Education

KwaZulu-Natal Department of Education
REPUBLIC OF SOUTH AFRICA

PHYSICAL SCIENCES: PHYSICS (P1)

COMMON TEST

JUNE 2017

NATIONAL SENIOR CERTIFICATE

GRADE 12

MARKS: 100

TIME : 2 hours

This question paper consists of 9 pages and a 1 page data sheet.

INSTRUCTIONS AND INFORMATION TO CANDIDATES

1. Write your name on the **ANSWER BOOK**.
2. This question paper consists of SIX questions. Answer ALL the questions in the ANSWER BOOK.
3. Start EACH question on a NEW page in the ANSWER BOOK.
4. Number the answers correctly according to the numbering system used in this question paper.
5. Leave ONE line between two subsections, for example between QUESTION 2.1 and QUESTION 2.2.
6. You may use a non-programmable calculator.
7. You may use appropriate mathematical instruments.
8. You are advised to use the attached DATA SHEET.
9. Show ALL formulae and substitutions in ALL calculations.
10. Round off your final numerical answers to a minimum of TWO decimal places.
11. Give brief motivations, discussions, et cetera where required.
12. Write neatly and legibly.

QUESTION 1: MULTIPLE CHOICE

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Write only the letter (A - D) next to the question number (1.1 – 1.7) in the ANSWER BOOK, for example 1.8 D.

1.1 An object is suspended by a string from the ceiling.

Which force forms a 'Newton's Third Law pair' with the weight of the object?

A The gravitational force exerted by the object on the Earth.

B The force from the ceiling acting on the object.

C The force of the object on the ceiling.

D The force of tension in the string acting on the object. (2)

1.2 Two blocks, A and B, of mass **m** and **2 m** respectively are connected together by means of a light inextensible cord as shown in the diagram.

A force F applied to the system causes the blocks to accelerate to the right. Which one of the following statements concerning this situation is TRUE?

A The magnitude of F is equal to the magnitude of T.

B The resultant acceleration of the system is directly proportional to the total mass of the system.

C The resultant acceleration of the system is inversely proportional to the total mass of the system.

D The acceleration of A is greater than that of B. (2)

1.3 A car, travelling at a velocity **v**, has a kinetic energy of E. What will be the CHANGE in the kinetic energy of the car when its velocity is increased to **2v**?

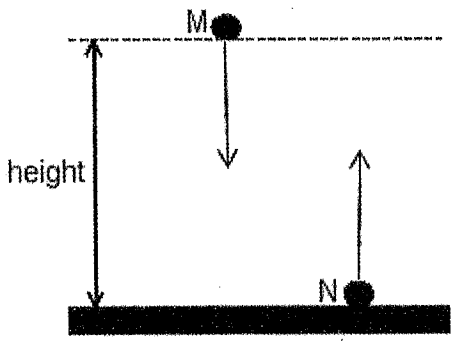
A 8E

B 4E

C 3E

D 2E (2)

1.4 The instant a steel ball M is dropped from rest from a certain height, another steel ball N is projected vertically upward from ground level. The maximum height that N reaches is the same height from which M is dropped. M does not bounce when it hits the ground.



Which one of the following pairs of statements, regarding the speed and acceleration of M and N, is true when they are at the same height? Air resistance is negligible.

	Speed	**Acceleration**
A.	Speed of M < Speed of N	The direction of the acceleration of M and N are both downward
B.	Speed of M = Speed of N	The direction of the acceleration of M and N are both downward
C.	Speed of M > Speed of N	The direction of the acceleration of M is downward and that of N is upward
D.	Speed of M = Speed of N	The direction of the acceleration of M is downward and that of N is upward

(2)

1.5 Two trolleys, A and B, of mass **M** and **2M** respectively are at rest on a horizontal surface. A resultant force **F** is now applied to each of the trolleys for the same time. If the momentum of trolley A is **p**, then the momentum of trolley B will be...

A **p**

B ½ **p**

C 2 **p**

D 4 **p** (2)

1.6 An electric motor lifts a load of mass **M** vertically through a height **h** at a constant speed **v**. Which one of the following expressions gives the power generated by the motor?

A Mgh

B Mgh + ½ Mv

C Mgv

D Mgv + Mgh (2)

1.7 Astronomers observe that the emitted light of a star shifts to the red part of the visible spectrum. This observation confirms that the ...

A star is moving closer towards Earth.

B Earth is moving towards the star.

C universe is expanding.

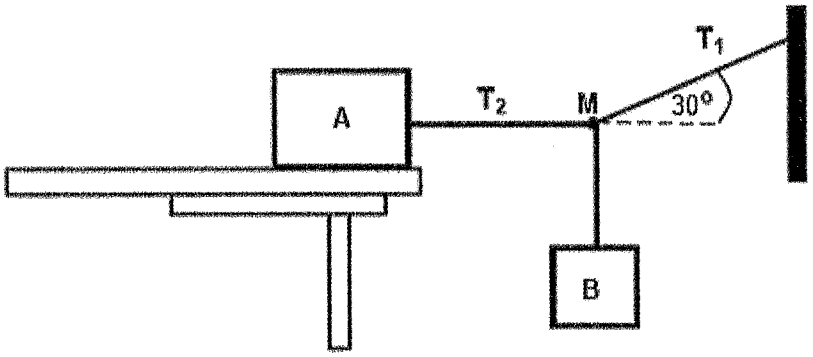
D temperature of Earth is increasing. (2)

[14]

QUESTION 2 (Start on a new page)

2.1 A block **A**, of mass 50 kg, is at rest on a table. It is connected to block **B** by means of two light inextensible strings knotted at M. A third string is arranged in such a way that the string connecting block A is horizontal as shown in the diagram below.

The coefficient of static friction between block A and the surface of the table is 0,20. The resultant of all forces acting at point M is zero.



The tension in the string connecting block A is T_2 and that for the string that pulls at 30^0 is T_1 as shown in the diagram.

2.1.1 Define *static frictional force.* (2)

2.1.2 Draw a labelled free-body diagram to show all the forces acting on the knot M. (3)

If Block B has a maximum mass for which block A will just begin to slip, calculate:

2.1.3 The magnitude of the tension T_2 (4)

2.1.4 The mass of B (5)

2.2 Satellite Aldock has a mass of 615 kg and is in orbit around the Earth.

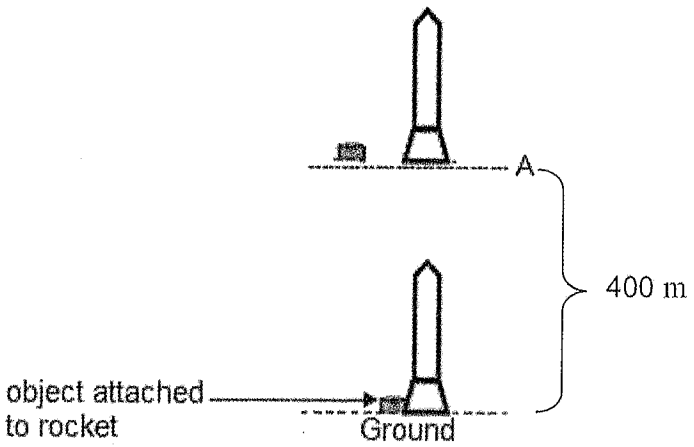
2.2.1 State Newton's Law of Universal Gravitation in words. (2)

2.2.2 If the Earth exerts a force of 5000 N on Satellite Aldock to keep it in orbit, calculate the height of the satellite's orbit above the surface of the Earth. (5)

[21]

QUESTION 3 (Start on a new page)

A stationary rocket with an object attached to it is fired vertically upwards from the ground. When the rocket is 400 m above the ground, the object is released from the rocket (point **A** on diagram). At this point, the velocity of the rocket is 100 $m \cdot s^{-1}$.



3.1 Give a reason why the object keeps moving upwards after it is released from the rocket. (2)

3.2 What is the direction of the net acceleration of the object whilst still attached to the rocket ? (1)

3.3 What is a *projectile*? (2)

3.4 Calculate the time taken for the object to:

3.4.1 Reach its maximum height after being released from the rocket. (3)

3.4.2 Reach the ground after being released from the rocket. (4)

3.5 Calculate the velocity of the object with which it will hit the ground. (3)

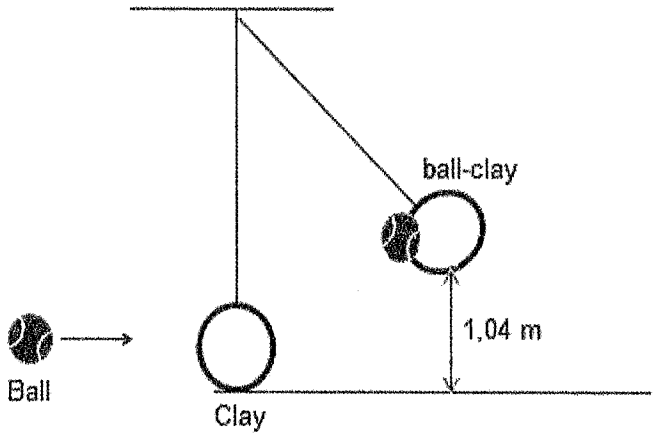
3.6 Sketch the velocity versus time graph for the complete motion of the object. On the graph indicate the following:

- Initial velocity of the object
- Time to reach its maximum height.
- Time when it reaches the ground
- The velocity with which it hits the ground

(5)
[20]

QUESTION 4 (Start on a new page)

A tennis ball of mass 57 g is moving horizontally when it collides with a stationary piece of clay of mass 500 g that is suspended from a string. When the ball hits the clay it remains attached to the clay. The ball and clay then rise to a height of 1,04 m. Neglect the effects of air resistance.



4.1 State the Principle of Conservation of Mechanical Energy. (2)

4.2 Calculate the magnitude of the velocity of the ball and clay immediately after they collide with each other. (4)

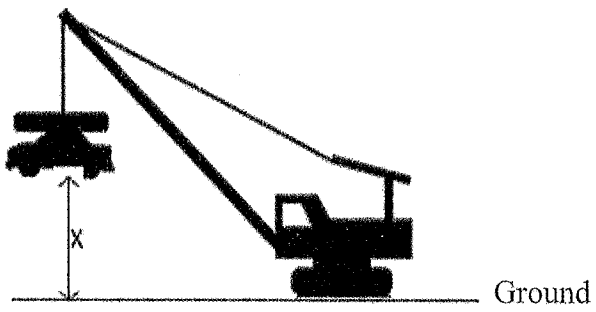
4.3 State the Principle of Conservation of Momentum. (2)

4.4 Calculate the speed of the tennis ball before it collided with the clay. (5)

[13]

QUESTION 5 (Start on a new page)

At the scrapyard, a large crane with an electromagnet is used to lift a car of mass 1000 kg from rest off the ground so that it can be placed on a scrap heap. When the car is at a height 'x' metres above the ground, the net work done on the car is 250 J and it gains 50000 J of potential energy.
Ignore the effects of air resistance.



5.1 State the work-energy theorem, in words. (2)

5.2 Calculate height 'x' above the ground. (3)

5.3 Using energy principles, calculate the velocity of the car at height 'x' metres. (5)

5.4 Calculate the work done by the crane on the car to lift it to height 'x' metres. (4)

5.5 The crane takes 2 minutes to raise the car to 'x' metres.
Calculate the power delivered by the crane. (4)
[18]

QUESTION 6 (Start on a new page)

Some motion-sensor burglar alarms installed in homes make use of ultra-sound waves that have a frequency of 30 kHz. Waves sent out from the device are reflected by all objects in a room. If the objects are stationary then the reflected waves reach the device with the same frequency as the outgoing wave (30 kHz). If an object moves, the frequency of the reflected waves is altered. Such a change in frequency will trigger the alarm.

(Take the speed of sound in air as 340 $m \cdot s^{-1}$ when answering these questions).

6.1 Name and state the scientific phenomenon upon which this technology is based. (3)

6.2 Convert 30 kHz to Hz. (1)

6.3 Calculate the wavelength of the waves being generated by the device. (3)

6.4 How will the frequency of a wave detected by the device change when it is reflected off an object moving towards the device?
(Choose from **INCREASES**, **DECREASES** or **REMAINS THE SAME**). (1)

6.5 A wave reflected off a moving object in the room is detected at a frequency of 29 500 Hz. Calculate the velocity of the object. (6)
[14]

GRAND TOTAL: [100]

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 1 (PHYSICS)

TABLE 1: PHYSICAL CONSTANTS/*TABEL 1: FISIESE KONSTANTES*

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Acceleration due to gravity *Swaartekragversnelling*	g	$9,8\ m\cdot s^{-2}$
Speed of light in a vacuum *Spoed van lig in 'n vacuum*	c	$3,0 \times 10^{8}\ m\cdot s^{-1}$
Planck's constant *Planck se konstante*	h	$6,63 \times 10^{-34}\ J\cdot s$
Universal gravitational constant *Universele gravitasiekonstante*	G	$6,67 \times 10^{-11}\ N\cdot m^2\cdot kg^{-2}$
Mass of Earth *Massa van Aarde*	M_E	$5,98 \times 10^{24}\ kg$
Radius of Earth *Radius van Aarde*	R_E	$6,38 \times 10^{6}\ m$

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

MOTION/*BEWEGING*

$v_f = v_i + a\Delta t$	$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$ or/*of* $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$
$v_f^2 = v_i^2 + 2a\Delta x$ or/*of* $v_f^2 = v_i^2 + 2a\Delta y$	$\Delta x = \left(\frac{v_f + v_i}{2}\right)\Delta t$ or/*of* $\Delta y = \left(\frac{v_f + v_i}{2}\right)\Delta t$

FORCE/*KRAG*

$F_{net} = ma$	$p = mv$
$F\Delta t = \Delta p = mv_f - mv_i$	$F_g = mg$
$f_s^{max} = \mu_s N$	$f_k = \mu_k N$
$F = \frac{Gm_1m_2}{r^2}$	$g = \frac{Gm}{r^2}$

WORK, ENERGY AND POWER/*ARBEID, ENERGIE EN DRYWING*

$W = F\Delta x\cos\theta$	$U = E_P = mgh$
$K = E_k = \frac{1}{2}mv^2$	$W = \Delta K = \Delta E_k = E_{kf} - E_{ki}$
$P = \frac{W}{\Delta t}$	$P = Fv$

WAVES, SOUND AND LIGHT/*GOLWE, KLANK EN LIG*

$v = f\lambda$ or/*of* $v = \nu\lambda$	$T = \frac{1}{f}$ or/*of* $T = \frac{1}{\nu}$
$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$	

Basic Education

KwaZulu-Natal Department of Basic Education
REPUBLIC OF SOUTH AFRICA

PHYSICAL SCIENCES P1

MARKING GUIDELINE

COMMON TEST

JUNE 2017

NATIONAL SENIOR CERTIFICATE

GRADE 12

N.B. This memorandum consists of 8 pages including this page.

SECTION A

QUESTION 1

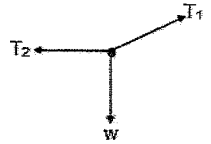
1.1 A✓✓
1.2 C✓✓
1.3 A✓✓
1.4 B✓✓
1.5 A✓✓
1.6 C✓✓
1.7 C✓✓

7x 2 = **[14]**

QUESTION 2

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

2.1.2



Criteria
T_1: Tension T_1 ✓
T_2: Tension T_2✓
w/F_g: Force of gravity✓

(3)

2.1.3 $T_2 + (-f_s) = 0$✓
$T_2 = f_s = u_sN$✓
$T_2 = (0,2)(50)(9,8)$ ✓ = 98 N✓ (4)

2.1.4 $T_1\cos30° + (-T_2) = 0$✓
$T_1\cos30° - 98 = 0$✓
$T_1 = 113,16$ N

$T_1\sin30° + (-w) = 0$✓
$(113,16)\sin30° - m(9,8) = 0$✓
m = 5,77 kg✓ (5)

2.2.1 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)

2.2.2 $F = \frac{Gm_1m_2}{r^2}$ ✓

5000✓ $= \frac{(6,67\times10^{-11})(5,98\times10^{24})(615)}{r^2}$ ✓

$r = 7,00\times10^6$ m

height = $7,00\times10^6$ –✓ $6,38\times10^6 = 6,20\times10^5$ m✓ (5)

OR denominator $(6,38\times10^6+x)^2$✓
$x = 6,20\times10^5$ m✓

[21]

QUESTION 3

3.1 The object has inertia. ✓✓ (2)

3.2 Upwards ✓ (1)

3.3 An object upon which the only force acting is the force of gravity. ✓✓ (2 or 0) (2)

3.4.1

Upward is positive	**Downward is positive**
$v_f = v_i + a\,\Delta t$ ✓	$v_f = v_i + a\,\Delta t$ ✓
$0 = 100 + (-9.8)\,\Delta t$✓	$0 = -100 + 9.8\Delta t$✓
$\Delta t = 10{,}20$ s ✓	$\Delta t = 10{,}20$ s✓

(3)

3.4.2 **OPTION 1**

Upward is positive	**Downward is positive**
$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓	$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓
-400✓ $= 100\Delta t + \frac{1}{2}(-9{,}8)\Delta t^2$ ✓	400✓ $= -100\Delta t + \frac{1}{2}(9{,}8)\Delta t^2$✓
$\Delta t = 23{,}83$ s or $-3{,}43$ s	$\Delta t = 23{,}83$ s or $-3{,}43$ s
$\Delta t = 23{,}83$ s✓	$\Delta t = 23{,}83$ s✓

(4)

OPTION 2

Upward is positive	**Downward is positive**
A→max. height→A	A→max. height→A
$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓	$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓
$0 = 100\Delta t + \frac{1}{2}(-9{,}8)\Delta t^2$✓	$0 = -100\Delta t + \frac{1}{2}(9{,}8)\Delta t^2$✓
$\Delta t = 20{,}408$ s	$\Delta t = 20{,}408$ s
Total time = $3{,}43+20{,}408$✓	Total time = $3{,}43+20{,}408$✓
$= 23{,}84$s✓	$= 23{,}84$s✓

OPTION 3

Upward is positive	**Downward is positive**
Height reached above point A	Height reached above point A
$v_f^2 = v_i^2 + 2a\Delta y$	$v_f^2 = v_i^2 + 2a\Delta y$
$0^2 = (100)^2 + 2(-9{,}8)\Delta y$	$0^2 = (-100)^2 + 2(9{,}8)\Delta y$
$\Delta y = 510{,}20$ m	$\Delta y = 510{,}20$ m
From max. height to the ground	From max. height to the ground
$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$	$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$
$-910{,}20 = (0)\Delta t + \frac{1}{2}(-9{,}8)\Delta t^2$✓	$910{,}20 = (0)\Delta t + \frac{1}{2}(9{,}8)\Delta t^2$✓
$\Delta t = 13{,}629$ s	$\Delta t = 13{,}629$ s
Total time = $10{,}20 + 13{,}629$✓	Total time = $10{,}20 + 13{,}629$✓
$= 23{,}83$ s✓	$= 23{,}83$ s ✓

3.5 **OPTION 1**

Upward is positive	**Downward is positive**
$v_f = v_i + a\,\Delta t$ ✓	$v_f = v_i + a\,\Delta t$ ✓
$= 100 + (-9.8)(23{,}83)$✓	$= -100 + (9.8)(23{,}83)$✓
$= -133{,}53$ m.s^{-1}	$= 133{,}53$ m.s^{-1}(downwards) ✓
$v_f = 133{,}53$ m.s^{-1} (downwards) ✓	

(3)

OPTION 2

Upward is positive	**Downward is positive**
From maximum height	From maximum height
$v_f = v_i + a\,\Delta t$ ✓	$v_f = v_i + a\,\Delta t$ ✓
$= 0 + (-9{,}8)(13{,}63)$✓	$= 0 + (9.8)(13{,}63)$✓
$= -133{,}53$ m.s^{-1}	$= 133{,}57$ m.s^{-1}(downwards) ✓
$v_f = 133{,}57$ m.s^{-1} (downwards) ✓	

(3)

OPTION 3

Upward is positive	**Downward is positive**
Point A (downwards)→Ground	Point A (downwards)→Ground
$v_f = v_i + a\,\Delta t$ ✓	$v_f = v_i + a\,\Delta t$ ✓
$= -100 + (-9.8)(3{,}43)$✓	$= 100 + (9.8)(3{,}43)$✓
$= -133{,}53$ m.s^{-1}	$= 133{,}61$ m.s^{-1}(downwards) ✓
$v_f = 133{,}61$ m.s^{-1} (downwards) ✓	

(3)

OPTION 4

Upward is positive	**Downward is positive**
(Point A→Ground), downwards	(Point A→Ground), downwards
$\Delta y = \frac{(v_i + v_f)}{2}\Delta t$✓	$\Delta y = \frac{(v_i + v_f)}{2}\Delta t$✓
$-400 = \frac{(-100 + v_f)}{2}(3{,}43)$✓	$400 = \frac{(100 + v_f)}{2}(3{,}43)$✓
$v_f = -133{,}24$ m.s^{-1}	$v_f = 133{,}24$ m.s^{-1} (downwards) ✓
$v_f = 133{,}24$ m.s^{-1} (downwards) ✓	

OPTION 5

Upward is positive From point A	**Downward is positive** From point A
$\Delta y = \frac{(v_i + v_f)}{2}\Delta t$ ✓	$\Delta y = \frac{(v_i + v_f)}{2}\Delta t$ ✓
$-400 = \frac{(100 + v_f)}{2}(23,83)$ ✓	$400 = \frac{(-100 + v_f)}{2}(23,83)$ ✓
$v_f = -133,57$ m.s^{-1}	$v_f = 133,57$ m.s^{-1} (downwards) ✓
$v_f = 133,57$ m.s^{-1} (downwards) ✓	

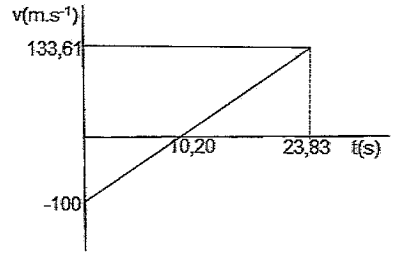
(3)

OPTION 6

Upward is positive From maximum height to ground	**Downward is positive** From maximum height to ground
$\Delta y = \frac{(v_i + v_f)}{2}\Delta t$ ✓	$\Delta y = \frac{(v_i + v_f)}{2}\Delta t$ ✓
$-910,20 = \frac{(0 + v_f)}{2}(13,629)$ ✓	$910,20 = \frac{(0 + v_f)}{2}(3,43)$ ✓
$v_f = -133,57$ m.s^{-1}	$v_f = 133,24$ m.s^{-1} (downwards) ✓
$v_f = 133,24$ m.s^{-1} (downwards) ✓	

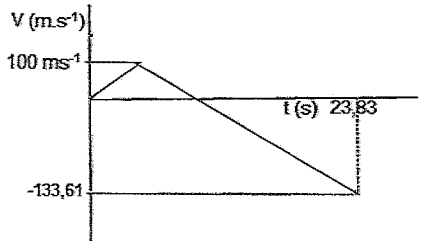
(3)

3.6 **Upward is positive**



Starts at -100 m.s^{-1}✓
Graph intercept at 10,20 s✓
Graph ends at 133,61 m.s^{-1}✓
Graph ends at 23,83 s✓
Shape✓

OR

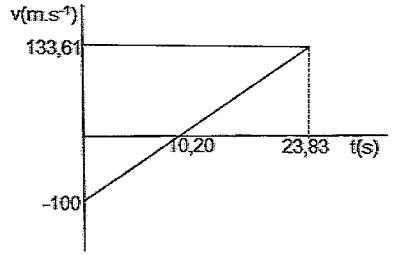


Criteria

Starts at 0 m.s^{-1}✓
Graph intercept at 10,20 s✓
Graph ends at -133,61 m.s^{-1}✓
Graph ends at 23,83 s✓
Shape✓

(5)

Downward is positive



Criteria

Starts at -100 m.s^{-1}✓
Graph intercept at 10,20 s✓
Graph ends at 133,61 m.s^{-1}✓
Graph ends at 23,83 s✓
Shape✓

(5)

[20]

QUESTION 4

4.1 The total mechanical energy (sum of gravitational potential energy and kinetic energy) in an isolated system remains constant. ✓✓/ in the absence of any non-conservative forces the sum of the gravitational potential energy and kinetic energy remains constant. ✓✓ (2)

4.2

$(Ek + Ep)_{bottom} = (Ek + Ep)_{top}$ ✓
$\frac{1}{2}mv^2 + 0 = \frac{1}{2}mv^2 + mgh$
$\frac{1}{2}(0,557)v^2$ ✓ $+ 0 = 0 + (0,557)(9,8)(1,04)$ ✓
$v = 4,51$ m.s^{-1} ✓ (4)

4.3 Total linear momentum of an isolated system remains constant. ✓✓ (2)

4.4 Total momentum before collision = Total momentum after
total $p(ball + clay)_{before}$ = total $p(ball) + p(clay)_{after}$ any one✓
$m_1v_{i1} + m_2v_{i2} = mv_f$
$(0,057)v_b$✓ $+ (0,5)(0) = (0,5 + 0,057$✓$)(4,51)$ ✓
$v_i(ball) = 44,07$ m.s^{-1}✓ (5)

[13]

QUESTION 5

5.1 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)

5.2 $U = mgh$ ✓
$50000 = (1000)(9,8)x$✓
$x = 5,10$ m ✓ (3)

5.3 $W_{net} = \Delta K$ ✓
250✓ $= \frac{1}{2}(1000)(v_f^2$✓ $- 0^2$✓$)$
$v_f = 0,707$ m.s^{-1} (upwards)✓ (5)

5.4 $W_{net} = W_{crane} + W_g$ ✓
250✓ $= W_{crane} - 50000$ ✓
$W_{crane} = 50250$ J ✓ (4)

5.5 $P = \frac{W_{crane}}{\Delta t}$ ✓
$= \frac{50\,250}{2 \times 60}$✓✓
$= 418,75$ W ✓ (4)
[19]

QUESTION 6

6.1 Doppler effect. ✓ It is 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

the change in the observed frequency of a sound wave when the source of the sound is moving relative to the listener.✓✓ (3)

6.2 30 000 Hz ✓ (1)

6.3 $\lambda = \frac{v}{f}$ ✓
$= \frac{340}{30000}$✓
$= 0,0113$ m ✓ (3)

6.4 increases ✓ (1)

6.5 Incident waves

$$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$$ ✓
$$= \frac{340 - v}{340}$$✓ (30000) ✓

Reflected waves

$$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$$
$$29500 = \left(\frac{340}{340 + v}\right)\left(\frac{340 - v}{340}\right)(30000)$$ ✓

$v = 2,86$ m.s^{-1} (away from device)✓ (6)
[14]

TOTAL: 100

