Hillcrest High School

PHYSICAL SCIENCE P1

June 2024

Grade 12

MARKS: 100
TIME: 2 Hours

EXAMINER: Ms N. Badenhorst
MODERATOR: Mrs J. Knox-Whitehead

Instructions:

1. Answer ALL the questions.
2. This question paper consists of TWO sections:
3. SECTION A (10)
   SECTION B (90)
4. Answer SECTIONS A and B in the ANSWER BOOK.
   Non-programmable calculators may be used.
5. Appropriate mathematical instruments may be used.
6. Number the answers correctly according to the numbering system used in this question paper.
7. Data sheets are attached for your use.
8. Give brief motivations, discussions, et cetera where required.
9. Numbers must be rounded off to two decimal places

SECTION A

QUESTION 1: MULTIPLE CHOICE QUESTIONS

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 (1.1-1.5) in the answer book..

1.1 An object slows down in such a way that its acceleration is constant. What can we say about the force acting on the object?

A. There is no force acting on it.

B. The net force acting on it increases steadily.

C. The net force acting on it decreases steadily.

D. The net force on it is constant.

1.2 A ball thrown vertically upwards from point **X** reaches its greatest height at point **Y** and returns to the same level as **X** at point **Z**, as shown in the diagram below.

Neglect the effects of air resistance.

Which ONE of the following statements is CORRECT?

A The acceleration at point **Y** equals zero

B The speed at **X** equals the speed at **Z**

C It takes longer time from **X** to **Y** than **Y** to **Z**

D The velocity at **X** equals the velocity at **Z**

1.3 Two bodies of mass 5kg and 7kg respectively are initially at rest on a horizontal frictional surface. A light spring is compressed between them. A thin string then ties the bodies together. After the string is released by burning through the thread, the 5kg body has a speed of $^{1}/_{5}\,m.s^{-1}$. The speed of the 7kg body is:

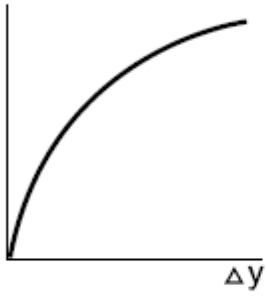
A. $^{1}/_{12}\,m.s^{-1}$

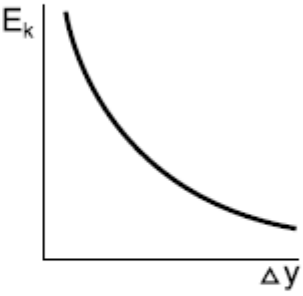
B. $^{1}/_{7}\,m.s^{-1}$

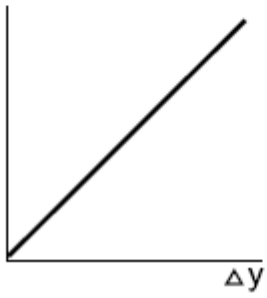
C. $^{1}/_{5}\,m.s^{-1}$

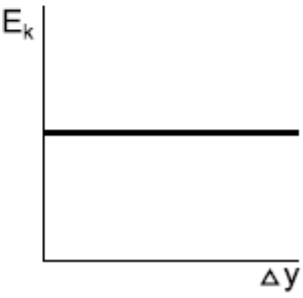
D. $^{7}/_{25}\,m.s^{-1}$

1.4 An object is dropped from a height h above the ground, and freely falls under the influence of gravity. Air resistance is negligible. Which one of the following graphs best represents the relationship between the kinetic energy and the displacement of the object measured from the point where it was dropped?

A. 

B. 

C. 

D. 

1.5 A major piece of scientific evidence that supports the theory that the universe is expanding is the fact that wavelength of light from galaxies moving away from Earth are observed to be

A. shorter than normal (a red shift)

B. shorter than normal (a blue shift)

C. longer than normal (a red shift)

D. longer than normal (a blue shift)

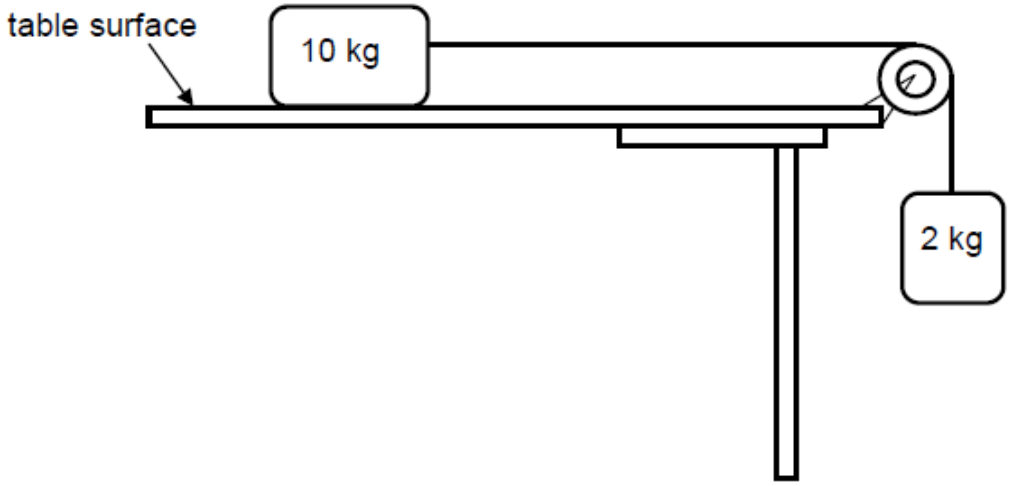
[2 x 5 = 10]

Section B

Question 2

The diagram below shows a 10 kg block lying on a flat, rough, horizontal surface of a table. The block is connected by a light, inextensible string to a 2 kg block hanging over the side of the table. The string runs over a light, frictionless pulley.

The blocks are **stationary**.



2.1 State Newton's FIRST law in words. (2)

2.2 Write down the magnitude of the NET force acting on the 10 kg block. (1)

When a 15 N force is applied vertically downwards on the 2 kg block, the 10 kg block accelerates to the right at 1,2 $m \cdot s^{-2}$.

2.3 Draw a free-body diagram for the 2 kg block when the 15 N force is applied to it. (3)

2.4 Calculate the coefficient of kinetic friction between the 10 kg block and the surface of the table. (7)

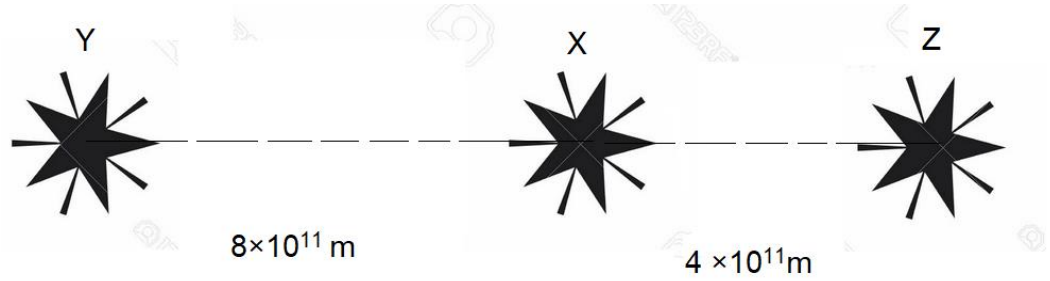
2.5 How does the value, calculated in QUESTION 2.4, compare with the value of the coefficient of STATIC friction for the 10 kg block and the table? Write down only LARGER THAN, SMALLER THAN or EQUAL TO. (1)

2.6 If the 10 kg block had a larger surface area in contact with the surface of the table, how would this affect the coefficient of kinetic friction calculated in QUESTION 2.4? Assume that the rest of the system remains unchanged. Write down only INCREASES, DECREASES or REMAINS THE SAME. Give a reason for the answer. (2)

[16]

Question 3

Two celestial bodies, Star X and Star Y, are located in space. Star X has a mass of 3×10^{30} kg and Star Y has a mass of 5×10^{30} kg. The distance between the centres of the two stars is 8×10^{11} m.



3.1 If a third star, Star Z, with a mass of 7×10^{30} kg, is introduced 4 x 10^{11} m away from Star X along the line connecting Star X and Star Y, what will be the net gravitational force on Star Y. (5)

3.2 State by what factor the force between X and Z would change if the distance between them becomes 1 x 10^{11}m. (2)

[7]

Question 4

A stone **X** is projected vertically upwards from the ground with a speed of **3v**. Stone **Y** is also projected vertically upwards with a speed **v**.

Ignore the effects of air resistance.

4.1 Define the term *free fall*. (1)

Stone **X** takes 10 seconds to return to the ground.

4.2 Calculate the time that stone **Y** takes to return to the ground. (4)

Stone **Y** reaches a maximum height of **H** meters.

4.3 Use an appropriate calculation to show that the height (in terms of **H**) that stone **X** reaches is **9H**. (5)

4.4 Sketch a velocity-time graph for the entire motion of stone **X**.

Clearly show the VALUES of the following on the graph:

- Initial and final velocities
- Time when it reaches the maximum height

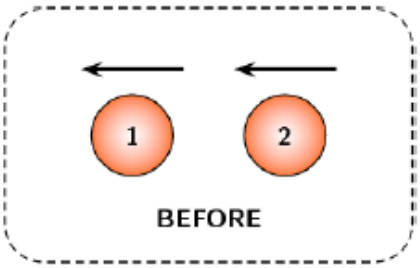
(3)

[13]

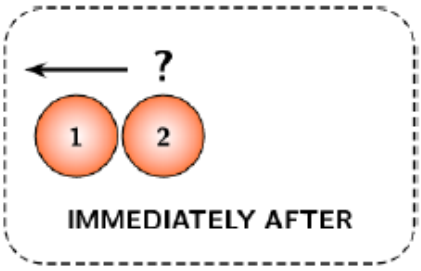
Question 5

A sample of Xenon gas (Xe) is sealed in a closed container. The Xenon atoms are all moving at high speeds and constantly colliding with each other as well as the container walls. A single Xenon atom has a mass of $2,2 \times 10^{-25}$ kg.

Consider a single collision between two of the atoms. Just before the collision, Atom 1 is moving with a velocity of 208 $m.s^{-1}$ to the left and Atom 2 is moving with a velocity of 272 $m.s^{-1}$ to the left.



Immediately after the two atoms collide, Atom 1 has a velocity of 272 $m.s^{-1}$ to the left.



5.1 Define the principle of *conservation of linear momentum* in words.

(2)

5.2 Determine the momentum of Atom 2 immediately after the collision.

(4)

5.3 According to the kinetic molecular theory (KMT), this collision should be elastic. Perform a suitable calculation to show that the collision between the two atoms is perfectly elastic.

(4)

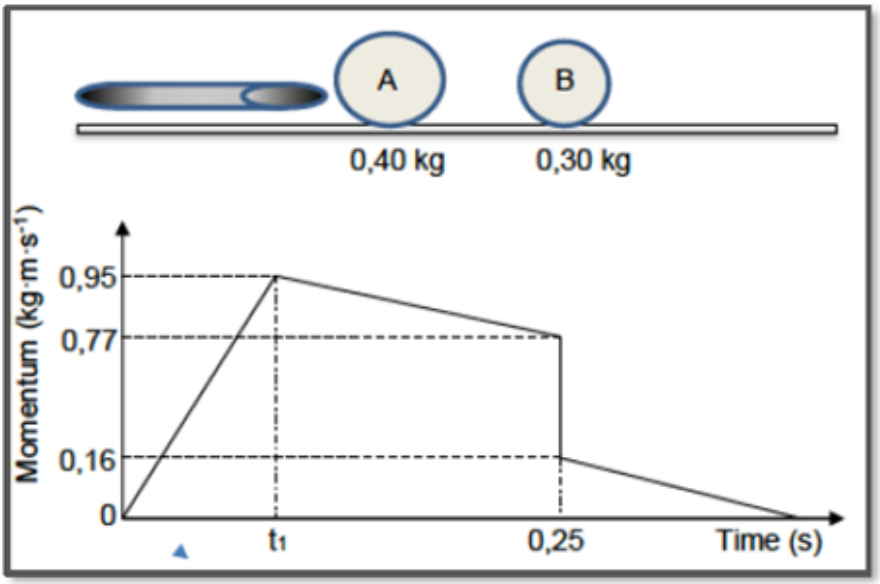
5.4 Determine the magnitude of the impulse experienced by Atom 1 during the collision.

(3)

[13]

Question 6

In a game of snooker / pool, the cue strikes ball A of mass 0,4 kg , as shown in the diagram below. Ball A rolls across the table and collides with Ball B of mass 0,3 kg.



The momentum versus time sketch is drawn (as shown above) for ball A from the moment it is struck by the cue (t = 0 s), as it leaves the cue (t = t_1 s) and as it collides with Ball B (t = 0,25 s).

6.1 Define *impulse* in words.

(2)

6.2 Use the information on the graph to:

6.2.1 Calculate the value of time t_1, if the force exterted by the cue is 65 N.
(round the answer off to 3 decimal places.) (4)

6.2.2 Explain why it is correct to say that the table surface is rough.

(2)

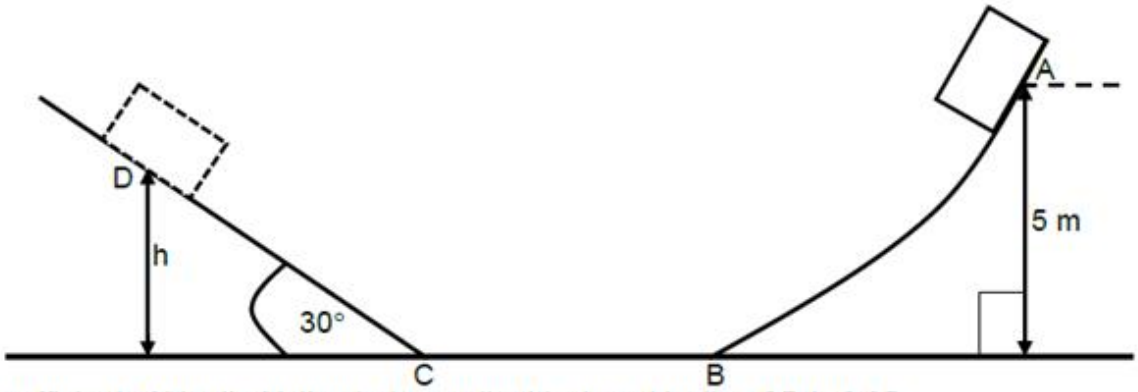
6.2.3 Calculate the velocity of ball B immediately after the collision.

(4)

[12]

Question 7

A block is released from rest at point **A** and slides down a curved frictionless track **AB** and then moves along a frictionless horizontal track **BC**, and finally moves up a ROUGH inclined plane **CD**.



The coefficient of kinetic friction between the block and incline **CD** is 0,35.

7.1 State, in words, the *principle of conservation of mechanical energy*. (2)

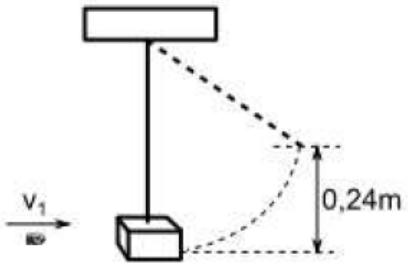
7.2 Use the *principle of conservation of mechanical energy* to calculate the speed of the block at point **B**. (4)

7.3 Using energy principles, calculate the maximum height **h** reached by the block. (6)

[12]

Question 8

Suppose a 8g bullet is fired into a 2,0kg block of a ballistic pendulum, which is originally at rest. The bullet embeds itself in the block and the combination swings upwards to a height of 0,24m. Calculate the initial velocity of the bullet.



[8]

Question 9

Bats use high frequency waves to detect obstacles. A bat emits a wave of frequency 68kHz and wavelength 5mm towards the wall of a cave. It detects the reflected wave 20ms later.

9.1 Calculate the speed at which the wave is travelling. (3)

9.2 How far is the bat from the wall of the cave? (3)

9.3 If the frequency of the reflected wave is 70kHz, calculate the speed at which the bat is approaching the wall of the cave. (3)

[9]

Total 100

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 1 (PHYSICS)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 1 (FISIKA)

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

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Acceleration due to gravity *Swaartekragversnelling*	g	$9{,}8\ m{\cdot}s^{-2}$
Universal gravitational constant *Universele gravitasiekonstant*	G	$6{,}67 \times 10^{-11}\ N{\cdot}m^2{\cdot}kg^{-2}$
Radius of the Earth *Radius van die Aarde*	R_E	$6{,}38 \times 10^{6}\ m$
Mass of the Earth *Massa van die Aarde*	M_E	$5{,}98 \times 10^{24}\ kg$
Speed of light in a vacuum *Spoed van lig in 'n vakuum*	c	$3{,}0 \times 10^{8}\ m{\cdot}s^{-1}$
Planck's constant *Planck se konstante*	h	$6{,}63 \times 10^{-34}\ J{\cdot}s$
Coulomb's constant *Coulomb se konstante*	k	$9{,}0 \times 10^{9}\ N{\cdot}m^2{\cdot}C^{-2}$
Charge on electron *Lading op elektron*	e	$-1{,}6 \times 10^{-19}\ C$
Electron mass *Elektronmassa*	m_e	$9{,}11 \times 10^{-31}\ kg$

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

FORCE/*KRAG*

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

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

$W = F\Delta x\cos\theta$	$U = mgh$ or/*of* $E_P = mgh$
$K = \frac{1}{2}mv^2$ or/*of* $E_k = \frac{1}{2}mv^2$	$W_{net} = \Delta K$ or/*of* $W_{net} = \Delta E_k$ $\Delta K = K_f - K_i$ or/*of* $\Delta E_k = E_{kf} - E_{ki}$
$W_{nc} = \Delta K + \Delta U$ or/*of* $W_{nc} = \Delta E_k + \Delta E_p$	$P = \frac{W}{\Delta t}$
$P_{ave} = Fv_{ave}$	

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

$v = f\lambda$	$T = \frac{1}{f}$
$f_L = \frac{v \pm v_L}{v \pm v_s}f_s$ $f_L = \frac{v \pm v_L}{v \pm v_b}f_b$	$E = hf$ or/*of* $E = h\frac{c}{\lambda}$
$E = W_o + E_k$ where/*waar* $E = hf$ and/*en* $W_0 = hf_0$ and/*en* $E_k = \frac{1}{2}mv^2$	