(4)

14.4



(2)
[11]

QUESTION 15

15.1 Doppler effect ✓ (1)

15.2 Measurement of foetal heartbeat. **OR** Measurement of blood flow. **OR** Doppler flow meter ✓ (1)

15.3 Directly proportional **OR** $f_L \propto f_S$ ✓ (1)

15.4

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

$Gradient = \frac{\Delta f_L}{\Delta f_S}$

$1{,}06$ ✓✓ $= \frac{f_L - 0}{f_S - 0}$

$f_L = 1{,}06 f_S$

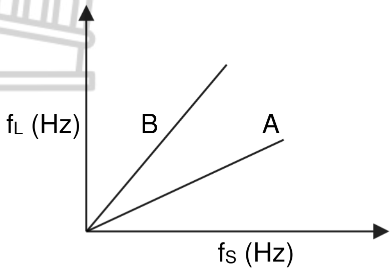
$f_L = \left(\frac{v \pm v_L}{v \pm v_S}\right) f_S$ ✓

$1{,}06 f_S$ ✓✓ $= \left(\frac{340 + v_L}{340}\right) f_S$ ✓

$v_L = 20{,}4\ m \cdot s^{-1}$ ✓

(5)

15.5



Straight line starting at the origin. ✓
Gradient of **B** is greater than gradient of **A**. ✓

(2)
[10]

QUESTION 16

16.1.1 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)

16.1.2

$f_L = \left(\frac{v \pm v_L}{v \pm v_S}\right) f_S$ ✓

$= \left(\frac{340 + 22}{340}\right)$ ✓$(24\ 000)$✓

$= 25\ 552{,}941\ Hz$

$f_L = \left(\frac{v \pm v_L}{v \pm v_S}\right) f_S$

$= \left(\frac{340}{340 - 22}\right)$ ✓$(25\ 552{,}941)$✓

$= 27\ 320{,}75\ Hz$ ✓

(6)

16.2 The frequencies of the spectral lines have decreased. ✓✓ (2)
[10]

QUESTION 17

17.1.1 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)

17.1.2

$f_L = \left[\frac{v \pm v_L}{v \pm v_S}\right] f_S$ ✓

$512{,}64$ ✓ $= \left[\frac{v}{v + 25}\right]$ ✓(550)✓

$v = 343{,}04\ m \cdot s^{-1}\ to\ 332{,}14\ m \cdot s^{-1}$ ✓

(5)

17.1.3 (a) Remains the same. (1)
(b) Remains the same. (1)
(c) Increases. (1)

17.2.1 Away from (1)

17.2.2 A lower frequency / longer wavelength ✓ is detected.
This lower frequency / longer wavelength corresponds to the red end of the spectrum ✓. (2)
[13]

QUESTION 18

18.1 It is the (apparent) change in frequency/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

$f_L = \left[\frac{v \pm v_L}{v \pm v_S}\right] f_S$ ✓

Moving towards observer: $615 = \left[\frac{v}{v-26}\right] f_S$ ✓ Moving away from observer: $526 = \left[\frac{v}{v+26}\right] f_S$ ✓

$\frac{615(v-26)}{v} = \frac{526(v+26)}{v}$ ✓

$v = 333{,}33\ m \cdot s^{-1}\ to\ 331{,}88\ m \cdot s^{-1}$ ✓

(5)

18.3

$f_L = \left[\frac{v \pm v_L}{v \pm v_S}\right] f_S$

$615 = \left[\frac{333{,}33}{333.33-26}\right] f_S$ ✓ **OR** $526 = \left[\frac{333.33}{333.33+26}\right] f_S$ ✓

$f_S = 567{,}03\ Hz$

$v = \lambda f$ ✓

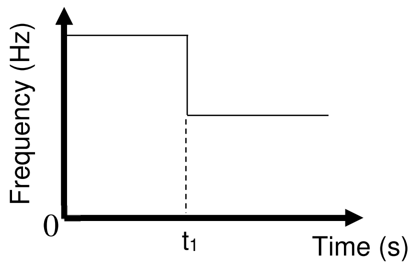
$333{,}33 = \lambda(567{,}03)$

$\lambda = 0{,}59\ m$ ✓

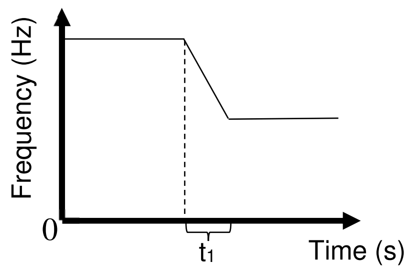
Range: 0,585 m ~ 0,59 m

(4)

18.4



OR



Criteria for graph	
The lines before and after t_1 are horizontal. If this criterion is not met: 0/3	✓
The frequency after t_1 is less than before t_1.	✓
Time t_1 correctly indicated where the frequency changes if everything else is correct.	✓

(3)
[14]

QUESTION 19

19.1 Doppler Effect ✓ (1)

19.2 Away from. ✓
Frequency detected by the listener is lower than the frequency of the source. **OR** $f_L < f_S$ **OR** Wavelength of sound detected/observed by the listener is longer than wavelength of sound emitted by the source. **OR** $\lambda_L > \lambda_S$ ✓ (2)

19.3.1

$v = \lambda f_S$ ✓

$343 = 0{,}38 f_S$ ✓

$f_S = 902{,}63\ Hz$ ✓

(3)

19.3.2

$f_L = \left[\frac{v \pm v_L}{v \pm v_S}\right] f_S$ ✓

$\frac{343}{0{,}4}$ ✓✓ $= \left[\frac{343+0}{343+v_S}\right] 902{,}63$ ✓✓ Range: 18,05 $m \cdot s^{-1}$ ~ 18,45 $m \cdot s^{-1}$

$v_S = 18{,}05\ m \cdot s^{-1}$ ✓

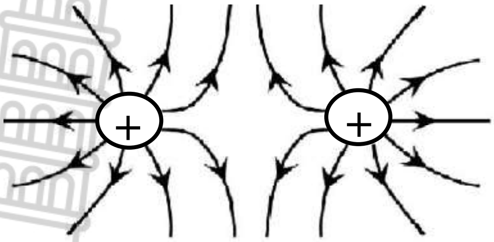
(6)
[12]

ELECTROSTATICS

QUESTION 1

1.1 The (electrostatic) force experienced by a unit positive charge (placed at that point). ✓✓ (2)

1.2



Marking guidelines	
Lines must not cross / Lines must touch the spheres but not enter spheres	✓
Arrows point outwards	✓
Correct shape	✓

(3)

1.3 $E = \frac{kQ}{r^2}$ ✓

$E_{Q1X} = \frac{(9\times10^9)(30\times10^{-6})}{(x)^2}$ ✓ & $E_{Q2X} = \frac{(9\times10^9)(45\times10^{-6})}{(0{,}15+x)^2}$ ✓

$E_{net} = 0 \quad \therefore E_{Q1X} = E_{Q2X} \therefore \frac{(9\times10^9)(30\times10^{-6})}{(x)^2} = \frac{(9\times10^9)(45\times10^{-6})}{(0{,}15+x)^2}$ ✓

$\therefore x = 0{,}67$ m ✓ (0,667 m) (5)

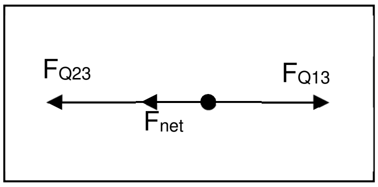
[10]

QUESTION 2

2.1 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)

2.2.1 Negative ✓✓ (2)

2.2.2 $F = k\frac{Q_1Q_3}{r^2}$ ✓



$0{,}012 = \frac{(9\times10^9)Q_1(2\times10^{-6})}{(2{,}5)^2}$ ✓ $\therefore Q_1 = 4{,}17 \times 10^{-6}$ 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 3

3.1.1 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)

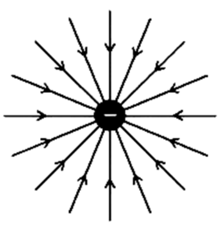
3.1.2 F_E/Electrostatic force ✓ (1)

3.1.3 The electrostatic force is inversely proportional to the square of the distance between the charges. ✓ (1)

3.1.4 Slope $= \frac{\Delta F_E}{\Delta \frac{1}{r^2}}$ ✓ $= \frac{0{,}027 - 0}{5{,}6 - 0}$ ✓ $= 4{,}82 \times 10^{-3}$ N·m²

Slope $= F_E r^2 = kQ_1Q_2 = kQ^2$ ✓ $\therefore 4{,}82 \times 10^{-3}$ ✓ $=$ <u>$9 \times 10^9\ Q^2$</u> ✓ $\therefore Q = 7{,}32 \times 10^{-7}$C ✓ (6)

3.2.1



Criteria for drawing electric field:	
Direction	✓
Field lines radially inward	✓

(2)

3.2.2 $E = \frac{kQ}{r^2}$ ✓

Right as positive:

$E_{PA} = \frac{(9\times10^9)(0,75\times10^{-6})}{(0,09)^2}$ ✓ = 8,33 x 10^5 N·C^{-1} to the left

$E_{PB} = \frac{(9\times10^9)(0,8\times10^{-6})}{(0,03)^2}$ ✓ = 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} ✓

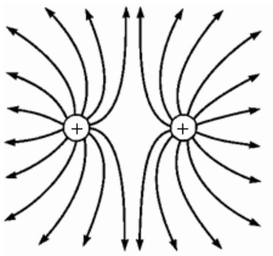
Left as positive: $E_{net} = E_{PA} + E_{PC}$ = <u>(8,33 x 10^5 + 8 x 10^6)</u> ✓✓ = 8,83 x 10^6 N·C^{-1} ✓ (5)

[17]

QUESTION 4

4.1 Electric field is a region of space in which an electric charge experiences a force. ✓✓ (2)

4.2



Marking criteria	
Correct shape as shown.	✓
Direction away from positive	✓
Field lines start on spheres and do not cross.	✓

(3)

4.3 $E_{PA} = \frac{kQ}{r^2}$ ✓ $= \frac{(9\times10^9)(5\times10^{-6})}{(1,25)^2}$ ✓ = 2,88 x 10^4 N·C^{-1} to the right

$E_{PB} = \frac{kQ}{r^2} = \frac{(9\times10^9)(5\times10^{-6})}{(0,75)^2}$ ✓ = 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]

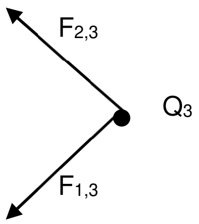
QUESTION 5

5.1.1 Removed ✓ (1)

5.1.2 $n = \frac{Q}{e}$ ✓ $= \frac{6\times10^{-6}}{1,6\times10^{-19}}$ ✓ = 3,75 x 10^{13} ✓electrons (3)

5.2.1 Negative ✓ (1)

5.2.2



(2)

5.2.3 $F = \frac{kQ_1Q_2}{r^2}$ ✓

$F_{1,3x} = \frac{(9\times10^9)(2\times10^{-6})(6\times10^{-6})}{r^2}(\cos 45°)$ ✓ $= \frac{(0,0764)}{r^2}$ ✓ *(3)*

5.2.4 $F = \frac{kQ_1Q_2}{r^2}$

$F_{2,3x} = \frac{(9\times10^9)(2\times10^{-6})(6\times10^{-6})}{r^2}$ ✓ $(\cos 45°) = \frac{0,0764}{r^2}$

$F_x = F_{1,3x} + F_{2,3x}$

$F_x = \frac{0,0764}{r^2} + \frac{0,0764}{r^2} = 2\frac{0,0764}{r^2}$ ✓ Addition

NOTE: $F_{y\ net} = 0$

(0,12) ✓ $= \frac{0,1528}{r^2}$ ∴ r = 1,128 m ✓ (4)

5.3.1 The electric field at a point is the (electrostatic) force experienced ✓ per unit positive charge ✓ placed at that point. (2)

5.3.2 $E = \frac{kQ}{r^2}$ ✓ $\therefore\ 100 = \frac{(9\times10^9)Q}{(0,6)^2}$ ✓ $\therefore$ Q = 4 x 10^{-9} C

When the electric field strength 50 is $N\cdot C^{-1}$:

$E = \frac{kQ}{r^2}\ \therefore\ 50 = \frac{(9\times10^9)(4\times10^{-9})}{r^2}$ ✓ ✓ equation

$\therefore$ r = 0,85 m ✓ (0,845) m (5)

[21]

QUESTION 6

6.1 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)

6.2 **OPTION 1**

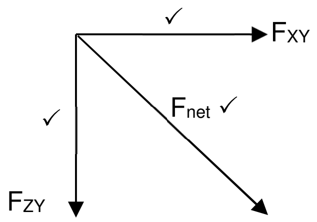
$F = \frac{kQ_1Q_2}{r^2}$ ✓ $= \frac{(9\times10^9)(6\times10^{-6})(8\times10^{-6})}{(0,2)^2}$ ✓ ✓ = 10,8 N ✓

OPTION 2

Both ✓ { $E = \frac{kQ}{r^2} = \frac{(9\times10^9)(8\times10^{-6})}{(0,2)^2}$ ✓ = 1,8 x 10^4 $N\cdot C^{-1}$

F = Eq = (1,8 x 10^4)(6 x 10^{-6}) ✓ = 10,8 N ✓ (4)

6.3



Marking criteria	
$F_{Z\ op\ Y}$ if correct direction	✓
$F_{X\ op\ Y}$ if correct direction	✓
Resultant vector	✓

(3)

6.4 **OPTION 1**

$F_{net}^2 = F_{XY}^2 + F_{ZY}^2$
$15{,}20^2 = 10{,}8^2 + F_{ZY}^2$ } ✓ Any one

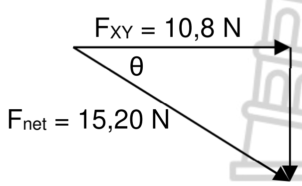
F_{ZY} = 10,696 N

$F_{ZY} = k\frac{Q_ZQ_Y}{r^2}\ \therefore\ 10{,}696$ ✓ $= 9\times10^9 \times \frac{8\times10^{-6}\times Q_Z}{(0{,}30)^2}$ ✓ $\therefore$ Q_Z = 1,34 x 10^{-5} C ✓

OPTION 2

$\cos\theta = \frac{10{,}8}{15{,}2}\ \therefore\ \theta = 44{,}72^\circ$

$\sin 44{,}72 = \frac{F_{ZY}}{15{,}2}$ ✓ **OR** $\tan 44{,}72 = \frac{F_{ZY}}{F_{XY}}$



$\therefore\ F_{ZY}$ = 10,696 N

$F_{ZY} = k\frac{Q_ZQ_Y}{r^2}$

$\therefore 10{,}696$ ✓ $= 9\times10^9 \times \frac{8\times10^{-6}\times Q_Z}{(0{,}30)^2}$ ✓

$\therefore$ Q_Z = 1,34 x 10^{-5} C ✓ (4)

[13]

QUESTION 7

7.1 Electric field at a point is the force per unit positive charge placed at that point. ✓✓ (2)

7.2 $E = \frac{kQ}{r^2}$ ✓

$E_{net} = (E_A + E_B)$

$= 9\times10^9 \frac{(1{,}5\times10^{-6})}{(0{,}4)^2} + 9\times10^9 \frac{(2{,}0\times10^{-6})}{(0{,}3)^2}$ ✓ ✓

$= 2{,}84 \times 10^5$ N·C^{-1} ✓ (4)

7.3 $F_E = qE$ ✓

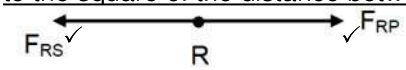
$= (3{,}0 \times 10^{-9})(2{,}84 \times 10^5)$ ✓

$= 8{,}52 \times 10^{-4}$ N ✓ (3)

[9]

QUESTION 8

8.1 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)

8.2 

(2)

8.3 To the right as positive:

$F = k\frac{Q_1Q_2}{r^2}$ ✓

$F_{netR} = F_{PR} + F_{SR}$

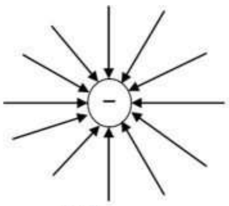
$F_{net} = \frac{kQ_1Q_2}{r^2} + \frac{kQ_1Q_2}{r^2}$

$-1{,}27\times10^{-6} = \left\{\frac{(9\times10^9)(1{,}5\times10^{-9})(Q)}{(0{,}3)^2} - \frac{(9\times10^9)(2\times10^{-9})(Q)}{(0{,}2)^2}\right\}$ ✓ ✓ ✓

$-1{,}27 \times 10^{-6} = 150Q - 450Q$ ✓ ∴ $4{,}23 \times 10^{-9}$ C ✓ (7)

[11]

QUESTION 9

9.1 

Marking criteria:
Shape (radial) ✓
Polarity of A ✓

(2)

9.2 $E = \frac{kQ}{r^2}$ ✓

$3 \times 10^7 = \frac{(9\times10^9)(Q)}{(0{,}5)^2}$ ✓

$Q = 8{,}33 \times 10^{-4}$ C ✓ (3)

9.3 $Q = ne$ ✓

$= (10^5)(1{,}6\times10^{-19})$ ✓

$= 1{,}6 \times 10^{-14}$ C

$E = \frac{F}{Q}$ ✓

$3 \times 10^7 = \frac{F}{1{,}6\times10^{-14}}$ ✓

$F = 4{,}8 \times 10^{-7}$ 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 10

10.1 The two forces must be equal in magnitude ✓ but in opposite directions. ✓ (2)

10.2 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)

10.3 $F = k\frac{Q_1Q_2}{r^2}$ ✓

$F_{PQ} = \frac{(9\times10^9)(Q)(5\times10^{-6})}{(x)^2}$ ✓ $= \frac{45\times10^3Q}{x^2}$

$F_{VQ} = \frac{(9\times10^9)(Q)(7\times10^{-6})}{(1-x)^2}$ ✓ $= \frac{63\times10^3Q}{(1-x)^2}$

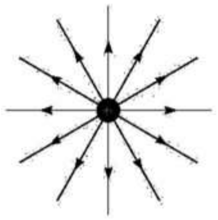
$(F_{net} = F_{PQ} - F_{VQ} = 0)$

$\frac{45\times10^3Q}{x^2} = \frac{63\times10^3Q}{(1-x)^2}$ ✓ ∴ 6,708(1 - x) = 7,937x ∴ *x* = 0,46 m away from P (5)

[9]

QUESTION 11

11.1



Criteria for sketch	
Lines are directed away from the charge.	✓
Lines are radial, start on sphere and do not cross.	✓

(2)

11.2 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

$E = \frac{kQ}{r^2}$ ✓

$E = \frac{(9\times10^9)(6,8\times10^{-6})}{(0,5)^2}$ ✓

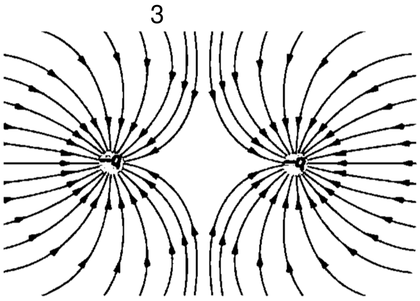
$= 2,45 \times 10^5\ N{\cdot}C^{-1}$ ✓ towards sphere ✓ (7)

[9]

QUESTION 12

12.1 $Q_{net} = \frac{Q_1+Q_2+Q_3}{3}$ ∴ $-3 \times 10^{-9} = \frac{-15\times10^{-9} + Q + 2\times10^{-9}}{3}$ ✓ ∴ $Q = +4 \times 10^{-9}$ C ✓ (2)

12.2



Correct shape ✓ Correct direction ✓ Lines must not cross and must touch spheres ✓

(3)

12.3 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)

12.4

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)

12.5 $E = \frac{F}{q}$ ✓ $= \frac{8,15\times10^{-6}}{3\times10^{-9}}$ ✓

= 2,72 x 10^3 N·C^{-1} ✓ (3)

12.6.1 Sphere P or T ✓ (1)

12.6.2 **SPHERE P:** $n_e = \frac{Q}{q_e}$ 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✓

SPHERE T:

$n_e = \frac{Q}{q_e}$ 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 13

13.1 The electric field at a point is the electrostatic force experienced per unit positive charge placed at that point. ✓✓ (2)

13.2 q_2 is positive ✓

The electric field due to q_1 points to the right because q_1 is negative. ✓ Since the net field is zero, the field due to q_2 must point to the left away from q_2, ✓ hence q_2 is positive.

OR Since E_{net} is zero, E_1 and E_2 are in opposite directions therefore q_1 and q_2 are oppositely charged. (3)

13.3 $E = k\frac{Q}{r^2}$ ✓

$E_{net} = 0$

$\therefore k\frac{q_1}{r_1^2} = k\frac{q_2}{r_2^2}$ **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)

13.4 The electrostatic force (of attraction/repulsion) between two point charges is directly proportional to the product of the charges and inversely proportional to the square of the distance between them. ✓✓ (2)

13.5 $F = \frac{kQ_1Q_2}{r^2}$ ✓

$F = \frac{(9\times10^9)(3\times10^{-9})(4,8\times10^{-8})}{(0,3)^2}$ ✓

= 1,44 x 10^{-5} N ✓ (3)

13.6 Yes ✓

Both charges are equal and positive ✓ (2)

[16]

QUESTION 14

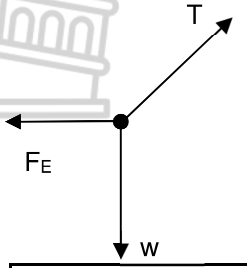
14.1.1 Positive ✓ (1)

14.1.2 $F = \frac{kQ_1Q_2}{r^2}$ ✓

$3{,}05 = \frac{(9\times10^9)(6\times10^{-6})Q}{0{,}2^2}$ ✓

$Q = 2{,}259 \times 10^{-6}$ C ✓ ($2{,}26 \times 10^{-6}$ C) (3)

14.1.3



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)

14.1.4

OPTION 1	**OPTION 2**
$F_{net} = 0$ $F_E = T\sin10°$ $F_E = T\cos80°$ } ✓Any one $3{,}05 = T\sin10°$ $= T\cos80°$ } ✓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)

14.2.1 The electric field at a point is the <u>(electrostatic) force</u> ✓ experienced <u>per unit positive charge</u> placed at that point. ✓ (2)

14.2.2 Electric field at **M** due to **A** ($+2 \times10^{-5}$ C):

$E_A = \frac{kQ}{r^2}$ ✓ $= 9\times10^9 \frac{(2\times10^{-5})}{(0{,}2)^2}$ ✓ $= 4{,}5 \times10^6$ N·C^{-1} (to the right)

Electric field at **M** due to **B** (-4×10^{-5} C):

$E_B = \frac{kQ}{r^2}$

$= 9\times10^9 \frac{(4\times10^{-5})}{(0{,}2)^2}$ ✓

$= 9 \times10^6$ N·C^{-1} (to the right)

OR

$q_B = 2x\ q_A$

$E_B = 2x\ E_A$✓

$= 9 \times 10^6$ N·C^{-1} (to the right)

E_{net} at **M** = $E_A + E_B$ = ($4{,}5 \times10^6 + 9 \times10^6$) ✓ = $1{,}35 \times10^7$ N·C^{-1} ✓ to the right ✓ (6)

[18]

QUESTION 15

15.1

$n = \frac{Q}{e}$ ✓

$= \frac{-4x10^{-6}}{-1{,}6x10^{-19}}$ ✓

$= 2{,}5x10^{13}$ ✓

A negative answer not accepted; substitute so that a positive answer is obtained.

(3)

15.2

$F = \frac{kQ_1Q_2}{r^2}$ ✓

$= \frac{(9x10^9)(4x10^{-6})(3x10^{-6})}{0{,}2^2}$ ✓

$= 2{,}7\ N$ ✓

(3)

15.3 Electric field is a <u>region</u> (in space) where (in which) an <u>(electric) charge experiences a (electric) force</u>. ✓✓ (2)

15.4

OPTION 1

Electric field at M due to: -4 x 10^{-6} C

$E_{AM} = \frac{kQ}{r^2}$ ✓

$= \frac{(9x10^9)(4x10^{-6})}{0,3^2}$ ✓

$= 4x10^5\ N \cdot C^{-1}\ (to\ left)$

Electric field at M due to: +3 x 10^{-6} C

$E_{BM} = \frac{kQ}{r^2}$

$= \frac{(9x10^9)(3x10^{-6})}{0,1^2}$ ✓

$= 2,7x10^6\ N \cdot C^{-1}\ (to\ right)$

Net electric field at M

$E_{net} = E_{BM} + E_{AM}$

= 4,0 x10^5 – 2,7 x10^6 ✓

= 2,3 x10^6 N·C^{-1} ✓(right)

OR

Net electric field at M

$E_{net} = E_{BM} + E_{AM}$

= -4,0 x10^5 + 2,7 x10^6 ✓

= - 2,3 x10^6 N·C^{-1}

= 2,3 x10^6 N·C^{-1} ✓ (right)

OPTION 2

$F_{AM} = \frac{kQ_1Q_2}{r^2}$

$= \frac{(9x10^9)(4x10^{-6})Q}{0,3^2}$ ✓

$= (4x10^5)(Q)$

$F_{BM} = \frac{kQ_1Q_2}{r^2}$

$= \frac{(9x10^9)(3x10^{-6})Q}{0,1^2}$ ✓

$= (2,7x10^6)(Q)$

F_{net} = 2,7 x 10^6Q + (-4 x 10^5Q)✓ = 2,3 x 10^6Q

$E = \frac{F}{Q}$ ✓

$= \frac{2,3x10^6 Q}{Q}$

$= 2,3x10^6\ N \cdot C^{-1}$ ✓ $(right)$

(5)

15.5 Positive (1)

15.6

$(F_{net})^2 = (F_{AD})^2 + (F_{AB})^2$
$(7,69)^2 = (F_{AD})^2 + (2,7)^2$ ✓
$F_{AD} = 7,2$ N
$F_{AD} = \frac{kQ_1Q_2}{r^2}$
$7,2 = \frac{(9 \times 10^9)(4 \times 10^{-6})Q}{0,15^2}$ ✓
$Q_D = 4,5 \times 10^{-6}\ C$ ✓

OR

$F_{AD} = \frac{kQ_1Q_2}{r^2}$
$= \frac{(9 \times 10^9)(4 \times 10^{-6})Q}{0,15^2}$ ✓
$= 1,6 \times 10^6\ Q$
$F_{net} = \sqrt{(F_{AB}^2 + F_{AD}^2)}$
$7,69 = \sqrt{2,7^2 + (1,6 \times 10^6 Q)^2}$ ✓
$Q = 4,50 \times 10^{-6}\ C$ ✓

(3)
[17]

QUESTION 16

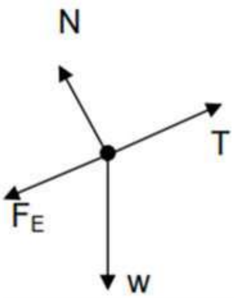
16.1 The magnitude of the electrostatic force exerted by one point charge (Q_1) on another point charge (Q_2) is directly proportional to the product of the (magnitudes) of the charges ✓ and inversely proportional to the square of the distance (r) between them. ✓ (2)

16.2

$F = \frac{kQ_1 Q_2}{r^2}$ ✓
$1,2 \times 10^{-3} = \frac{(9 \times 10^9)(6 \times 10^{-9})(5 \times 10^{-9})}{r^2}$ ✓
$r = 0,015\ m$ ✓

(3)

16.3



(4)

16.4.1

Up, parallel to the incline, is positive.
$F_{net} = ma$ ✓
$T + F_E + w_{II} = ma$
$T - 1,2 \times 10^{-3}$ ✓ $- (0,01)(9,8)(\sin 25°)$ ✓ $= 0$
$T = 0,04$ N ✓ (0,0426 N)

(4)

16.4.2

$E_{net} = E_R + E_S$ ✓
$E_{net} = \frac{kQ_R}{r^2} + \frac{kQ_S}{r^2}$
$= \frac{(9 \times 10^9)(5 \times 10^{-9})}{(0,015 + 0,03)^2}$ ✓ $- \frac{(9 \times 10^9)(6 \times 10^{-9})}{0,03^2}$ ✓
$= -37\ 777,78\ N \cdot C^{-1}$
$E_{net} = 37\ 777,78\ N \cdot C^{-1}$ ✓ *down the incline* ✓

(5)
[18]

QUESTION 17

17.1.1 Added ✓ (1)

17.1.2

$n = \frac{Q}{q_e}$ ✓
$= \frac{-1,95 \times 10^{-6}}{-1,6 \times 10^{-19}}$ ✓
$= 1,22 \times 10^{13}$ ✓

(3)

17.1.3 The (electrostatic) force experienced per unit positive charge placed at that point. ✓✓ (2)

17.1.4
$$E = \frac{kQ}{r^2} \checkmark$$
$$= \frac{(9x10^9)(1,95x10^{-6})}{0,5^2} \checkmark$$
$$= 7,02x10^4\ N \cdot C^{-1} \checkmark$$
(3)

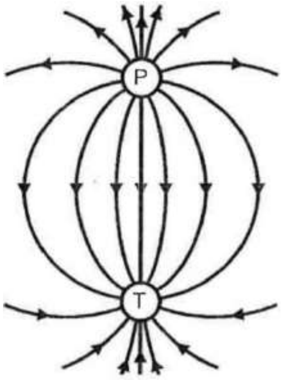
17.2
WEST +

$$F_{net} = F_{q2} + F_{q1}$$
$$= \left(+\frac{kQ_1Q_2}{r^2}\right) + \left(-\frac{kQ_1Q_2}{r^2}\right) \checkmark$$
$$1,38 \checkmark = \left(+\frac{(9x10^9)(1,95x10^{-6})q_2}{0,03^2}\right) + \left(-\frac{(9x10^9)(1,95x10^{-6})q_2}{0,05^2}\right) \checkmark\checkmark$$
$$q_2 = 1,11x10^{-7}\ C \checkmark$$
(5)
[14]

QUESTION 18

18.1.1 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)

18.1.2



(3)

18.1.3 Positive ✓ (1)

18.1.4
$$F_{net}^2 = F_{TP}^2 + F_{TS}^2$$
$$= \left(\frac{kQ_1Q_2}{r^2}\right)^2 \checkmark + \left(\frac{kQ_1Q_2}{r^2}\right)^2$$
$$10^2 = \left(\frac{(9x10^9)(3x10^{-6})(3x10^{-6})}{0,1^2}\right)^2 \checkmark + \left(\frac{(9x10^9)(3x10^{-6})Q_2}{0,15^2}\right)^2 \checkmark\checkmark$$
$$Q_2 = 4,887x10^{-6}\ C$$

$$Q_S = ne$$
$$4,887x10^{-6} = n(1,6x10^{-19}) \checkmark$$
$$n = 3,05x10^{13}\ electrons \checkmark$$
(6)

18.2.1
E is directly proportional to $\frac{1}{r^2}$.

OR

$E \propto \frac{1}{r^2}$ (1)

18.2.2
$$Gradient = \frac{\Delta E}{\Delta\left(\frac{1}{r^2}\right)} \checkmark$$
$$680 \checkmark = \frac{E_A - 0}{\left(\frac{1}{0,04^2}\right) - 0} \checkmark$$
$$E_A = 4,25x10^5\ N \cdot C^{-1} \checkmark$$
(4)

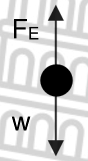
18.2.3 Greater than ✓
For the same $\frac{1}{r^2}$, E is greater for sphere **B**. ✓✓ (3)
[20]

QUESTION 19

19.1 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)

19.2 Negative ✓ (1)

19.3



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)

19.4

$$F = \frac{kQ_MQ_N}{r^2} ✓$$

$$(2{,}04x10^{-3})(9{,}8) ✓✓ = \frac{(9x10^9)(Q_M)(8{,}6x10^{-8})}{0{,}3^2} ✓$$

$$Q_M = 2{,}33x10^{-6}\ C ✓$$

(5)

19.5.1 Equal **OR** The same ✓ (1)

19.5.2 Opposite **OR** upwards ✓ (1)

19.6

<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 $E = \frac{kQ}{r^2}$ ✓

$$E_{net} = E_M + E_N$$

$$E_{net} = \frac{kQ_M}{r^2} + \frac{kQ_N}{r^2}$$

$$= -\frac{(9x10^9)(2{,}33x10^{-6})}{0{,}4^2} ✓ + \frac{(9x10^9)(8{,}6x10^{-8})}{0{,}1^2} ✓$$

$$= -5{,}37x10^4\ N \cdot C^{-1}$$

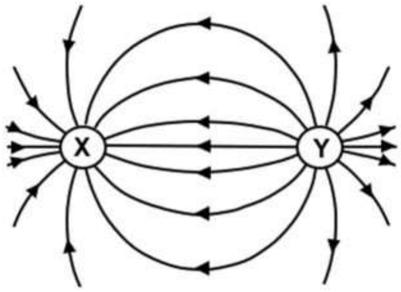
$$E_{net} = 5{,}37x10^4\ N \cdot C^{-1} ✓;\ upwards ✓$$

(5)
[17]

QUESTION 20

20.1 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)

20.2



Marking criteria
Correct shape ✓
Correct direction from **Y** to **X** ✓
Lines must not cross and must touch the spheres. ✓

(3)

20.3

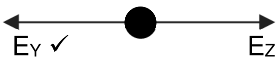
$$F = \frac{kQ_YQ_X}{r^2} ✓$$

$$= \frac{(9x10^9)(7{,}2x10^{-9})(7{,}2x10^{-9})}{0{,}03^2} ✓$$

$$= 5{,}184x10^{-4}\ C ✓$$

(3)

20.4



(2)

20.5

OPTION 1

$E_{net} = E_Z + E_Y$

$E_{net} = \frac{kQ_Z}{r^2} ✓ + \frac{kQ_Y}{r^2}$

$4,91x10^5 ✓ = \frac{(9x10^9)Q_Z}{0,01^2} - ✓ \frac{(9x10^9)(7,2x10^{-9})}{0,03^2} ✓$

$Q_Z = 6,25x10^{-9}\ C$ ✓

OPTION 2

$E = \frac{F}{Q}$ ✓

$4,91x10^5 = \frac{F}{7,2x10^{-9}}$

$F_{net} = 3,54x10^{-3}\ N$

$F_{net} = F_{Z\ on\ X} + F_{Y\ on\ X}$

$F_{net} = \frac{kQ_ZQ_X}{r^2} + \frac{kQ_YQ_X}{r^2}$

$3,54x10^{-3} ✓ = \frac{(9x10^9)(7,2x10^{-9})Q_Z}{0,01^2} ✓ - ✓ 5,18x10^{-4}$

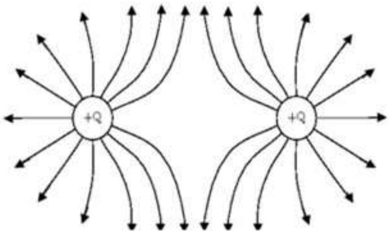
$Q_Z = 6,26x10^{-9}\ C$ ✓

(5)
[15]

QUESTION 21

21.1 Electric field is a region in space in which an electric charge experiences a force. ✓✓ (2)

21.2



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)

21.3

OPTION 1

$E = \frac{kQ}{r^2}$ ✓

$E_A = \frac{(9x10^9)(3x10^{-9})}{r^2}$ ✓

$E_B = \frac{(9x10^9)(3x10^{-9})}{(2r)^2}$ ✓

RIGHT AS POSITIVE

$E_{net} = E_A + E_B$

$27 = \frac{(9x10^9)(3x10^{-9})}{r^2} + \left[-\frac{(9x10^9)(3x10^{-9})}{(2r)^2}\right]$ ✓

$r = 0,87\ m$ ✓

OPTION 2

$F = \frac{kQ_1Q_2}{r^2}$ ✓

$F_A = \frac{(9x10^9)(3x10^{-9})(Q)}{r^2}$ ✓

$F_B = \frac{(9x10^9)(3x10^{-9})(Q)}{(2r)^2}$ ✓

RIGHT AS POSITIVE

$F_{net} = F_A + F_B$

$27Q = \frac{(9x10^9)(3x10^{-9})(Q)}{r^2} + \left[-\frac{(9x10^9)(3x10^{-9})(Q)}{(2r)^2}\right]$ ✓

$r = 0,87\ m$ ✓

(5)

21.4

OPTION 1

$F = EQ$ ✓

$= (27)(1,6x10^{-19})$ ✓

$= 4,32x10^{-18}\ N$ ✓

OPTION 2

$F = \frac{kQ_1Q_2}{r^2}$ ✓

RIGHT AS POSITIVE

$F_{net} = F_A + F_B$

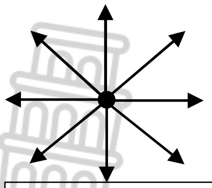
$= \frac{(9x10^9)(3x10^{-9})(1,6x10^{-19})}{0,87^2} + \left[-\frac{(9x10^9)(3x10^{-9})(1,6x10^{-19})}{(2x0,87)^2}\right]$ ✓

$= 4,28x10^{-18}\ m$ ✓

(3)
[13]

QUESTION 22

22.1.1



Criteria for sketch	
Correct shape	✓
Correct direction away from charge.	✓

(2)

22.1.2

$E = \frac{kQ}{r^2}$ ✓

$= \frac{(9x10^9)(4x10^{-9})}{0,025^2}$ ✓

$= 5,76x10^4\ N\cdot C^{-1}$ ✓

(3)

22.2.1 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)

22.2.2

OPTION 1

F_E ✓ $= wtan9°$

$= (0,012)(9,8)tan9°$ ✓

$= 0,0186\ N$

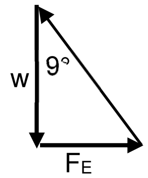
$F_E = \frac{kQ^2}{r^2}$ ✓

$0,0186 = \frac{(9x10^9)Q^2}{0,10^2}$ ✓

$Q = 1,44x10^{-7}\ C$

$Q_B = 2x1,44x10^{-4}$ ✓

$= 2,88x10^{-7}\ C$ ✓



OPTION 2

$w = mg$

$= (0,012)(9,8)$

$= 0,1176\ N$

$T_y = w$

$Tcos9° = 0,1176\ N$ ✓

$T = 0,1191\ N$

$F_E = T_x$

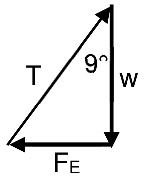
$\frac{kQ^2}{r^2}$ ✓ $= Tsin9°$ ✓

$\frac{(9x10^9)Q^2}{0,10^2} = (0,1191)sin9°$ ✓

$Q = 1,44x10^{-7}\ C$

$Q_B = 2x1,44x10^{-4}$ ✓

$= 2,88x10^{-7}\ C$ ✓



(6)

[13]

QUESTION 23

23.1

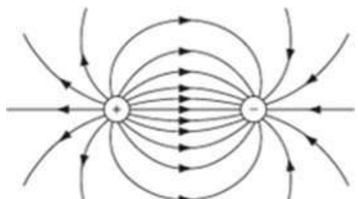
$E = \frac{kQ}{r^2}$ ✓

$= \frac{(9x10^9)(2x10^{-9})}{0,06^2}$ ✓

$= 5\ 000\ N\cdot C^{-1}$ ✓

(3)

23.2



Criteria

Correct direction of field lines.	✓
Correct shape of the electric field lines between charges and on the outside of the charges.	✓
No field lines crossing each other. Field lines must touch the charge, but not go inside the charge.	✓

(3)

23.3.1 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 their charges and inversely proportional to the square of the distance between them. ✓✓ (2)

23.3.2 Positive (1)

23.3.3

$F_{S\ on\ T} = \frac{kQ_1Q_2}{r^2}$ ✓

$= \frac{(9x10^9)(2x10^{-9})Q_T}{0,02^2}$

$= 45\ 000Q_T$

← ✓ →

$F_{P\ on\ T} = \frac{kQ_1Q_2}{r^2}$

$= \frac{(9x10^9)(2x10^{-9})Q_T}{0,06^2}$

$= 5\ 000Q_T$

Right as positive:

$F_{net} = F_{P\ on\ T} + F_{S\ on\ T}$

$-2,5x10^{-4}$ ✓ $= 5\ 000Q_T + (-45\ 000Q_T)$ ✓

$Q_T = 6,25x10^{-9}\ C$ ✓

OR

Left as positive:

$F_{net} = F_{P\ on\ T} + F_{S\ on\ T}$

$2,5x10^{-4}$ ✓ $= -5\ 000Q_T + 45\ 000Q_T$ ✓

$Q_T = 6,25x10^{-9}\ C$ ✓

(5)

[14]

ELECTRIC CIRCUITS

QUESTION 1

1.1.1 Maximum work done (or energy transferred) by a battery per unit charge passing through it. ✓✓ (2)

1.1.2 12 V ✓ (1)

1.1.3 0 V / Zero ✓ (1)

1.1.4

OPTION 1	OPTION 2
$\varepsilon = I(R + r)$ **OR** $\varepsilon = V_{ext} + V_{int}$ ✓ $12 = 11{,}7 + Ir$ $\underline{0{,}3 = I_{tot}(0{,}2)}$ ✓ $\therefore I_{tot} = 1{,}5$ A ✓	$V = IR$ ✓ $\underline{0{,}3 = I_{tot}(0{,}2)}$ ✓ $I_{tot} = 1{,}5$ A ✓

(3)

1.1.5 $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{10} + \frac{1}{15}$ ✓ $\therefore R = 6\ \Omega$ ✓ (2)

1.1.6

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)

1.2.1

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)

1.2.2

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 $V_T = IR_T$ $\underline{8{,}91 = (0{,}46)R_T}$ ✓ $\therefore R_T = 19{,}37\ \Omega$ ✓	$P = \frac{V^2}{R}$ ✓Any one $1{,}37 = \frac{3^2}{R}$ ✓ $R = 6{,}57\ \Omega$ $P = VI$ $\underline{1{,}37 = (3)I}$ ✓ $I = 0{,}46$ A $\varepsilon = I(R + r)$ $\underline{12 = 0{,}46(6{,}57 + R_T + 0{,}2)}$ ✓ $\therefore R_T = 19{,}38\ \Omega$ ✓

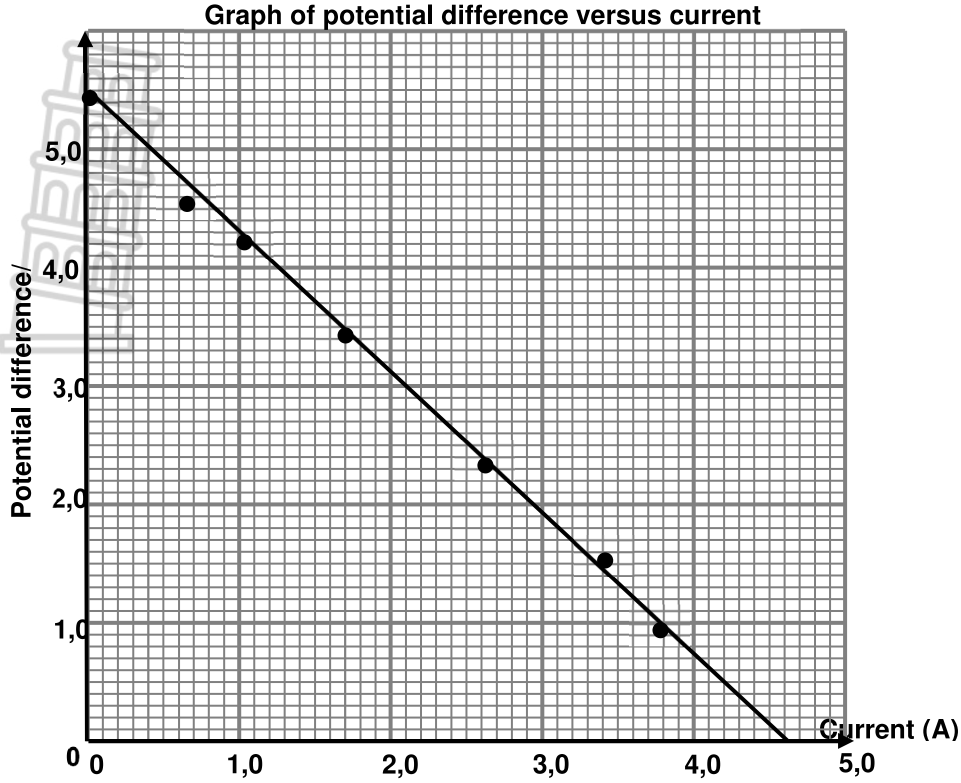
(5)
[21]

QUESTION 2

2.1.1 The potential difference across a conductor is directly proportional to the current in the conductor ✓ at constant temperature. ✓ (2)

2.1.2

Graph of potential difference versus current



Straight line passing through 4 or five points. ✓ Straight line with intercepts on both axes. ✓

(2)

2.1.3 5,5 V (Accept any value from 5,4 V to 5,6 V.) **NOTE:** The value must be the y-intercept. (1)

2.1.4 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)

2.2.1 V = IR ∴ 21,84 = I_{tot}(8) ✓ ∴ I_{tot} = 2,73 A ✓ (3)

2.2.2 $\frac{1}{R_{//}} = \frac{1}{R_{30}} + \frac{1}{R_{20}}$ ∴ $\frac{1}{R_{//}} = \frac{1}{30} + \frac{1}{20}$ ✓ ∴ $R_{//}$ = 12 Ω ✓ (2)

2.2.3

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)

2.2.4

OPTION 1 W = $\frac{V^2}{R}\Delta t$ ✓ W = $\frac{(54{,}6)^2}{20}(0{,}2)$ ✓ = 29,81 J✓	**OPTION 2** W = $I^2R\Delta t$✓ = $(2{,}73)^2$ (20)(0,2) ✓ = 29,81 J✓	**OPTION 3** W = VIΔt✓ = (54,6)(2,73)(0,2) ✓ = 29,81 J ✓

(3)
[20]

QUESTION 3

3.1.1 P and Q burn with the same brightness ✓ same potential difference/same current. ✓ (2)

3.1.2 **P** is dimmer (less bright) than **R.**/**R** is brighter than **P.**✓
R is connected across the battery alone therefore the voltage (terminal pd) is the same as the emf source (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)

3.1.3 **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)

3.2.1 $\frac{1}{R_{//}} = \frac{1}{R_5} + \frac{1}{R_{10}}$ ✓ $= \frac{1}{5} + \frac{1}{10}$ ∴ $R_{//}$ = 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	$R = R_8 + R_{//} = 8 + 3,33 = 11,33$ Ω
$I_{tot} = \frac{V}{R}$ ✓ $= \frac{20}{12,33}$ ✓ = 1,62 A	ε = I(R + r)✓ 20 = I[(11,33 + 1)✓] ✓ I = 1,62 A ✓
∴ I_8 = 1,62 A ✓	

(6)

3.2.2 **OPTION 1**
V = IR
$V_5 = ε – (V_8 + V_1)$ } ✓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 ✓

3.2.3

OPTION 1	**OPTION 2**
P = IV ✓	$P = I^2R$ ✓
= (1,62)(20) ✓	$P_{tot} = P_{8Ω} + P_{//} + P_{1Ω}$ $= I^2(R_8 + R_{//} + R_1)$
= 32,4 W ✓	$= (1,62)^2[8 + 3,33 + 1)]$ ✓ = 32,36 W ✓

(3)
[19]

QUESTION 4

4.1.1 The potential difference (voltage) across a conductor is <u>directly</u> proportional to the current in the conductor at <u>constant temperature</u>. ✓✓ (1)

4.1.2 Equivalent resistance ✓ (1)

4.1.3 Gradient $= \frac{\Delta V}{\Delta I} = \frac{2 - 0}{0,5 - 0}$ ✓ = 4 (Ω) ✓ **NOTE:** Any correctly chosen pair of coordinates. (2)

4.1.4

OPTION 1	**OPTION 2**
In series $R_1 + R_2 = 4$ Ω ✓................(1)	For graph X: $R_1 + R_2 = 4$ ✓ ....(1)
In parallel $\frac{R_1R_2}{R_1 + R_2} = 1$ Ω ✓✓ ....(2)	For graph Y: $\frac{1}{R_{//}} = \frac{1}{R_1} + \frac{1}{R_2}$
$R_1R_2 = 4$ Ω ∴ $R_1 = R_2 = 2$ Ω ✓	$\left\{\left(\frac{1}{R_1} + \frac{1}{R_2}\right) = \left(\frac{1}{1}\right)\right\}$ ✓✓...................(2) $R_1^2 - 4R_1 + 4 = 0$ ∴ R_1 = 2 Ω✓

(4)

4.2.1 $I = \frac{V}{R}$ ✓ $= \frac{5}{(R_M + R_N)} = \frac{5}{(6)}$ ✓ = 0,83 A ✓ (3)

4.2.2

OPTION 1	**OPTION 2**
ε = I(R + r) ✓ = 0,83[(6 +1,5) ✓+ 0,9✓]	$ε = (V_s + V_{//} + V_r)$ ✓ / $V_{ext} + V_{int}$
= 6,997 V = 7(,00) V ✓ (6,972 – 7,00 V)	= [5 + (0,833 x 1,5) ✓+ (0,9 x 0,833)] ✓✓ = 6,999 V = 7(,00) V ✓ (6,972 – 7,00 V)

(4)

4.2.3 The resistance R_N will be 3 Ω ✓
The voltage divides (proportionately) in a series circuit. <u>Since the voltage across **M** is half the total voltage, it means the resistances of **M** and **N** are equal.</u> ✓ (2)
[18]

QUESTION 5

5.1.1 The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature. (2)

5.1.2 Graph X. ✓ Graph X is a straight line (passing through the origin) therefore potential difference is directly proportional to current. ✓ (2)

5.2.1 $\frac{1}{R_{//}} = \frac{1}{R_{10}} + \frac{1}{R_{15}}$

$\frac{1}{R_{//}} = \frac{1}{10} + \frac{1}{15}$ ✓

$R_{//} = 6\ \Omega$

R = 10 + 6 + 2 ✓
= 18 Ω

$R = \frac{V}{I}$ ✓

$I = \frac{6}{18}$ ✓
= 0,33 A ✓ (5)

5.2.2 Decrease ✓
The total resistance of the circuit increases. ✓ (2)

5.2.3 Increase ✓ (1)

5.2.4 The total resistance in the external circuit increases, ✓
Current decreases ✓
"Lost" volts decreases ✓ (3)

[15]

QUESTION 6

6.1.1 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)

6.1.2 $V_1 = IR$ ✓ = (0,6)(4) ✓ = 2,4 V ✓ (3)

6.1.3

OPTION 1	**OPTION 2**	**OPTION 2**
$I_{6\Omega} = \frac{V}{F} = \frac{2,4}{6}$ ✓ = 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)

6.1.4 $V_2 = IR$ = (0,4 + 0,6)(5,8) ✓ = 5,8 V ✓ (2)

6.1.5

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)

6.1.6

OPTION 1	**OPTION 2**	**OPTION 3**
W = V I Δt ✓ = (0,8)(1) (15) ✓ = 12 J ✓	W = $I^2R\ \Delta t$ ✓ = $(1)^2$ (0,8)(15) ✓ = 12 J ✓	$W = \frac{V^2 \Delta t}{R}$ ✓ $= \frac{0,8^2(15)}{0,8}$ ✓ = 12 J ✓

(3)

6.2.1 $R = \frac{V}{I} = \frac{2,8}{0,7}$ ✓ = 4 Ω ✓ (2)

6.2.2 Increases ✓
Total resistance decreases,✓ current/power increases, ✓ motor turns faster (3)

[20]

QUESTION 7

7.1 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)

7.2

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)

7.3

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	OPTION 5
$V_{total} = IR_{total}$ $12 = (2)R_{total}$ $R_{total} = 6\ \Omega$ $R = 6 – 0,5$ ✓ $= 5,5\ \Omega$ ✓	$\varepsilon = I(R + r)$ $12 = 2(R + 0,5)$ ✓ $R = 5,5\ \Omega$ ✓

(2)

7.4 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 ∴ $V_{ext/eks}$ decreases (4)
[11]

QUESTION 8

8.1 Temperature ✓ (1)

8.2 *r* = 3 Ω ✓✓ (2)

8.3 **Any correct values from the graph**

OPTION 1	OPTION 2	OPTION 3
ε = slope (gradient) of the graph ✓ $\varepsilon = \frac{7,5-(-3)}{1,5-0}$ ✓ = 7 V ✓	$R = \frac{\varepsilon}{I} - r$ ✓ 7,5 = 1,5 ε - 3 ✓ ε = 7 V ✓	$\varepsilon = I(R + r)$ ✓ = 0,5(11 + 3) ✓ ε = 7 V ✓

(3)
[6]

QUESTION 9

9.1.1 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)

9.1.2

$P = \frac{V^2}{R}$ ✓ $6 = \frac{(12)^2}{R}$ ✓ R = 24 Ω ✓	$W = \frac{V^2\Delta t}{R}$ ✓ $6 = \frac{(12)^2(1)}{R}$ ✓ R=24 Ω ✓	P = VI 6 = (12)(I) ∴I = 0,5 A $P = I^2R$ ✓ $6 = (0,5)^2 R$ ✓ R = 24 Ω ✓	P = VI ✓ 6 = (12)(I) ∴I = 0,5 A V = IR 12 = (0,5)R ✓ R = 24 Ω ✓

(3)

9.1.3

OPTION 1	OPTION 2
$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$ $= \frac{1}{24} + \frac{1}{24}$ ✓ $R_{//} = 12\ \Omega$ $R_{ext} = (R_s + R_{//})$ $R_{ext} = (24 + 12)$ ✓ = 36 Ω V = IR **OR** ε = I(R + r) ✓ 12 = I(36 + 2) ✓ I = 0,32 A ✓ (0,316 A)	$R_{ext} = (R_s + R_{//})$ $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$ $= \frac{1}{24} + \frac{1}{24}$ ✓ ∴ $R_{//} = 12\ \Omega$ $R_{ext} = (24 + 12)$ ✓ = 36 Ω $P = I^2R = \frac{V^2}{R}$ ✓ $I^2(36+2) = \frac{(12)^2}{38}$ ✓ I = 0,32 A ✓ (0,316)

(5)

9.1.4

OPTION 1	OPTION 2
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) ∴V_C = 3,78 V (3,68 V) ✓	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)

9.1.5 **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

$P = I^2 R$ 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)

9.2.1 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)

9.2.2 The current in B is equal ✓ to the current in A. The circuit becomes a series circuit. ✓ (2)

[20]

QUESTION 10

10.1 Maximum work done (or energy provided) ✓ by a battery per unit charge passing through it. ✓ (2)

10.2 13 V ✓ (1)

10.3.1 $R = \frac{V}{I}$ ✓ $\therefore 5,6 = \frac{10,5}{I}$ ✓ $\therefore I = 1,88$ A ✓ (1,875 A) (3)

10.3.2

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)

10.3.3

OPTION 1	**OPTION 2**
$\varepsilon = I(R + r)$ ✓ 13 = 1,88 (5,6 + r) ✓ r = 1,31 Ω ✓	$r = \frac{V_{internal}}{I}$ ✓ $= \frac{2,5}{1,88}$ ✓ = 1,33 Ω ✓

(3)

10.4.1 Decreases ✓

$V_{internal\ resistance}$/Internal volts increase ✓ (2)

10.4.2

OPTION 1	**OPTION 2**
$\varepsilon = I(R + r)$ ✓ $13 = 4 (R_{ext} + 1,31)$ ✓ 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)	$\varepsilon = I(R + r)$ ✓ $13 = 4(R_{ext} + 1,31)$ ✓ 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

Ɛ = I(R + r) ✓

13 = 4(R_{ext} + 1,31) ✓

R_{ext} = 1,94 Ω (1,92 Ω)

$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$

$\frac{1}{1,94} = \frac{1}{5,6} + \frac{1}{2X}$ ✓

2X = 2,97 Ω (2,92 Ω)

$X = \frac{1}{2}(2,97)$ ✓

= 1,49 Ω ✓ (1,46 – 1,49 Ω)

OPTION 4

Ɛ = I(R + r) ✓

13 = 4(R_{ext} + 1,31) ✓

R_{ext} = 1,94 Ω (1,92 Ω)

$R_p = \frac{R_1 R_2}{R_1 + R_2}$

$1,94 = \frac{(5,6)(2X)}{5,6 + 2X}$ ✓✓

(1,94)(5,6 + 2X) = 11,2 X

X = 1,49 Ω ✓

(5)

[19]

QUESTION 11

11.1 (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)

11.2 Energy (per coulomb of charge) is converted to heat in the battery due to the internal resistance. ✓✓ (2)

11.3.1

$I = \frac{V}{R}$ ✓

$= \frac{1,5}{0,5}$ ✓

$= 3\ A$ ✓

(3)

11.3.2

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 Ω

R_{ext} = 9,375 + 4 ✓ = 13,38 Ω ✓ (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 Ω

R_{ext} = 9,375 + 4 ✓ = 13,38 Ω ✓ (13,375 Ω)

(4)

11.3.3

OPTION 1

Ɛ = I(R + r) ✓

= 3(13,38 + 0,5) ✓

= 41,64 V ✓ (Range: 41,625 – 41,64)

OPTION 2

Ɛ = $V_{ext/}$ + V_{int} ✓

= (3)(13,38) + 1,5 ✓

= 41,64 V ✓ (Range: 41,625 – 41,64)

(3)

11.4 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)

11.5 Remains the same. (1)
[18]

QUESTION 12

12.1 (a) electrical energy
(b) unit charge (2)

12.2
$R_S = R_1 + R_2$
$= 4 + 3$ ✓
$= 7\ \Omega$
$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$ ✓
$\frac{1}{R_p} = \frac{1}{7} + \frac{1}{7}$ ✓
$R_p = 3,5\ \Omega$ ✓
(4)

12.3.1
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)

12.3.2
$\varepsilon = 2,8 + 0,4r$
$= 2,8 + (0,4)(0,49)$ ✓
$= 3\ V$ ✓

OR

$\varepsilon = 2,629 + 0,751r$
$= 2,629 + (0,751)(0,49)$ ✓
$= 3\ V$ ✓
(2)
[16]

QUESTION 13

13.1.1 12 V ✓ (1)

13.1.2 0 V ✓ (1)

13.2 The rate at which work is done or energy is expended/transferred. ✓✓ (2)

13.3

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)

13.4

$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$

$\frac{1}{R_p} = \frac{1}{6} + \frac{1}{8{,}4}$ ✓

$R_p = 3{,}5\ \Omega$

$R_T = 3{,}5 + 4$ ✓ $= 7{,}5\ \Omega$ ✓

(3)

13.5

$V_P = I_T R_P = (1{,}2)(3{,}5)$ ✓ $= 4{,}2\ V$

$I = \frac{V}{R}$

$= \frac{4{,}2}{8{,}4}$ ✓

$= 0.5\ A$

$V_2 = IR$ ✓

$= (0{,}5)(6)$ ✓

$= 3\ V$ ✓

(5)

13.6 Decreases ✓

Total resistance decreases. ✓

Total current increases. ✓

$V_{internal}$ /Internal voltage ("lost volts") increases. ✓

$V_{external}$ /external voltage decreases. (4)

[19]

QUESTION 14

14.1 A conductor (resistor) which obeys Ohm's law. ✓✓ (2)

14.2.1
$R = \frac{V}{I}$ ✓
$4 = \frac{3,2}{I}$ ✓
$I = 0,8\ A$ ✓
(3)

14.2.2

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)

14.3.1
$V_{int} = 10 - 8,8$
$= 1,2\ V$

$V_{int} = I_{tot} r$
$1,2 = I_{tot}(0,5)$ ✓
$I_{tot} = 2,4\ A$

$I_{serie\ branch} = \frac{V}{R}$
$= \frac{8,8}{8 + 4}$ ✓
$= 0,733\ A$

$I_R = I_{tot} - I_{serie\ branch}$
$= 2,4 - 0,733$ ✓
$= 1,667\ A$

$R = \frac{V}{I_R}$
$= \frac{8,8}{1,667}$ ✓
$= 5,28\ \Omega$ ✓
(5)

14.3.2 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 15

15.1 The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature. ✓✓ (2)

15.2.1
$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$ ✓
$= \frac{1}{1} + \frac{1}{5}$ ✓
$R_P = 0,833\ \Omega$

$R_{ext} = R_P + R_4$
$= 0,833 + 4$ ✓
$= 4,833\ \Omega$ ✓
(4)

15.2.2

OPTION 1
$R_{ext} = \frac{V_1}{I_T}$ ✓
$4,833 = \frac{V_1}{3,5}$ ✓
$V_1 = 16,916\ V$ ✓

OPTION 2
$R_P = \frac{V_2}{I_T}$ ✓
$0,833 = \frac{V_2}{3,5}$
$V_2 = 2,916\ V$

✓ (for both)

$R_4 = \frac{V}{I_T}$
$4 = \frac{V}{3,5}$
$V = 14\ V$

$V_1 = V_2 + V$
$= 2,916 + 14$
$= 16,916\ V$ ✓
(3)

15.2.3 Smaller than ✓ (1)

15.3.1 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)

15.3.2 No ✓ (1)

15.3.3 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)

15.4.1 Decreases ✓ (1)

15.4.2 Increases ✓ (1)

15.5 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 16

16.1 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)

16.2.1

OPTION 1

$R = \frac{V}{I}$ ✓

$7 = \frac{V}{1,5}$ ✓

$V = 10,5\ V$ ✓

OPTION 2

$R = \frac{V}{I}$ ✓ $\quad R = \frac{V}{I}$

$2 = \frac{V}{1,5} \quad 5 = \frac{V}{1,5}$ ✓

$V = 3\ V \quad V = 7,5\ V$

$V_T = V_1 + V_2$
$= 3 + 7,5$
$= 10,5\ V$ ✓

(3)

16.2.2

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)

16.2.3

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)

16.3

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)

16.4 Increases ✓
Total resistance increases. ✓
Current decreases. ✓
$V_{internal}$ /Internal volts decreases. ✓ (4)
[21]

QUESTION 17

17.1 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)

17.2.1

$$\frac{1}{R_{p(1\&2)}} = \frac{1}{R_1} + \frac{1}{R_2} \checkmark$$
$$= \frac{1}{10} + \frac{1}{10} \checkmark$$
$$R_{p(1\&2)} = 5\ \Omega$$

$$R_{1\&2\&L} = R_{p(1\&2)} + R_L$$
$$= 5 + 10 \checkmark$$
$$= 15\ \Omega$$

$$\frac{1}{R_{ext}} = \frac{1}{R_{1\&2\&L}} + \frac{1}{R_3}$$
$$= \frac{1}{15} + \frac{1}{15} \checkmark$$
$$= 7{,}5\ \Omega \checkmark$$
(5)

17.2.2

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)

17.2.3

$$R_{ext} = \frac{V_{ext}}{I_T}$$
$$7{,}5 = \frac{V_{ext}}{1{,}5}$$
$$V_{ext} = 11{,}25\ V$$

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
$$P = I^2R \checkmark$$
$$= (0{,}75^2)(15) \checkmark\checkmark$$
$$= 8{,}44\ W \checkmark$$

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)

17.3.1 Increases ✓ (1)
17.3.2 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]

QUESTION 18

18.1 The resistor/R_Z is short circuited. **OR** Current follows the path of least resistance. **OR** Branch with switch has no resistance. ✓ (1)

18.2

$$r = \frac{V_{int}}{I_T} \checkmark$$
$$0{,}2 = \frac{V_{int}}{5{,}5} \checkmark$$
$$V_{int} = 1{,}1\ V$$
$$V = 12 - 1{,}1$$
$$= 10{,}9\ V$$

OR

$$\varepsilon = I(R + r) \checkmark$$
$$\varepsilon = V + Ir$$
$$12 = V + (5{,}5)(0{,}2) \checkmark$$
$$V = 10{,}9\ V$$

$$I_y = \left(\frac{1}{3}\right)(5{,}5)\checkmark = 1{,}833\ A$$
$$R_Y = \frac{V}{I_Y}$$
$$= \frac{10{,}9}{1{,}833} \checkmark$$
$$= 5{,}95\ \Omega \checkmark$$
(5)

18.3

OPTION 1

$I_X = \frac{2}{3} I_T$

$= \left(\frac{2}{3}\right)(5,5)$ ✓

$= 3,667\ A$

$P_X = VI_X$ ✓

$= (10,9)(3,667)$ ✓

$= 39,97\ W$ ✓

OR

$P_X = I_X^2 R_X$ ✓

$= (3,667^2)\left(\frac{1}{2}\ x\ 5,95\right)$ ✓

$= 40\ W$ ✓

OPTION 2

$P_X = \frac{V^2}{R_X}$ ✓

$= \frac{10,9^2}{\frac{1}{2}\ x\ 5,95}$ ✓

$= 39,94\ W$ ✓

Range: 39,84 W ~ 40 W

(4)

18.4

$R_Y = \frac{V_Y}{I_T}$ ✓

$5,95 = \frac{V_Y}{1,3}$ ✓

$V_Y = 7,74\ V$ ✓

Range: 7,70 V ~ 7,75 V

(3)

18.5

Determine R_Z with both S_1 and S_2 open:

$\varepsilon = I(R + r)$ ✓

$12 = 1,3(R + 0,2)$ ✓

$R = 9,03\ \Omega$

$R = R_Y + R_Z$

$9,03 = 5,95 + R_Z$ ✓

$R_Z = 3,08\ \Omega$

OR

$r = \frac{V_{int}}{I_T}$ ✓

$0,2 = \frac{V_{int}}{1,3}$ ✓

$V_{int} = 0,26\ V$

$Emf = V_Z + V_Y + V_{int}$

$12 = V_Z + 7,74 + 0,26$

$V_Z = 4\ V$

$R_Z = \frac{V_Z}{I_T}$

$= \frac{4}{1,3}$ ✓

$= 3,077\ \Omega$

Determine I_T with S_1 open and S_2 closed:

$\frac{1}{R_P} = \frac{1}{R_X} + \frac{1}{R_Y}$

$= \frac{1}{2,975} + \frac{1}{5,95}$

$R_P = 1,983\ \Omega$

$R_T = R_P + r + R_Z$

$= 1,983 + 0,2 + 3,077$ ✓

$= 5,26\ \Omega$

$R_T = \frac{\varepsilon}{I_T}$

$5,26 = \frac{12}{I_T}$ ✓

$I_T = 2,28\ A$ ✓

OR

$\varepsilon = I(R + r)$

$\varepsilon = I(R_P + R_Z + r)$

$12 = I(1,983 + 3,077 + 0,2)$ ✓

$I = 2,28\ A$ ✓

(6)

[19]

QUESTION 19

19.1 The rate at which work is done/dissipated **OR** energy transferred. **OR** Work done per unit time. ✓✓ (2)

19.2.1

OPTION 1

$P = VI$ ✓

$48 = 32I$ ✓

$I = 1,5\ A$ ✓

OPTION 2

$P = \frac{V^2}{R}$

$48 = \frac{32^2}{R}$

$R = 21,333\ \Omega$

→

$P = I^2R$ ✓

$48 = I^2(21,333)$ ✓

$I = 1,5\ A$ ✓

OR

$R = \frac{V}{I}$ ✓

$21,333 = \frac{32}{I}$ ✓

$I = 1,5\ A$ ✓

(3)

19.2.2

OPTION 1

For L_1

$P = VI$

$36 = 20I$ ✓

$I = 1,8\ A$

OPTION 2

For L_1

$P = \frac{V^2}{R}$

$36 = \frac{20^2}{R}$

$R = 11,111\ \Omega$

→

$P = I^2R$

$36 = I^2(11,111)$ ✓

$I = 1,8\ A$

OR

$R = \frac{V}{I}$

$11,111 = \frac{20}{I}$ ✓

$I = 1,8\ A$

$I_T = 1,5 + 1,8$ ✓ $= 3,3\ A$ ✓

(3)

19.2.3

OPTION 1

$R_1 = \frac{V}{I}$ ✓

$= \frac{32 - 20 ✓}{1,8 ✓}$

$= 6,67\ \Omega$ ✓

OPTION 2

$R = \frac{V}{I}$ ✓

$= \frac{32}{1,8}$ ✓

$= 17,777\ \Omega$

$P = \frac{V^2}{R}$

$36 = \frac{20^2}{R}$

$R = 11,111\ \Omega$

$R_1 = 17,777 - 11,111$ ✓

$= 6,67\ \Omega$ ✓

(4)

19.2.4

$R_2 = \frac{V}{I_T}$

$4 = \frac{V}{3,3}$

$V = 13,2\ V$

$V_{ext} = 32 + 13,2$ ✓

$= 45,2\ V$

$r = \frac{V_{int}}{I_T}$

$0,6 = \frac{V_{int}}{3,3}$ ✓

$V_{int} = 1,98\ V$

→

$Emf = V_{ext} + V_{int}$ ✓

$= 45,2 + 1,98$ ✓

$= 47,18\ V$ ✓

Range: 47,16 V ~ 47,19 V

OR

$\varepsilon = I(R + r)$ ✓ $= IR + Ir = V_{ext} + IR$

$\therefore \varepsilon = 45,2$ ✓ $+ (3,3)(0,6)$ ✓

$= 47,18\ V$ ✓

(5)

19.3 No ✓

Show that the total current is greater than 1,5 A.

Originally for L2:

$R = \frac{V}{I}$

$= \frac{32}{1,5}$ ✓

$= 21,333\ \Omega$

OR

$P = \frac{V^2}{R}$

$48 = \frac{32^2}{R}$ ✓

$R = 21,333\ \Omega$

$R_T = r + R_{L2} + R_2$

$= 0,6 + 21,333 + 4$

$= 25,933\ \Omega$

$R_T = \frac{\varepsilon}{I_T}$ ✓

$25,933 = \frac{47,18}{I_T}$ ✓

$I_T = 1,82\ A$ ✓

OR

$\varepsilon = I(R + r)$ ✓

$47,18 = I(21,33 + 4 + 0,6)$ ✓

$I = 1,82\ A$ ✓

(5)

[21]

ELECTRICAL MACHINES

QUESTION 1

1.1.1 a to b ✓ (1)
1.1.2 Fleming's left hand rule /Left hand motor rule ✓ (1)
1.1.3 Split rings /commutator ✓ (1)
1.2.1 Mechanical/Kinetic energy to electrical energy ✓✓ (2)

1.2.2

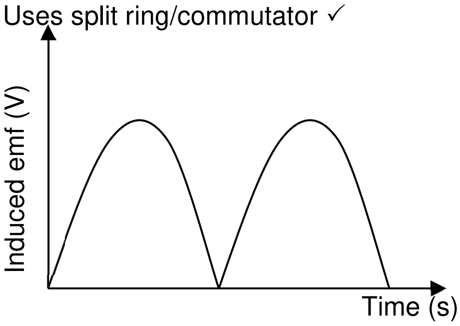
OPTION 1	**OPTION 2**
$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓ $= \frac{430}{\sqrt{2}}$ ✓ $= 304{,}06$ V $I = \frac{V}{R}$ ✓ $= \frac{304{,}06}{400}$ ✓ $= 0{,}76$ A ✓	$V_{max} = I_{max}R$ ✓ $430 = I_{max}(400)$ ✓ $I_{max} = 1{,}075$ $I_{rms} = \frac{I_{rms}}{\sqrt{2}}$ ✓ $= \frac{1{,}075}{\sqrt{2}}$ ✓ $= 0{,}76$ A ✓
OPTION 3	**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 $P_{ave} = I_{rms}V_{rms}$ ✓ $231{,}13 = I_{rms}(304{,}06)$ ✓ $\therefore I_{rms} = 0{,}76$ A ✓	$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓ $= \frac{430}{\sqrt{2}}$ ✓ $= 304{,}06$ 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]

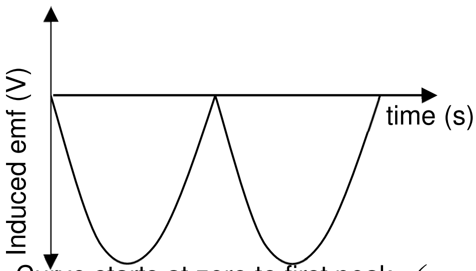
QUESTION 2

2.1.1 DC-generator ✓
Uses split ring/commutator ✓ (2)

2.1.2



OR



Curve starts at zero to first peak. ✓
Shape and one complete DC cycle. ✓ (2)

2.2.1

OPTION 1	**OPTION 2**
$V_{rms} = \frac{V_{max}}{\sqrt{2}} = \frac{340}{\sqrt{2}} = 240{,}416$ V $P_{ave} = V_{rms}I_{rms}$ ✓ $800 = I_{rms}(240{,}416)$ ✓ $I_{rms} = 3{,}33$ A ✓	$V_{rms} = \frac{V_{max}}{\sqrt{2}} = \frac{340}{\sqrt{2}}$ $P_{ave} = V_{rms}I_{rms}$ ✓ $800 = \frac{340}{\sqrt{2}}I_{rms}$ ✓ $\therefore I_{rms} = 3{,}33$ A ✓
OPTION 3	**OPTION 4**
$P_{ave} = \frac{V_{rms}^2}{R} = \frac{V_{max}^2}{2R}$ $800 = \frac{(340)^2}{(\sqrt{2})^2 R}$ $\therefore R = 72{,}25\ \Omega$ $V_{rms} = I_{rms}R$ ✓ $I_{rms} = \frac{240{,}416}{72{,}25}$ ✓ $= 3{,}33$ A ✓	$P_{ave} = I_{rms}^2 R$ ✓ $800 = I_{rms}^2(72{,}25)$ ✓ $I_{rms} = 3{,}33$ A ✓

(3)

2.2.2

OPTION 1	**OPTION 2**
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 ✓	$P_{ave} = V_{rms}I_{rms}$ ✓ $= \frac{V_{max}I_{max}}{2}$ $2\,800 = \frac{340}{2}I_{max}$ ✓ $\therefore I_{max} = 16{,}47$ A $I_{rms} = \frac{I_{max}}{\sqrt{2}} = \frac{16{,}47}{\sqrt{2}}$ ✓ $\therefore I_{rms} = 11{,}65$ A ✓

(4)
[11]

QUESTION 3

3.1.1 **R:** armature/coil(s) ✓
T: Carbon brushes ✓
X: Slip rings ✓ (3)

3.1.2 Faraday's Law ✓ (1)

3.2.1 15 V ✓ (1)

3.2.2

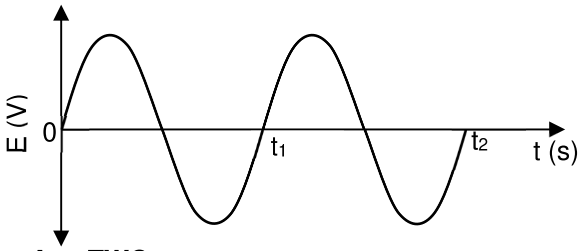
OPTION 1	OPTION 2
$V_{rms} = I_{rms}R$ $I_{rms} = \frac{15}{45}$ ✓ $= 0{,}333$ A $I_{rms} = \frac{I_{max}}{\sqrt{2}}$ ✓any one $I_{max} = (0{,}333)\sqrt{2}$ ✓ $= 0{,}47$ A ✓	$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ $V_{max} = (15)\sqrt{2}$ ✓ $= 21{,}213$ V ✓any one $V_{max} = I_{max}R$ $I_{max} = \frac{21{,}213}{45}$ ✓ $= 0{,}47$ A ✓

(4)
[9]

QUESTION 4

4.1 Slip rings ✓ (1)

4.2



Marking criteria	
Sine graph starts from 0.	✓
Two complete waves (between t_0 and t_2)	✓

(2)

4.3 **Any TWO:**
Increase the speed of rotation. ✓
Increase the number of coils (turns). ✓
Use stronger magnets. (2)

4.4 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)

4.5

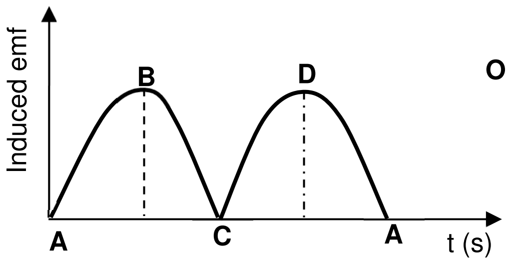
OPTION 1	OPTION 2
$P_{ave} = I_{rms}V_{rms}$ ✓ $1500 = I_{rms/wgk}(240)$ ✓ $I_{rms} = \frac{1500}{240} = 6{,}25$ A ✓	$P_{ave} = \frac{V^2}{R}$ ✓ $\therefore 1500 = \frac{240^2}{R}$ $\therefore R = 38{,}4\ \Omega$ $I_{rms} = \frac{V}{R} = \frac{240}{38{,}4}$ ✓ $= 6{,}25$ A✓

(3)
[10]

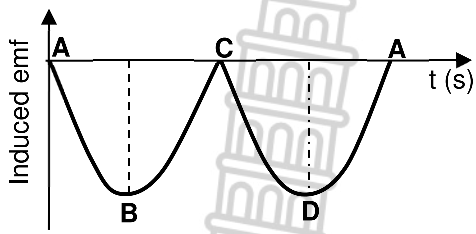
QUESTION 5

5.1.1 <u>Mechanical to electrical</u> ✓ (1)

5.1.2



OR



Criteria for graph	
Correct DC shape, starting from zero	✓
Positions ABCDA correctly indicated on the graph	✓

(2)

5.2.1 20,5 Ω ✓ (1)

5.2.2

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 ✓	$W = I_{rms}^2 R \Delta t$ $= (1,22)^2\ (0,5)(1)$ $= 0,74$ 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 $P_{ave} = \frac{V_{rms}^2}{R}$ ✓ $= \frac{(24,39)^2}{20}$ ✓ $= 29,74$ W ✓ (5)

[9]

QUESTION 6

6.1.1 **ANY THREE**

Permanent magnets; coils (armature); commutator; brushes; power supply/battery (3)

6.2.1 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)

6.2.2

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 7

7.1.1 Split ring/commutator ✓ (1)

7.1.2 Anticlockwise ✓✓ (2)

7.1.3 Electrical energy ✓to mechanical (kinetic) energy ✓ (2)

7.2.1 DC generator: split ring/commutator and AC generator has slip rings ✓ (1)

7.2.2 $V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓ $= \frac{320}{\sqrt{2}}$ ✓ $= 226,27$ V ✓ (3)

7.2.3 $I_{max} = \frac{V_{max}}{R} = \frac{320}{35}$ ✓ $= 9,14$ A $\therefore I_{rms} = \frac{I_{max}}{\sqrt{2}}$ ✓ $= \frac{9,14}{\sqrt{2}}$ ✓ $= 6,46$ A ✓ (4)

[13]

QUESTION 8

8.1.1 Y to/*na* X ✓ (1)

8.1.2 Faraday's Law Electromagnetic Induction ✓

OR Electromagnetic induction/Faraday's Law ✓ (1)

8.1.3 Mechanical (kinetic) energy ✓to electrical energy ✓ (2)

8.2.1 340 V ✓ (1)

8.2.2 $V_{rms/wgk} = \frac{V_{max/maks}}{\sqrt{2}}$ ✓ $= \frac{340}{\sqrt{2}}$ ✓ $\therefore V_{rms/wgk} = 240,42$ V ✓ (3)

8.2.3

OPTION 1	**OPTION 2**
$P_{ave/gemid} = \frac{V_{rms/wgk}^2}{R}$ ✓ $1\ 600 = \frac{(240,42)^2}{R}$ ✓ $\therefore R = 36,13\ \Omega$ ✓	$P_{ave/gemid} = \frac{V_{rms/wgk}^2}{R}$ ✓ $= \frac{\frac{V_{max/maks}^2}{2}}{R} = \frac{V_{max/maks}^2}{2R}$ $\therefore 1\ 600 = \frac{(340)^2}{2R}$ ✓ $\therefore R = 36,13\ \Omega$ ✓

(3)

[11]

QUESTION 9

9.1 Slip rings ✓ (1)

9.2 B ✓ (1)

9.3 $V_{rms/wgk} = \frac{V_{max/maks}}{\sqrt{2}}$ ✓ $= \frac{312}{\sqrt{2}}$ ✓ $= 220,62$ V ✓ (3)

9.4.1

OPTION 1

$P_{aver\ /\ gemid} = \frac{V^2_{rms\ /\ wgk}}{R}$ ✓ $= \frac{(220,62)^2}{40}$ ✓ $= 1216,83$ 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)

9.4.2

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)

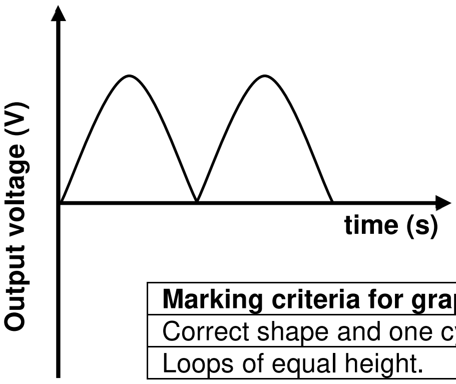
[12]

QUESTION 10

10.1.1 DC ✓ (1)

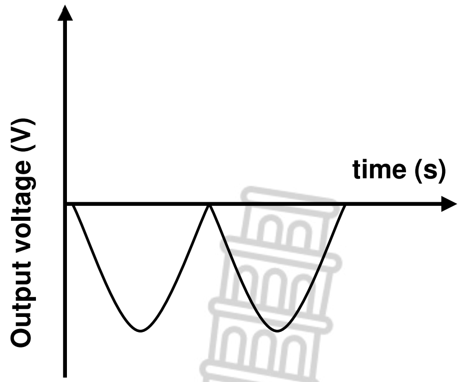
10.1.2 Emf is induced as a result of <u>the rate of change of magnetic flux linked</u> ✓✓ with the coil. (2)

10.1.3



Marking criteria for graph:	
Correct shape and one cycle.	✓
Loops of equal height.	✓

OR



(2)

10.2.1 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)

10.2.2

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 11

11.1.1 (DC) motor ✓ (1)

11.1.2 Electrical to mechanical/kinetic (energy). (2)

11.1.3 Split ring/commutator (1)

11.1.4 Anticlockwise (2)

11.2.1 The AC voltage/potential difference which dissipates the same amount of energy/heat/power as an equivalent DC voltage/potential difference. ✓✓ (2)

11.2.2

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)

11.2.3

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 12

12.1 Slip rings ✓ (1)

12.2 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)

12.3 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)

12.4 P to Q ✓✓ (2)

12.5

$T = \frac{1}{f} = \frac{1}{50}$ ✓
$= 0{,}02\ s$

$t = (1{,}5)(0{,}02)$ ✓
$= 0{,}03\ s$ ✓

OR

$t = 0{,}02 + \left(\frac{1}{2}\right)(0{,}02)$ ✓
$= 0{,}03\ s$ ✓

(3)

12.6

$V_{rms} = \frac{V_{max}}{\sqrt{2}}$
$= \frac{311}{\sqrt{2}}$ ✓
$= 219{,}91\ V$

$I_{rms} = \frac{V_{max}}{\sqrt{2}}$
$= \frac{219{,}91}{100}$ ✓
$= 2{,}1991\ V$

OPTION 1

$W = \frac{V^2\Delta t}{R}$ ✓
$= \frac{(219{,}91^2)(60)}{100}$ ✓✓
$= 29\ 016{,}24\ J$ ✓

OPTION 2

$W = VI\Delta t$ ✓
$= (219{,}91)(2{,}20)(60)$ ✓✓
$= 29\ 028{,}12\ J$ ✓

OPTION 3

$W = I^2R\Delta t$ ✓
$= (2{,}20^2)(100)(60)$ ✓✓
$= 29\ 040\ J$ ✓

(5)
[14]

QUESTION 13

13.1 Slip rings ✓ (1)

13.2 Y to X ✓✓ (2)

13.3 The AC potential difference which dissipates the same amount of energy as an equivalent DC potential difference. ✓✓ (2)

13.4

OPTION 1

$V_{rms;wgk} = \frac{V_{max;maks}}{\sqrt{2}}$
$= \frac{100}{\sqrt{2}}$ ✓
$= 70{,}71\ V$

$I_{rms;wgk} = \frac{V_{rms;wgk}}{R}$ ✓
$= \frac{70{,}71}{25}$ ✓
$= 2{,}83\ A$ ✓

OPTION 2

$I_{max;maks} = \frac{V_{max;maks}}{R}$
$= \frac{100}{25}$ ✓
$= 4\ A$

$I_{rms;wgk} = \frac{I_{max;maks}}{\sqrt{2}}$ ✓
$= \frac{4}{\sqrt{2}}$ ✓
$= 2{,}83\ A$ ✓

(4)

13.5

OPTION 1

$P_{ave;gem} = \frac{V^2_{rms;wgk}}{R}$ ✓
$= \frac{70{,}71^2}{25}$ ✓
$= 200\ W$ ✓

OPTION 2

$P_{ave;gem} = V_{rms;wgk}I_{rms;wgk}$ ✓
$= (70{,}71)(2{,}83)$ ✓
$= 200{,}11\ W$ ✓

OPTION 3

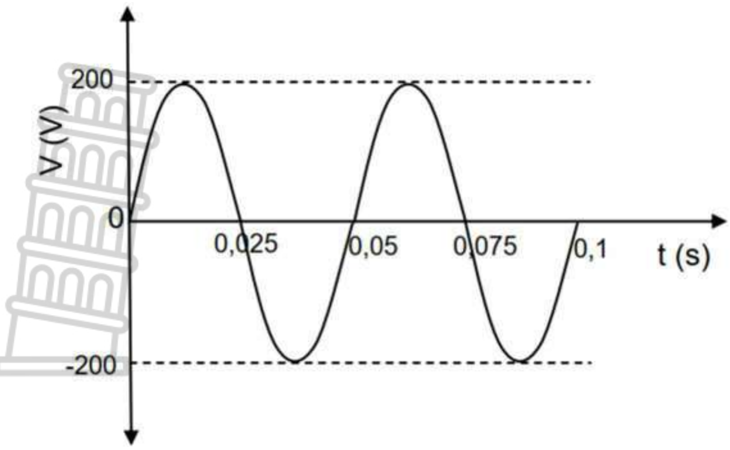
$P_{ave;gem} = I^2_{rms;wgk}R$ ✓
$= (2{,}83)(25)$ ✓
$= 200{,}22\ W$ ✓

OPTION 4

$P_{ave;gem} = \frac{V_{max;maks}I_{max;maks}}{2}$ ✓
$= \frac{(100)(4)}{2}$ ✓
$= 200\ W$ ✓

(3)

13.6



(3)
[15]

QUESTION 14

14.1.1 Electrical to mechanical/kinetic/rotational ✓ (1)

14.1.2 DC ✓ (1)

14.1.3 Ensures continuous rotation of the coil. ✓ **OR**
Ensures the change in direction of the current in the coil. (1)

14.2.1

OPTION 1	**OPTION 2**	**OPTION 3**
$P_{ave} = \frac{V_{rms}^2}{R}$ ✓ $100 = \frac{220^2}{R}$ ✓ $R = 484\ \Omega$ ✓	$P_{ave} = V_{rms}I_{rms}$ $100 = 220I_{rms}$ $I_{rms} = 0{,}4545\ A$ $I_{rms} = \frac{V_{rms}}{R}$ ✓ $0{,}4545 = \frac{220}{R}$ ✓ $R = 484{,}05\ \Omega$ ✓	$P_{ave} = V_{rms}I_{rms}$ $100 = 220I_{rms}$ $I_{rms} = 0{,}4545\ A$ $P_{ave} = I_{rms}^2R$ ✓ $100 = (0{,}4545^2)R$ ✓ $R = 484{,}10\ \Omega$ ✓

(3)

14.2.2

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 15

15.1.1 Split ring/commutator ✓ (1)

15.1.2 Y to X **OR** No current ✓ (1)

15.1.3

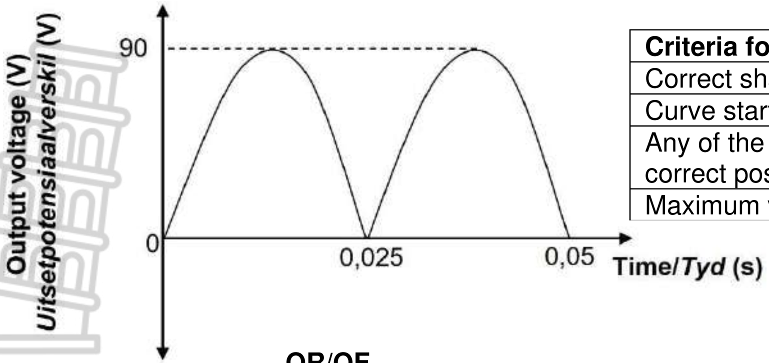
$T = \frac{1}{f}$

$= \frac{1}{20}$

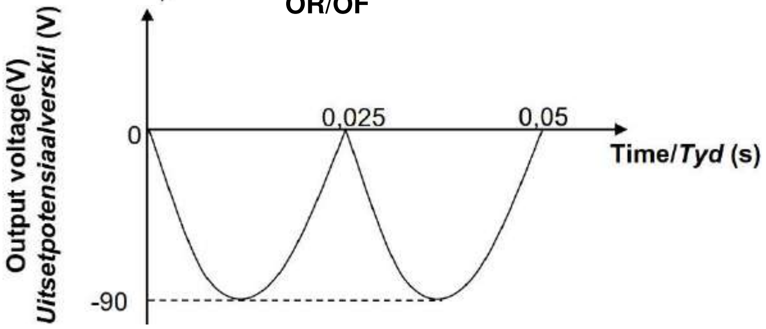
$= 0{,}05\ s$ ✓

(1)

15.1.4



OR/OF



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.	✓

(4)

15.2

OPTION 1

$W_{ave} = \frac{V_{rms}^2 \Delta t}{R}$ ✓

$= \frac{(220^2)(120)}{32}$ ✓ ✓

$= 181\ 500\ J$ ✓

Other energy and power formulae may be used.

OPTION 3

$R = \frac{V_{rms}}{I_{rms}}$

$32 = \frac{220}{I_{rms}}$ ✓

$= 6{,}875\ A$

$W_{ave} = V_{rms} I_{rms} \Delta t$ ✓

$= (220)(6{,}875)(120)$ ✓

$= 181\ 500\ J$ ✓

OPTION 2

$P_{ave} = \frac{V_{rms}^2}{R}$

$= \frac{220^2}{32}$ ✓

$= 1\ 512{,}5\ W$

$P = \frac{W}{\Delta t}$ ✓

$1\ 512{,}5 = \frac{W}{120}$ ✓

$W = 181\ 500\ J$ ✓

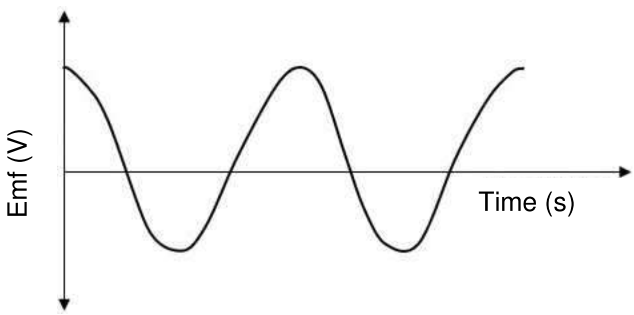
(4)
[11]

QUESTION 16

16.1.1 North pole ✓ (1)

16.1.2 Y to X ✓ (1)

16.1.3



Marking criteria
Correct shape ✓
Graph starts from maximum value. ✓
Two complete waves ✓

(3)

16.2.1

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)

16.2.2

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 17

17.1.1 Split ring/Commutator ✓ (1)

17.1.2 Electrical to mechanical/kinetic ✓ (1)

17.1.3 Clockwise ✓✓ (2)

17.1.4 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)

17.2.1 Root-mean-square current is the alternating current that dissipates the same amount of energy as an equivalent DC current. ✓✓ (2)

17.2.2

$I_{rms} = \frac{I_{max}}{\sqrt{2}}$ ✓

$= \frac{3,6}{\sqrt{2}}$ ✓

$= 2,55\ A$ ✓

(3)

17.2.3

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]

QUESTION 18

18.1 Y to X ✓✓ (2)

18.2 Mechanical/Kinetic to electrical energy ✓ (1)

18.3 The rms potential difference is the alternating current potential difference which dissipates/produces the same amount of energy/heating effect as an equivalent DC potential difference. ✓✓ (2)

18.4

$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓

$= \frac{125}{\sqrt{2}}$ ✓

$= 88{,}39\ V$ ✓

(3)

18.5

OPTION 1

$R_T = \frac{V_{max}}{I_{max}}$ ✓

$42{,}4 = \frac{125}{I_{max}}$ ✓

$I_{max} = 2{,}95\ A$ ✓

OPTION 2

$R_T = \frac{V_{rms}}{I_{rms}}$

$42{,}4 = \frac{88{,}39}{I_{rms}}$

$I_{rms} = 2{,}084\ A$

$I_{rms} = \frac{I_{max}}{\sqrt{2}}$ ✓

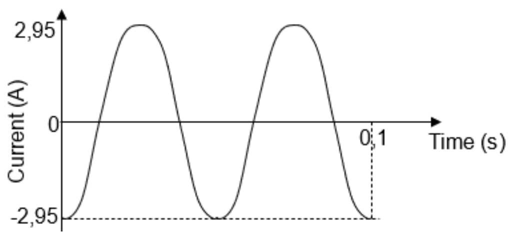
$2{,}084 = \frac{I_{max}}{\sqrt{2}}$ ✓

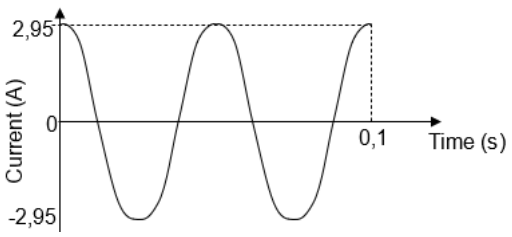
$I_{max} = 2{,}95\ A$ ✓

Range: 2,94 A ~ 2,95 A

(3)

18.6





Criteria	
Two complete cycles indicated.	✓
Graph stops at 0,1 s. **OR** One cycle in 0,05 s.	✓
Maximum current as a positive of negative value correctly indicated.	✓
Correct shape (cosine graph).	✓

(4)
[15]

QUESTION 19

19.1 DC generator ✓ (1)

19.2 Mechanical/kinetic to electrical ✓✓ (2)

19.3 Power/Energy/Voltage loss cannot be reduced / will be too large. ✓ **OR**
Current cannot be made smaller. (1)

19.4

$f = \frac{\text{number of cycles or waves}}{\text{time}}$

$= \frac{2}{0{,}04}$ ✓

$= 50\ Hz$ ✓

OR

$f = \frac{I}{T}$

$= \frac{1}{0{,}02}$ ✓

$= 50\ Hz$ ✓

(2)

19.5 Root-mean-square current is the alternating current that dissipates the same amount of energy as an equivalent DC current. ✓✓ (2)

19.6

$I_{rms} = \frac{I_{max}}{\sqrt{2}}$ ✓

$= \frac{1{,}2}{\sqrt{2}}$ ✓

$= 0{,}85\ A$ ✓

(3)

19.7 Speed of rotation halved. ✓✓ Accept: Frequency was halved. / Period was doubled.
½ for: Speed of rotation slower. / Frequency decreases. / Period increased. (2)
[13]

OPTICAL PHENOMENA AND PROPERTIES OF MATERIALS

QUESTION 1

1.1.1 Light has a particle nature. ✓ (1)

1.1.2 Remains the same. ✓
For the same colour/ frequency/wavelength the energy of the photons will be the same. ✓
(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)

1.1.3 $E = W_0 + E_k$ **OR** $hf = hf_0 + E_k$ **OR** $hf = hf_0 + \frac{1}{2}mv^2$ **OR** $E = W_0 + \frac{1}{2}mv^2$

$$\frac{(6{,}63\times10^{-34})(3\times10^{8})}{420\times10^{-9}} ✓ = \frac{(6{,}63\times10^{-34})(3\times10^{8})}{\lambda_o} ✓ + \frac{1}{2}(9{,}11\times10^{-31})(4{,}76\times10^{5})^2 ✓$$

$\therefore \lambda_o = 5{,}37 \times 10^{-7}$ m $\therefore$ the metal is sodium ✓ (5)

1.2 **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 2

2.1.1 The minimum frequency of a photon/light needed ✓ to emit electrons from a certain metal surface. ✓ (2)

2.1. 2 Silver ✓
Threshold frequency / cut-off frequency (of Ag) is higher. ✓ and $W_o \propto f_o$ / $W_o = hf_o$ ✓ (3)

2.1.3 Planck's constant ✓ (1)

2.1.4 Sodium ✓ (1)

2.2.1 Energy radiated per second by the blue light = $(\frac{5}{100})(60 \times 10^{-3})$ ✓ = 3×10^{-3} J·s^{-1}

$$E_{photon} = \frac{hc}{\lambda} ✓ = \frac{(6{,}63\times10^{-34})(3\times10^{8})}{470\times10^{-9}} ✓ = 4{,}232 \times 10^{-19}\text{J}$$

Total number of photons incident per second = $\frac{3\times10^{-3}}{4{,}232\times10^{-19}}$ ✓ = $7{,}09 \times 10^{15}$ ✓ (5)

2.2.2 $7{,}09 \times 10^{15}$ (electrons per second) ✓
OR: Same number as that calculated in Question 7.2.1 above. (1)

[13]

QUESTION 3

3.1 It is the process whereby electrons are ejected from a metal surface when light of suitable frequency is incident/shines on that surface. ✓✓ (2)

3.2 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)

3.3

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** $E = W_o + \frac{1}{2}mv^2$ ✓

$$(6{,}63 \times 10^{-34} \times 5{,}9 \times 10^{14}) ✓ = \frac{(6{,}63 \times10^{-34})(3\times10^{8})}{\lambda_0} + 2{,}9 \times 10^{-19}$$

$$39{,}117 \times 10^{-20} - 2{,}9 \times 10^{-19} = \frac{19{,}89\times10^{-26}}{\lambda_o} \quad \therefore \lambda_o = 1{,}97 \times 10^{-6}\text{ m} ✓$$

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** $E = W_o + \frac{1}{2}mv^2$ ✓

$((6{,}63 \times 10^{-34} \times 5{,}9 \times 10^{14})$ ✓ $= (6{,}63 \times 10^{-34})f_0 + 2{,}9 \times 10^{-19}$ $\therefore f_o = 1{,}52 \times 10^{14}$ Hz

$c = f_o\lambda_o$ $\therefore$ $3 \times 10^8 = (1{,}52 \times 10^{14})\lambda_0$ ✓ $\therefore$ $\lambda_o = 1{,}97 \times 10^{-6}$ 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** $E = W_o + \frac{1}{2}mv^2$ ✓

$(6{,}63 \times 10^{-34} \times 5{,}9 \times 10^{14})$ ✓ $= W_0 + 2{,}9 \times 10^{-19}$ $\therefore W_o = 1{,}01 \times 10^{-19}$ J

$W_o = hf_o$ $\therefore 1{,}01 \times 10^{-19} = (6{,}63 \times 10^{-34})f_o$ $\therefore f_o = 1{,}52 \times 10^{14}$ Hz

$c = f_o\lambda_o$ $\therefore$ $3 \times 10^8 = (1{,}52 \times 10^{14})\lambda_0$ ✓ $\therefore$ $\lambda_o = 1{,}97 \times 10^{-6}$ m ✓ (5)

3.4 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 4

4.1 The minimum frequency of light ✓ needed to emit electrons from the surface of a metal. ✓ (2)

4.2 The speed remains unchanged. ✓ (1)

4.3 **OPTION 1**

$c = f\lambda$ ✓

$\therefore 3 \times 10^8 = f(6 \times 10^{-7})$ ✓

$\therefore f = 5 \times 10^{14}$ 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: $W_0 = hf_0$ ✓ $= (6,63 \times 10^{-34})(6,8 \times 10^{14})$ ✓ $= 4,51 \times 10^{-19}$ J

For the given wavelength:

$E_{photon} = \frac{hc}{\lambda} = \frac{(6,63\times10^{-34})(3\times10^8)}{6\times10^{-7}}$ ✓ **OR** $E_{photon} = hf = (6,63 \times 10^{-34})(5 \times 10^{14})$ ✓✓

$= 3,32 \times 10^{-19}$ J $= 3,32 \times 10^{-19}$ J

Energy is less than work function ✓ of metal, therefore photoelectric effect not observed. ✓ (5)

4.4 $E = W_0 + E_{k(max)}$ **OR** $E = W_o + \frac{1}{2}mv^2_{max}$ **OR** $h\frac{c}{\lambda} = hf_0 + \frac{1}{2}mv^2_{max}$ **OR** $hf = hf_0 + \frac{1}{2}mv^2_{max}$

$(6,63 \times 10^{-34})(7,8 \times 10^{14})$ ✓ $= (6,63 \times 10^{-34})(6,8 \times 10^{14})$ ✓ $+ \frac{1}{2}mv^2_{max}$

$\frac{1}{2}mv^2_{max} = 6,63 \times 10^{-20}$ J thus $\frac{1}{2}(9,11 \times 10^{-31})v^2_{max}$ ✓ $= 6,63 \times 10^{-20}$ $\therefore$ $v_{max} = 3,82 \times 10^5$ m·s^{-1} ✓ (5)

[13]

QUESTION 5

5.1.1 (Line) emission (spectrum) ✓ (1)

5.1.2 (Line) absorption (spectrum) ✓ (1)

5.2.1 Emission ✓ (1)

5.2.2 Energy released in the transition from E_4 to $E_2 = E_4 - E_2$

$E_4 - E_2 = (2,044 \times 10^{-18} - 1,635 \times 10^{-18})$ ✓ $= 4,09 \times 10^{-19}$ J

$E = hf$ ✓ $\therefore$ $4,09 \times 10^{-19} = (6,63 \times 10^{-34})f$ ✓ $\therefore$ $f = 6,17 \times 10^{14}$ Hz ✓ (4)

5.2.3 $E = W_o + E_{k(max)}$ **OR** $hf = hf_o + E_{k(max)}$ **OR** $hf = hf_o + \frac{1}{2}mv^2$ **OR** $E = W_o + \frac{1}{2}mv^2$ ✓

$4,09 \times 10^{-19}$ ✓ $= (6,63 \times 10^{-34})(4,4 \times 10^{14})$ ✓ $+ E_{k(max)}$ $\therefore$ $E_{k(max)} = 1,17 \times 10^{-19}$ J ✓

OR

$E_{k(max)} = E_{light} - W_o$
$= hf_{light} - hf_o$ } ✓ Any one

$= (6,63 \times 10^{-34})(6,17 \times 10^{14})$ ✓ $- (6,63 \times 10^{-34})(4,4 \times 10^{14})$ ✓ $= 1,17 \times 10^{-19}$ J ✓ (4)

5.2.4 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 6

6.1.1 Greater than ✓

Electrons are ejected from the metal plate. ✓ (2)

6.1.2 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)

6.1.3 Light has a particle nature. ✓ (1)

6.2.1 The minimum frequency needed for the emission of electrons from the surafce of a metal. ✓✓ (2)

6.2.2 $W_o = hf_o$ ✓

$= (6,63 \times 10^{-34})(5,73 \times 10^{14})$ ✓

$= 3,8 \times 10^{-19}$ J ✓ (3)

6.2.3 $E = W_o + E_{k(max)}$ **OR** $hf = hf_o + E_{k(max)}$ **OR** $hf = hf_o + \frac{1}{2}mv^2$ **OR** $E = W_o + \frac{1}{2}mv^2$ ✓

$(6,63 \times 10^{-34})f = 3,8 \times 10^{-19} + [\frac{1}{2}(9,11\ 10^{-31})(4,19 \times 10^5)^2]$ ✓

$f = 9,94 \times 10^{14}$ Hz ✓ (3)

[13]

QUESTION 7

7.1 The minimum energy needed to eject electrons ✓ from the surface of a certain metal. ✓ (2)

7.2 (Maximum) kinetic energy of the ejected electrons ✓ (1)

7.3 Wavelength/Frequency (of light) ✓ (1)

7.4 Silver✓
According to Photoelectric equation, $hf = W_o + \frac{1}{2} mv^2$
(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)

7.5 $hf = W_o + \frac{1}{2}mv^2_{max/maks}$ **OR** $h\frac{c}{\lambda} = W_o + E_{k(max/maks)}$ ✓

$\frac{(6{,}63\times10^{-34})(3\times10^{8})}{2\times10^{-8}}$ ✓ $= W_o + 9{,}58 \times 10^{-18}$ ✓

$9{,}945 \times 10^{-18} = W_o + 9{,}58 \times 10^{-18}$
$\therefore W_o = 3{,}65 \times 10^{-19}$ J ✓ (4)

7.6 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 8

8.1 The minimum energy needed to eject electrons ✓ from the surface of a certain metal. ✓ (2)

8.2 Potassium / K ✓
f_o for potassium is greater than f_o for caesium ✓
OR
Work function is directly proportional to threshold frequency ✓ (2)

8.3
OPTION 1
$c = f\lambda$ ✓ ∴ $3 \times 10^8 = f(5{,}5 \times 10^{-7})$ ✓ ∴ $f = 5{,}45 \times 10^{14}$ Hz ∴ $f_{uv} < f_{o \text{ of K(potassium)}}$
∴Ammeter in circuit **B** will not show a reading ✓

OPTION 2
$E = \frac{hc}{\lambda} = \frac{(6{,}63\times10^{-34})(3\times10^{8})}{5{,}5\times10^{-7}}$ $\frac{(6{,}63\text{x}10^{-34})(3\text{x}10^{8})}{5{,}5\text{x}10^{-7}} = 3{,}6164 \times 10^{-19}$ 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)

8.4
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)

8.5 Remains the same ✓ (1)
[13]

QUESTION 9

9.1 The minimum frequency of light needed to eject electrons from a metal surface. ✓✓ (2)

9.2

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✓	$c = f\lambda$ $3 \times 10^8 = f(5 \times 10^{-7})$ $f = 6 \times 10^{14}$ Hz $E = hf$ ✓Both $= (6{,}63 \times 10^{-34})(6 \times 10^{14})$ ✓ $= 3{,}98 \times 10^{-19}$ J✓

(3)

9.3 **OPTION 1**

$E = W_0 + E_{kmax}$

$hf = W_0 + \frac{1}{2}mv^2_{max}$

$h\frac{c}{\lambda} = W_0 + E_{K(max/maks)}$

$h\frac{c}{\lambda} = hf_0 + E_{K(max/maks)}$

✓Any one

$3{,}98 \times 10^{-19} = (6{,}63 \times 10^{-34})(5{,}55 \times 10^{14}) + E_{K(max)}$ ✓

$E_{K(max)} = 3{,}0 \times 10^{-20}$ 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)

9.4 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 10

10.1 The process whereby electrons are ejected from a metal surface ✓ when light of suitable frequency is incident/shines on the surface. ✓ (2)

10.2 $7{,}48 \times 10^{-19}$ (J) ✓
$E = W_0 + E_{kmax}$ $(= W_0 + ½mv^2_{max})$ ✓
When $E_k = 0$, $E = W_0$✓ (3)

10.3 Mass (of photo-electron) ✓ (1)

10.4 **OPTION 1**

Gradient = ½m ✓

$\frac{11{,}98\times10^{-19} - 7{,}48\times10^{-19}}{X - 0}$ ✓✓ $= ½(9{,}11 \times 10^{-31})$ ✓

$X = 0{,}9868$ ✓

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)

10.5.1 Remains the same ✓ (1)

10.5.2 Increases ✓ (1)

[13]

QUESTION 11

11.1 Photoelectric effect ✓ (1)

11.2 Work function (of potassium) ✓ (1)

11.3 Potassium ✓ It has the lowest work function / threshold frequency / highest threshold wavelength. ✓ (2)

11.4 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)

11.5.1

$W_o = hf_o$ ✓
$= (6,63 \times 10^{-34})(1,75 \times 10^{15})$ ✓
$= 1,160 \times 10^{-18}$ J ✓

OR/*OF*

$E = W_o + E_{k(max)}$
$hf = W_o + E_{k(max)}$
} ✓ Any one

$(6,63 \times 10^{-34})(1,75 \times 10^{15}) = W_o + 0$ ✓
$W_o = 1,160 \times 10^{-18}$ J ✓ (3)

11.5.2

$E = W_o + E_{k(max)}$
$hf = hf_o + \frac{1}{2}mv^2_{max}$
} ✓ Any one/

$(6,63 \times 10^{-34})f$ ✓ $= 1,160 \times 10^{-18} + \frac{1}{2}(9,11 \times 10^{-31})(5,60 \times 10^5)^2$ ✓
$\therefore f = 1,97 \times 10^{15}$ Hz ✓ (4)

[13]

QUESTION 12

12.1 $11,6 \times 10^{-19}$ J ✓ (1)

12.2 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)

12.3 The work function of a metal/surface is the minimum energy needed to remove/release an electron from a (metal) surface. ✓✓ (2)

12.4

OPTION 1

$W_o = hf_o$ ✓
OR OF
$W_o = \frac{hc}{\lambda_o}$
$W_o = \frac{(6{,}63x10^{-34})(3x10^8)}{4{,}9x10^{-7}}$ ✓ ✓
$W_o = 4{,}06x10^{-19}\ J$ ✓

OPTION 2

$E = W_o + E_{k(max)}$ ✓
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 4×10^{-7} m (refer to the table below 12.5 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)

12.5

$E = W_o + E_{k(max)}$ ✓
$\frac{hc}{\lambda} = W_o + E_{k(max)}$
$\frac{(6{,}63x10^{-34})(3x10^8)}{0{,}5x10^{-7}}$ ✓ $= 3{,}3725x10^{-19}$ ✓ $+ E_{k(max)}$
$E_{k(max)} = 3{,}641x10^{-18}\ J$ ✓ (4)

		Q12.4	Q12.5
λ	**$E_{k(max)}$**	**W_o**	**$E_{k(max)}$**
$4,9 \times 10^{-7}$	0	$4,06 \times 10^{-19}$	$3,752 \times 10^{-18}$
$0,75 \times 10^{-7}$ – $0,8 \times 10^{-7}$	$14,0 \times 10^{-19}$	$1,252 \times 10^{-18}$ – $1,086 \times 10^{-18}$	$2,762 \times 10^{-18}$
$1,5 \times 10^{-7}$	$8,0 \times 10^{-19}$	$5,26 \times 10^{-19}$	$3,452 \times 10^{-18}$
2×10^{-7}	$6,0 \times 10^{-19}$ – $6,2 \times 10^{-19}$	$3,745 \times 10^{-19}$ – $3,95 \times 10^{-19}$	$3,6035 \times 10^{-18}$ – $3,945 \times 10^{-18}$
3×10^{-7}	$3,6 \times 10^{-19}$	$3,03 \times 10^{-19}$	$3,675 \times 10^{-18}$
4×10^{-7}	$1,6 \times 10^{-19}$	$3,3725 \times 10^{-19}$	$3,64075 \times 10^{-18}$

[13]

QUESTION 13

13.1 The minimum frequency of light needed to eject electrons from a metal / surface. ✓✓ (2)

13.2 Greater than ✓ (2)

13.3

$E = W_o + E_{k(max)}$ ✓

$hf = hf_o + E_{k(max)}$

$(6,63x10^{-34})f_x$ ✓ $= (6,63x10^{-34})(10,4x10^{14})$ ✓ $+ 23,01x10^{-19})$ ✓

$f_x = 4,51x10^{15}\ Hz$ ✓

(5)

13.4.1 No effect ✓ (1)

13.4.2 Increases ✓ (1)

13.4.2 No effect ✓ (1)

[12]

QUESTION 14

14.1.1 The process whereby electrons are ejected from a (metal) surface when light of suitable frequency is incident on that surface. ✓✓ (2)

14.1.2

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)

14.1.3

$E = W_o + K_{max}$ ✓

$hf = hf_o + \frac{1}{2}mv_{max}^2$

$7,96x10^{-19}$ ✓ $= (6,63x10^{-34})(9,09x10^{14})$ ✓ $+ \frac{1}{2}(9,11x10^{-31})v_{max}^2$ ✓

$v_{max} = 6,51x10^{5}\ m \cdot s^{-1}$ ✓

(5)

14.2 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 15

15.1 Light has a particle nature/is quantized. ✓ (1)

15.2 The minimum energy (of incident photons) that can eject electrons from a metal/surface. ✓✓ (2)

15.3

$E = W_o + E_{k(max)}$ ✓

$hf = W_o + E_{k(max)}$

$(6,63x10^{-34})(5,96x10^{14})$ ✓ $= 3,42x10^{-19} + E_{k(max)}$ ✓

$E_{k(max)} = 5,31x10^{-20}\ J$ ✓

(4)

15.4

$I = \frac{Q}{\Delta t}$

$0,012 = \frac{Q}{10}$ ✓

$Q = 0,12\ C$

$n = \frac{Q}{e}$

$= \frac{0,12}{1,6x10^{-19}}$ ✓ ✓

$= 7,5x10^{17}$

$Number\ of\ photons = 7,5x10^{17}$ ✓ (4)

15.5 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 16

16.1 6,63 x 10^{-34} (1)

16.2 The minimum energy needed to eject an electron from a (metal) surface. ✓✓ (2)

16.3.1

$W_o = hf_o$ ✓

$= (6,63x10^{-34})(5x10^{14})$ ✓

$= 3,32x10^{-19}\ J$ ✓ (3)

16.3.2

$E = W_o + E_{k(max)}$ ✓

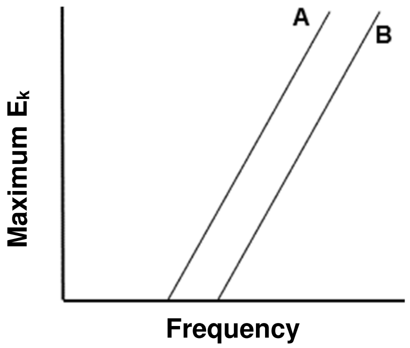
$(6,63x10^{-34})(12,54x10^{14})$ ✓ $= 3,32x10^{-19} + E_{k(max)}$ ✓

$E_{k(max)} = 4,99x10^{-19}\ J = X$ ✓ (4)

16.4.1 No effect ✓ (1)

16.4.2 Increases ✓ (1)

16.5



Marking criteria
Graph **B** to the right of graph **A** ✓
Lines are parallel. ✓

(2)
[14]

QUESTION 17

17.1.1 The minimum energy (of incident photons) that can eject electrons from a metal/surface. ✓✓ (2)

17.1.2

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)

17.1.3

$F = \frac{kQ_AQ_B}{r^2}$ ✓

$0{,}027$ ✓ $= \frac{(9x10^9)(5{,}4x10^{-6})Q_B}{0{,}1^2}$ ✓

$Q_B = 5{,}56x10^{-9}\ C$

$n = \frac{Q_B}{e}$ ✓

$= \frac{5{,}56x10^{-9}}{1{,}6x10^{-19}}$ ✓

$= 3{,}47x10^{10}$

Number of electrons $= 3{,}47 \times 10^{10}$ ✓ (6)

17.2.1 (Line) Absorption ✓ (1)

17.2.2 Continuous spectrum of white light/rainbow of colours ✓ with dark/black lines ✓ (replacing specific frequencies). (2)

17.2.3 Diagram B ✓✓ (2)

[17]

QUESTION 18

18.1 The process whereby electrons are ejected from a (metal) surface when light of suitable frequency is incident on that surface. ✓✓ (2)

18.2

$E = W_o + K_{max}$ ✓

$\frac{hc}{\lambda} = hf_o + \frac{1}{2}mv_{max}^2$

$\frac{(6{,}63x10^{-34})(3x10^8)}{4{,}7x10^{-7}}$ ✓ $= (6{,}63x10^{-34})(4{,}37x10^{14})$ ✓ $+ \frac{1}{2}(9{,}11x10^{-31})v_{max}^2$ ✓

$v_{max} = 5{,}41x10^5\ m \cdot s^{-1}$ ✓ Range: 541 289,67 $m \cdot s^{-1}$ ~ 541 292,69 $m \cdot s^{-1}$ (5)

18.3.1 Higher than ✓ (1)

18.3.2 (Photons of UV light) eject electrons (from the disc/Zn). ✓
The negative charge on the electroscope decreases/becomes zero. ✓
The electrostatic/repulsive force on the foil decreases/becomes zero. ✓ (3)

18.3.3 No ✓. Increasing the intensity increases the number of photons, but does not increase the energy of the photon(s). ✓ **OR** Photons will still have the same energy. **OR** Frequency stays the same / does not increase.

[13]

QUESTION 19

19.1 The process whereby electrons are ejected from a metal surface when light (of suitable frequency) is incident/shining on that surface. ✓✓ (2)

19.2.1 Green ✓ (1)

19.2.2 Only green and blue light eject electrons. / Red light does not eject electrons. ✓
Green has a lower frequency than blue. / Green has longer wavelength than blue. / Photons of blue light has more energy than photons of green light. ✓ (2)

19.2.3

$E = W_o + E_{k(\max)}$ ✓

$hf = W_o + E_{k(\max)}$

$(6{,}63x10^{-34})(5{,}85x10^{14})$ ✓ $= W_o + 2{,}65x10^{-20}$ ✓

$W_o = 3{,}614x10^{-19}\ J$

$E = W_o + E_{k(\max)}$

$hf = W_o + E_{k(\max)}$

$(6{,}63x10^{-34})f = 3{,}614x10^{-19} + 6{,}96x10^{-20}$ ✓

$f = 6{,}5x10^{14}\ Hz$ ✓ (5)

19.2.4 Remain the same. ✓✓ (2)

19.3.1 (Line) emission spectrum ✓ (1)

19.3.2 Coloured lines represent (associated) frequencies/wavelengths / energy of emitted photons ✓ when atoms/electrons move to a lower energy level. ✓ (2)

[15]

BIBLIOGRAPHY

Department of Basic Education, *National Senior Certificate Physical Sciences Question papers*, 2014 – 2024, Pretoria

