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ST JOHN'S COLLEGE

Upper V Physical Science

Paper 1 - Physics

Examiners: N Stocks & J Trickett

Time: 3 hours

Moderator: R MacDonald

Total: 200

20 July 2020

Student Name: _____

Please circle your teacher's initials:

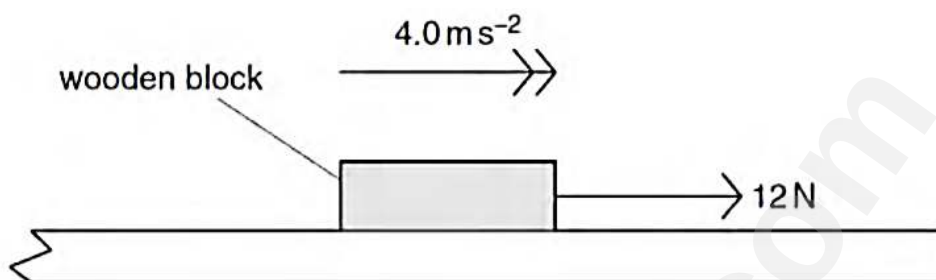
IDC	GH	RM	KMc	NYS	JCT
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- 1) The paper consists of 21 pages of questions. There is a separate 2-page answer sheet. A three-page data sheet is also provided separately.
- 2) Answer Question 1 on the answer sheet provided in the answer book.
- 3) Questions 2 – 14 must be answered in the answer book and on the answer sheet.
- 4) **Start each new question on a new page in the answer book.**
- 5) Calculators may be used.
- 6) Round off to a maximum of **two** decimal places where appropriate.

QUESTION 1

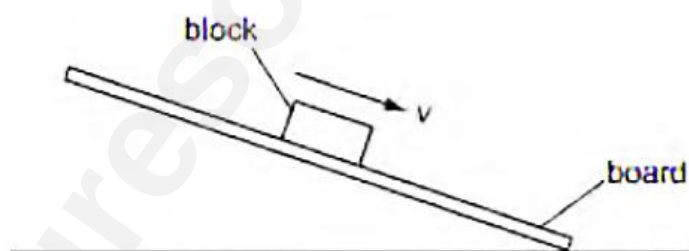
Place an X over the correct option in your answer grid.

- 1.1 A wooden block of mass 0,6 kg is accelerated along a rough horizontal surface at 4 m.s^{-2} by a pulling force of 12 N.



What is the magnitude of the frictional force acting on the block?

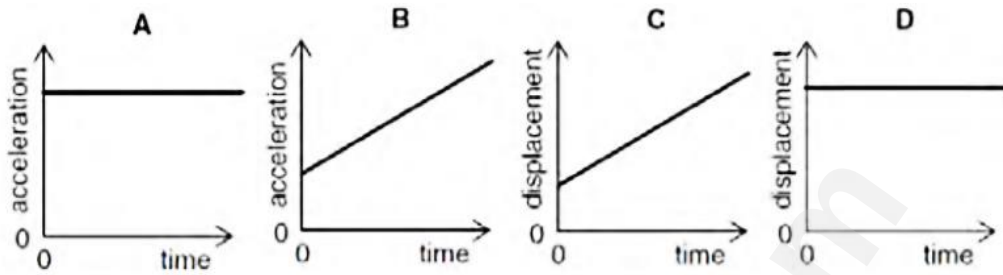
- A. 2.4 N
- B. 9.6 N
- C. 14 N
- D. 16 N
- 1.2 A wooden block rests on a rough board. The end of the board is then raised until the block slides down the plane of the board at a constant velocity, v .



	Frictional force	Resultant force
A	Down the plane	Down the plane
B	Down the plane	zero
C	Up the plane	Down the plane
D	Up the plane	Zero

Which row correctly describes the forces acting **on the block** while it is sliding?

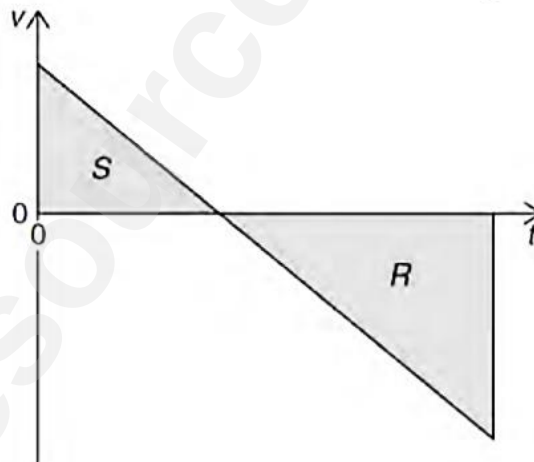
- 1.3 Which graph represents the motion of a car that is travelling along a straight road with uniformly increasing speed?



- 1.4 A stone is thrown upwards from the top of a cliff. After reaching its maximum height, it falls back past the cliff-top and into the sea.

The graph shows how the vertical velocity v of the stone varies with time t , after being thrown upwards.

R and S are the magnitudes of the areas of the two triangles



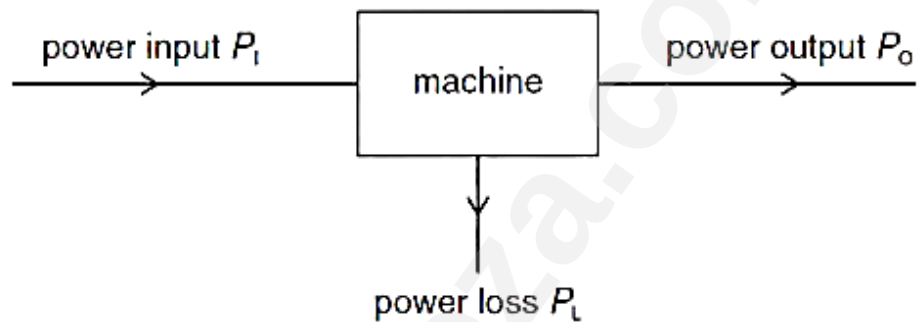
What is the height of the cliff-top above the sea?

- A. R
- B. S
- C. $R + S$
- D. $R - S$

1.5 To reduce the "sting" in catching a hard ball one usually...

- A. increases momentum change
- B. increases the contact force
- C. increases the impulse
- D. increases the contact time

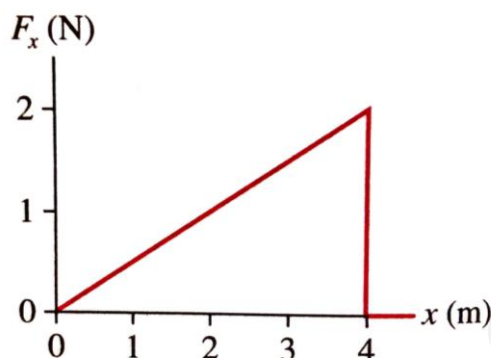
1.6 Power is transferred through a machine as shown.



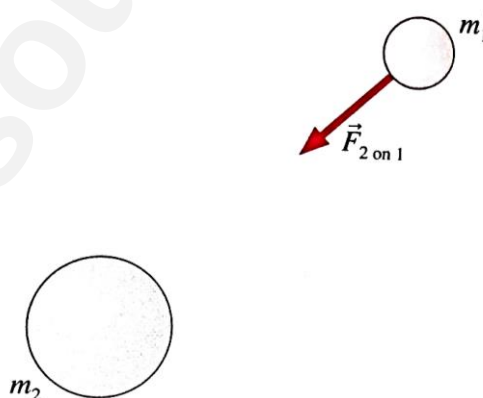
What is the percentage efficiency of the machine?

- A. $\frac{P_I}{(P_O + P_L)} * 100$
- B. $\frac{P_L}{P_I} * 100$
- C. $\frac{P_L}{P_O} * 100$
- D. $\frac{P_O}{P_I} * 100$

- 1.7 A particle moving along the x-axis experiences a force shown in the graph. If the particle has 2,0 J of kinetic energy as it passes $x = 0$ m, what is its kinetic energy when it reaches $x = 4$ m?

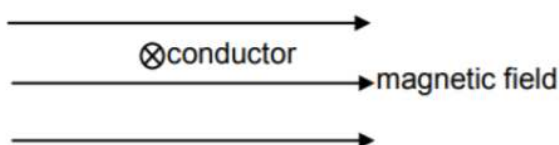


- A. 4 J
B. 6 J
C. 8 J
D. 10 J
- 1.8 The figure shows a binary star system. The mass of star 2 is twice the mass of star 1. Compared to the force of star 1 on star 2 ($F_{1 \text{ on } 2}$), the magnitude of the force of star 2 on star 1 ($F_{2 \text{ on } 1}$) is:



- A. Four times as big
B. Twice as big
C. The same size
D. Half as big

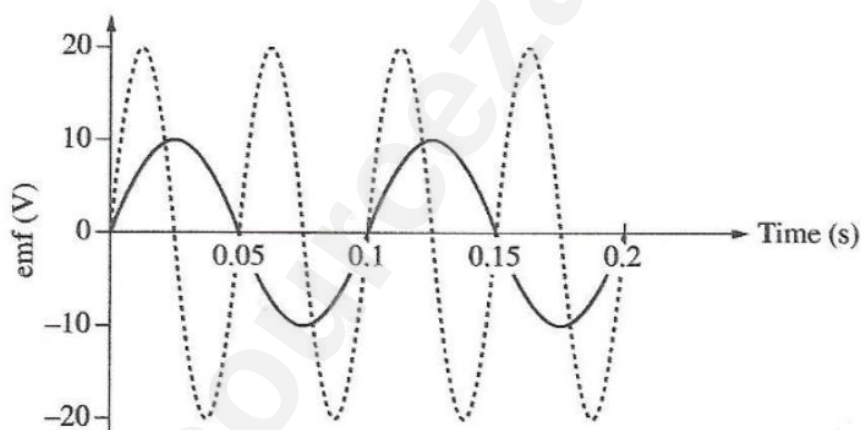
- 1.9 The diagram below shows a current-carrying conductor lying in a uniform magnetic field.



Which one of the following arrows shows the direction of the force acting on the conductor?



- 1.10 In the graph shown, the solid curve shows how the emf produced by a simple generator varies with time. The dashed curve is the output from the same generator after a modification has been made to the generator.



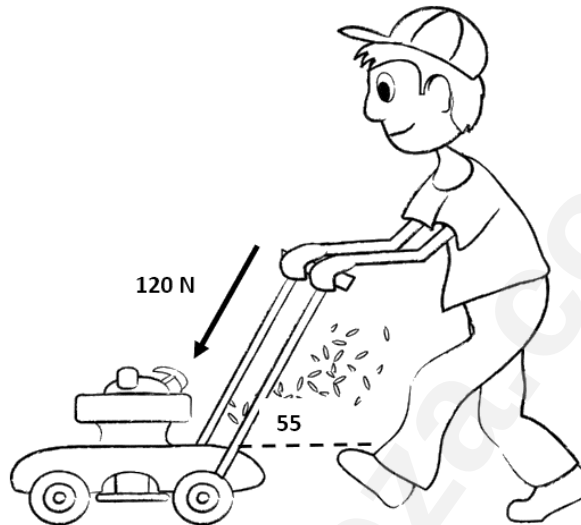
Which modification was made to produce the result shown?

- A. The area of the coil was doubled
- B. The coil was turned half as fast
- C. The number of turns in the coil was quadrupled
- D. The speed of rotation of the coil was doubled

(10 x 2 = 20)

QUESTION 2

During the lockdown period, the whole family is involved in the household chores. While mowing the lawn, Sam exerts a force of 120 N at an angle of 55° to the horizontal, on the handle of a 38 kg mower.

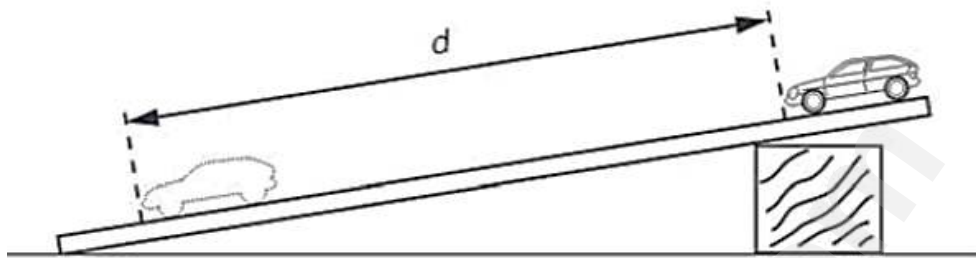


- Calculate the horizontal and vertical components of the force exerted by the boy on the mower. (State the directions of these two component forces). [4]
- Calculate the magnitude of the normal force acting on the mower while it is being pushed. [4]
- The coefficient of kinetic friction between the mower and the lawn is 0,14. Calculate the magnitude of the frictional force acting on the mower while it is being pushed. [3]
- Calculate the magnitude of the acceleration of the mower. [3]
- In question (b), you found the normal force acting on the mower. **Explain** whether this force is Newton's third law partner to the mower's weight. [3]

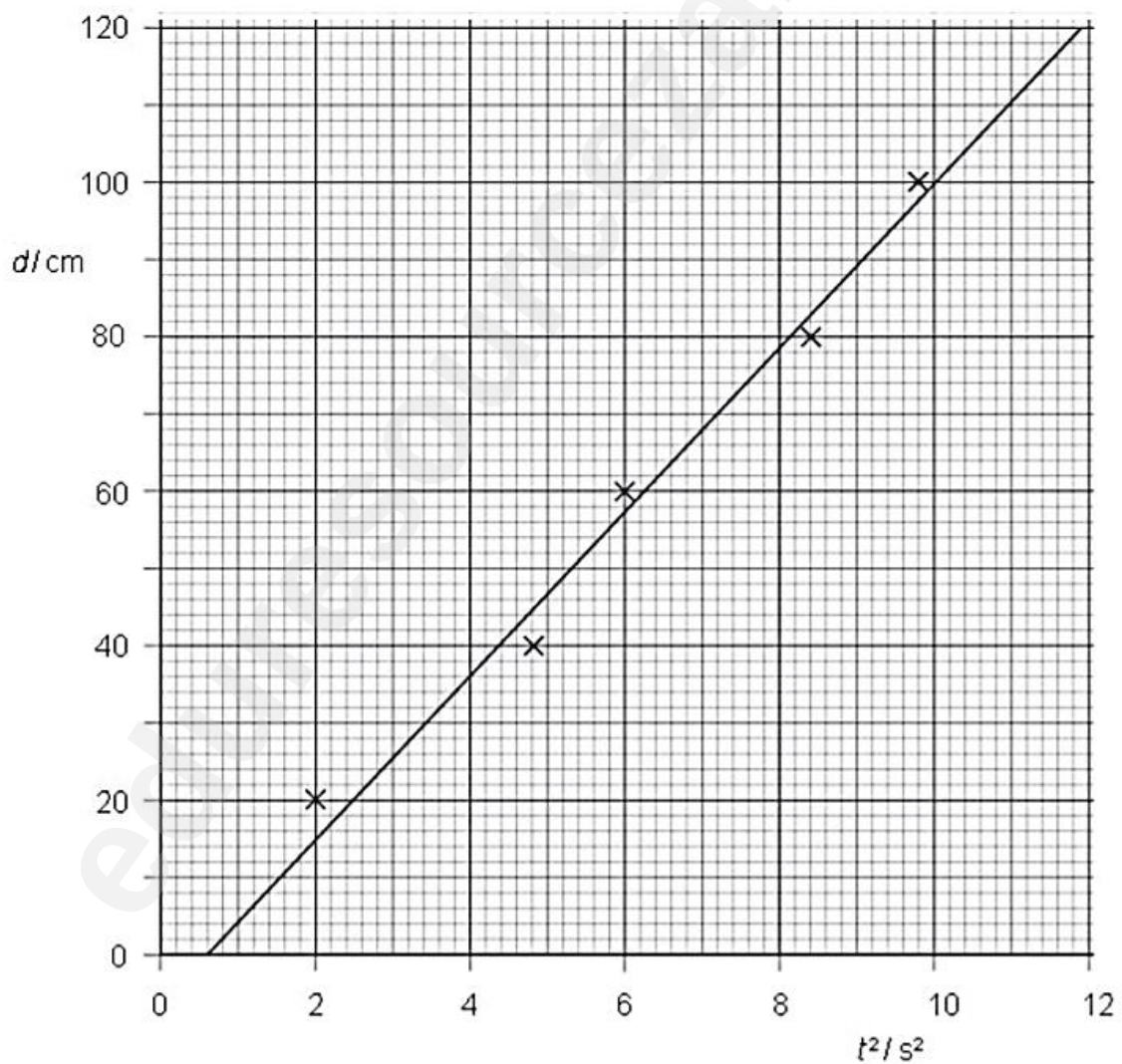
(17)

QUESTION 3

A student has been asked to determine the acceleration of a toy car as it moves, unassisted, down a rough slope. He sets up the apparatus as shown below.



The time t to move from rest through a distance d , is found for different values of d . A graph of d (y axis) is plotted against t^2 (x axis).



- a. Suggest one variable that would need to be kept constant in this experiment, for it to be considered a fair test. [2]
- b. Define *acceleration*. [2]
- c. Draw a labelled free-body diagram to show all the forces acting on the toy car as it moves down the slope. [3]
- d. By referring to your labelled forces in (c) – explain why the toy car accelerates down the slope [3]
- e. Determine the gradient of the line on the graph above **and** show the units of the gradient. [5]
- f. The equation for the straight line on the graph can be aligned with the following equation of motion: $s = ut + \frac{1}{2}at^2$

Use your answer to (e) to calculate the acceleration (in m.s^{-2}) of the toy car down the slope. Show all your working. [3]
- g. If the ramp incline is increased, how would the graph change? Explain your answer. [3]

(21)

QUESTION 4

- 4.1 The 2019 Comrades Marathon was an “up-run” from Durban to Pietermaritzburg. The race distance is approximately 87 km and the men’s race was won by Edward Mothibi in a time of 5 h 31 min 33 s.

a. Calculate Edward’s average speed in $\text{km}\cdot\text{h}^{-1}$ [4]

A helicopter flew along a straight path from the start of the race in Durban to land at the finish in Pietermaritzburg. It travelled for 30 minutes at an average speed of $120 \text{ km}\cdot\text{h}^{-1}$

b. Distinguish between *distance* and *displacement*. [4]

c. Calculate the magnitude of Edward’s displacement at the end of the race. [2]

- 4.2 John waits on his bicycle at the end of his driveway for Paul to arrive. As Paul rides past on his bike with a constant speed of $6 \text{ m}\cdot\text{s}^{-1}$, John gives him a 3 s head start before setting out after him. John starts from rest and rides with a constant acceleration of $1,2 \text{ m}\cdot\text{s}^{-2}$.

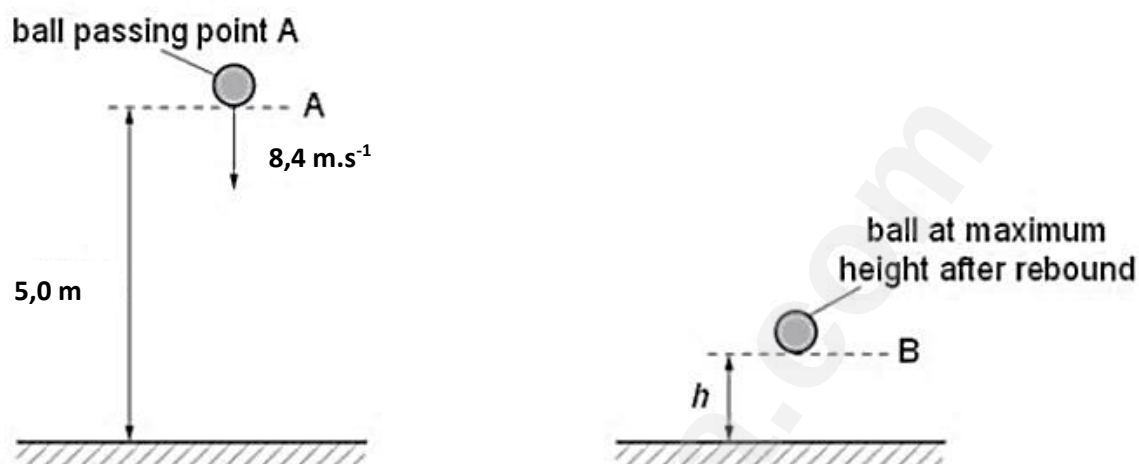
a. Calculate the time taken from when John sets off to when he catches up with Paul. [5]

b. Calculate the distance from John’s driveway to the position where he catches up with Paul. [2]

(17)

QUESTION 5

A ball is thrown vertically down towards the ground and rebounds as illustrated below. (Air resistance can be ignored)



As the ball passes Position A, it has a speed of $8,4 \text{ m.s}^{-1}$. The height of A is $5,0 \text{ m}$ above the ground. The ball strikes the ground and rebounds to Position B.

- Calculate the speed of the ball as it hits the ground. [3]
- Show that the time taken for the ball to reach the ground from position A is $0,47 \text{ s}$. [3]

The ball rebounds vertically with a speed of $4,2 \text{ m.s}^{-1}$ as it leaves the ground. The time for which the ball is in contact with the ground is $0,1 \text{ s}$. The ball rebounds to a maximum height h (Position B).

The ball passes A at time $t = 0 \text{ s}$.

- On your answer sheet:** sketch a graph to show how the velocity, v , of the ball changes with time, t . You need to label relevant y axis values.

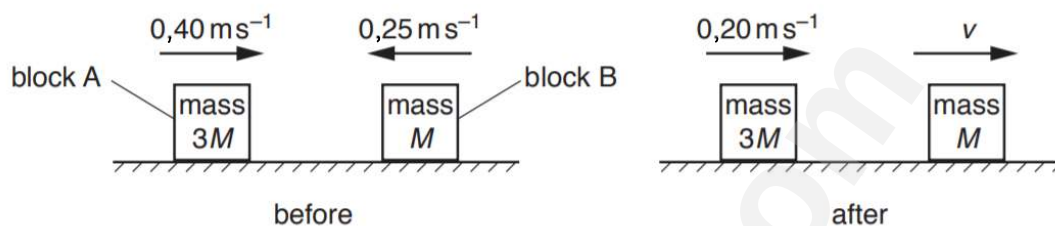
Continue the graph until the ball reaches position B. [5]

(11)

QUESTION 6

6.1. State the principle of conservation of momentum. [2]

6.2 Two blocks travel directly towards each other along a horizontal, frictionless surface. The blocks collide.



Block A has mass $3M$ and block B has mass M . Before the collision, block A moves to the right with speed $0,40 \text{ ms}^{-1}$ and block B moves to the left with speed $0,25 \text{ ms}^{-1}$. After the collision, block A moves to the right with speed $0,20 \text{ ms}^{-1}$ and block B moves to the right with speed v .

6.2.1 Use Newton's third law to explain why, during the collision, the change in momentum of block A is equal and opposite to the change in momentum of block B. [3]

6.2.2 Determine the speed, v . [5]

(10)

QUESTION 7

A physics student aimed to verify the Impulse-Momentum Theorem that states that the change in **momentum** of an object equals the **impulse** applied to it:

$$\text{Change in momentum} = m(\Delta v) = \text{Impulse} = F \cdot \Delta t$$

He used a simulation that modelled a cricket ball bowled to a batsman. The batsman swings the bat and hits the ball straight back. For a constant mass of cricket ball, the simulation allowed the student to adjust the Force of the bat on the ball. The ball-bat contact time was kept constant at 0.001 seconds, throughout the simulation. He then measured the velocity of the delivered ball and the velocity of the ball as it came off the bat.

He repeated the experiment for five different values of Force, to measure five different sets of readings for the delivered and batted ball velocities. He recorded the calculated change in velocity of the ball in the table below.

Force of bat on ball (N)	Impulse $F \cdot \Delta t$ (N.s)	Change in velocity of ball (Δv) (m/s)
2000	2,0	13,0
3000	3,0	16,0
5000	5,0	35,0
7000	7,0	39,0
8000	8,0	51,0

- State the independent variable in this simulation. [2]
- Plot a graph to establish the relationship between the **impulse** applied to the ball and **its change in velocity**. (Use the graph paper provided in your answer sheet) [8]
- State the relationship described by your graph. [2]
- Calculate the value of the gradient. [4]
- What information does the gradient give the student? [2]

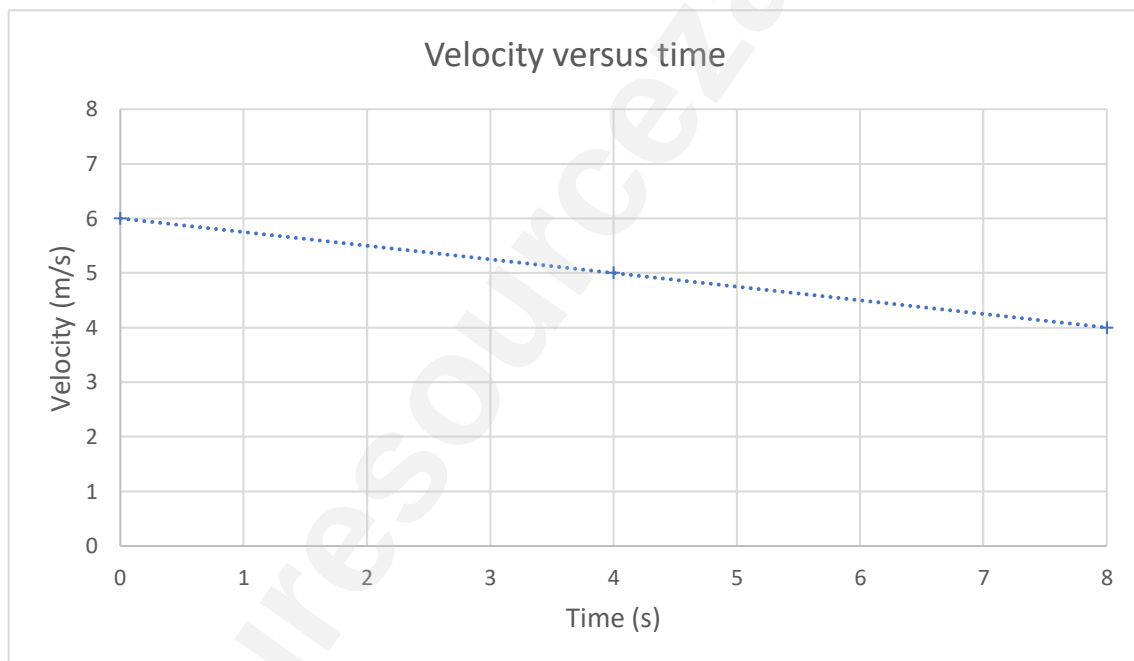
(18)

QUESTION 8

8.1 A 150 000 kg rocket is launched vertically upwards. The rocket motor generates a thrust of $4,0 \times 10^6$ N. *Ignore air resistance and any slight mass loss.*

- Draw and label a free-body diagram showing the forces acting on the rocket at the instant of launch. Your force vectors should be drawn to relative, representative sizes. [3]
- State the *work-energy theorem*. [2]
- Use the work-energy theorem to determine the rocket's speed at a height of 500 m. [5]

8.2 A cyclist is moving up a slope that has a constant gradient. The cyclist takes 8 s to climb the slope. The variation with time, t , of the speed of the cyclist, v , is shown in the graph below.



- Use the graph to calculate the total distance moved up the slope. [4]
- State the law of conservation of energy. [2]

The bicycle and cyclist have a combined mass of 92 kg. The vertical height through which the cyclist moves is 1,3 m.

For the movement of the bicycle and the cyclist from $t = 0$ s to $t = 8$ s,

- Use the graph above to calculate the change in kinetic energy. [3]
- Calculate the change in gravitational potential energy. [3]

The cyclist pedals continuously so that the useful power delivered to the bicycle is 75 W.

- e. Calculate the useful work done by the cyclist in climbing up the slope. [3]

A total of 1492 J of energy is used in overcoming frictional forces.

- f. Determine the average magnitude of the frictional forces. [3]

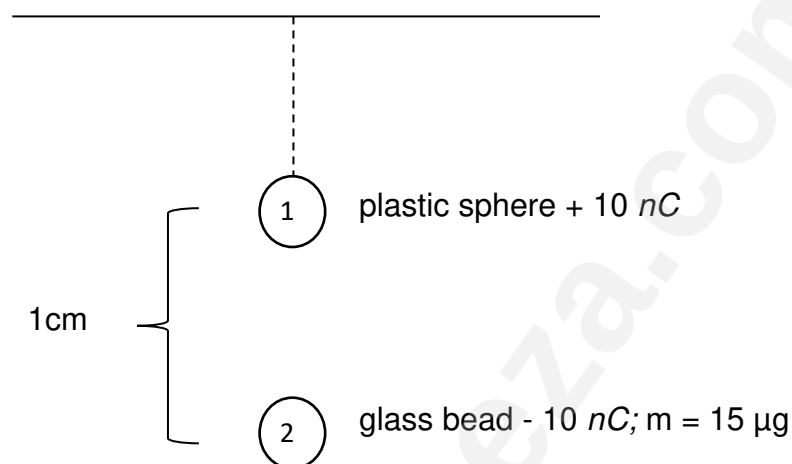
(28)

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QUESTION 9

9.1 State Coulomb's Law [2]

9.2 A small plastic sphere is charged to $+10 \text{ nC}$ and suspended $1,0 \text{ cm}$ above a small glass bead at rest on a surface. (The centre of masses of the sphere and bead are 1 cm apart). The bead has a mass of $15 \mu\text{g}$ and a charge of -10 nC .



- Draw and label a free-body diagram of the glass bead that shows all the forces acting on the bead. [3]
- Calculate the force that the plastic sphere exerts on the glass bead. [5]
- Will the glass bead “accelerate upwards” toward the plastic sphere? Support your answer with calculations. *Ignore air resistance.* [4]

(14)

QUESTION 10

The hypothetical Space-X station, of mass M , will orbit Mars at a distance, h_1 , from Mars's centre of mass.

A hypothetical satellite, Starlink-9, of mass, m , will also orbit Mars. The mass of Starlink-9 is one quarter ($\frac{1}{4}$) of the mass of the Space-X station. The distance between Starlink-9 and the centre of mass of Mars, h_2 , is half ($\frac{1}{2}$) that of the distance, h_1 .

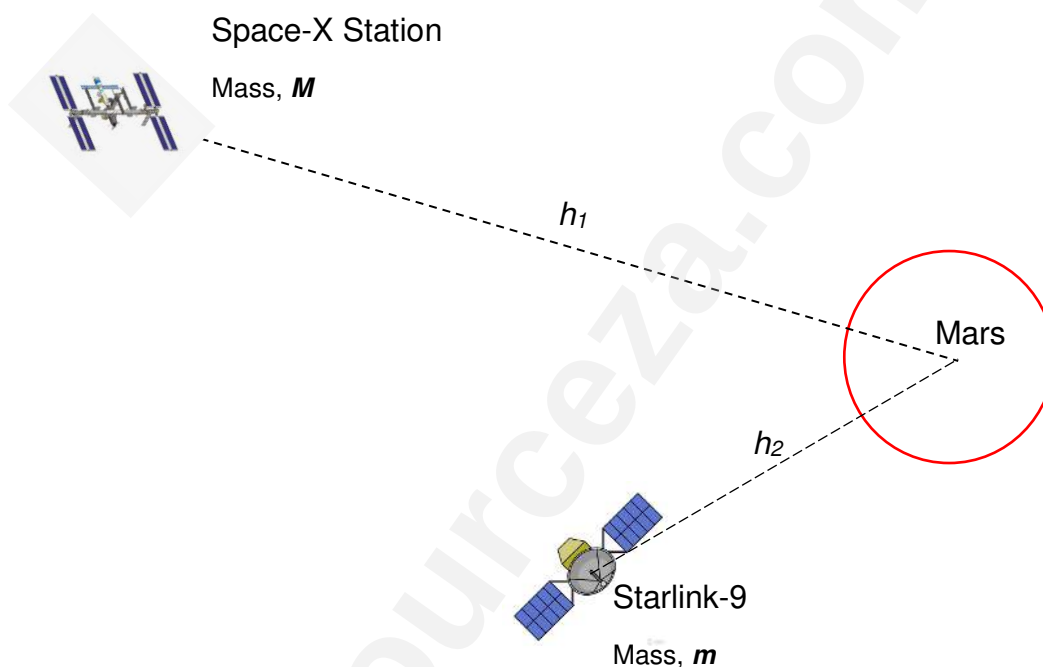


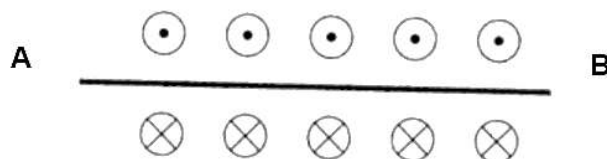
Diagram not drawn to scale.

What is the ratio between the gravitational force of attraction between Space-X Station and Mars, and the gravitational force of attraction between Starlink-9 and Mars. Show all your working.

(4)

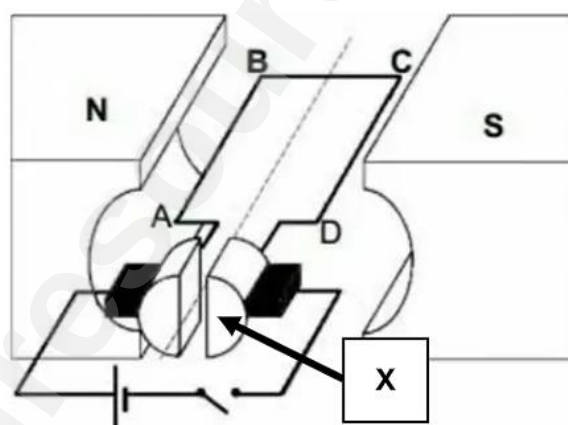
QUESTION 11

11.1 The magnetic field set up around a current-carrying conductor is represented below:



- a. State the direction of conventional current in the conductor, **A to B** or **B to A**? [1]
- b. This current-carrying conductor is placed in a permanent magnetic field causing it to experience a force INTO THE PAGE.
Resketch the above diagram and include the direction of the permanent magnetic field that causes the conductor to experience a force INTO the page. Briefly **explain** the origin of the force on the conductor. [3]

11.2 Consider the following diagram of a simple d.c motor. Assume that the switch is closed when answering the following questions.

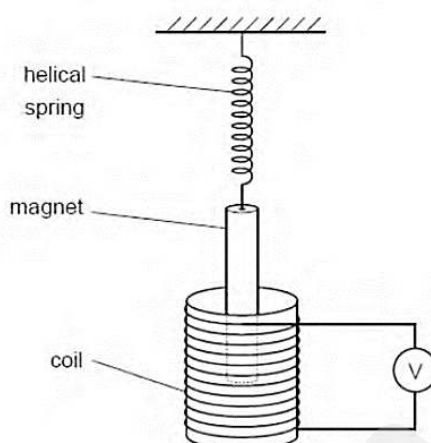


- a. Describe the energy conversion that occurs in this device. [2]
- b. In what direction, clockwise or anticlockwise, would the coil in this motor rotate when viewed as in the diagram. [2]
- c. Name the component labelled X and **explain** its function. [4]
- d. Why does length BC of the coil not experience a force when in the position shown in the diagram? Refer to a relevant equation to support your answer. [4]

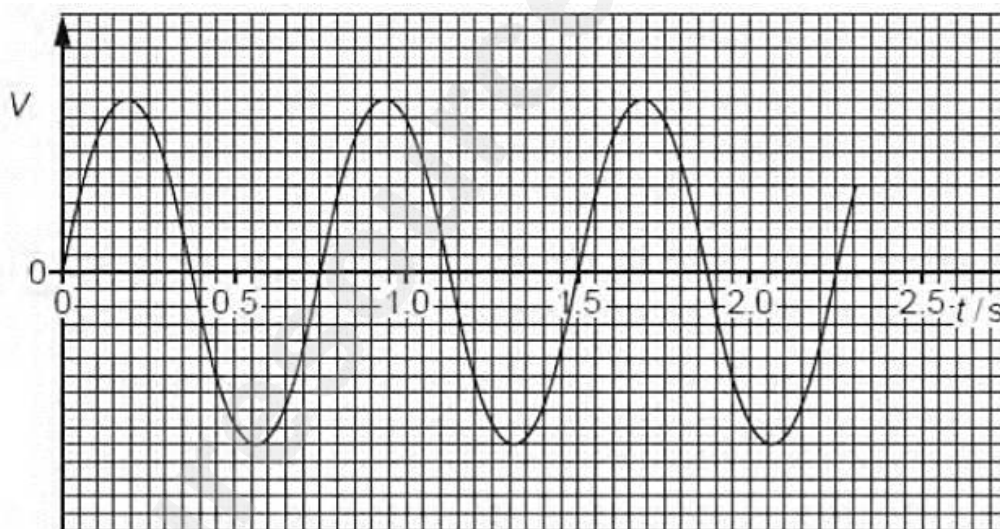
(16)

QUESTION 12

A bar magnet is suspended vertically from the free end of a spring. One pole of the magnet lies inside a coil (solenoid) and the coil is connected in series with a voltmeter.



The magnet is displaced vertically and then released. The variation of the voltmeter reading V with time t is shown below.

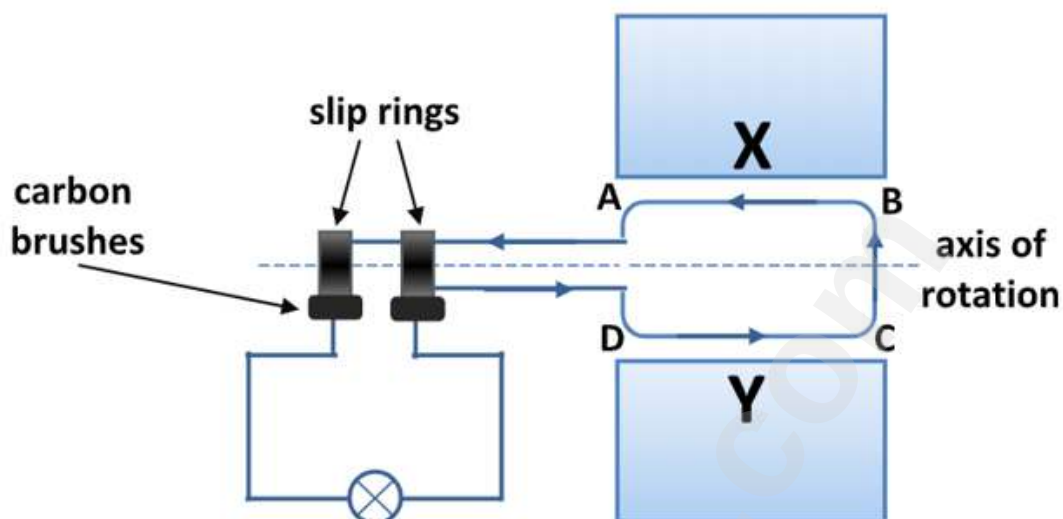


- a. State Faraday's law of electromagnetic induction [2]
- b. Use Faraday's law to explain why:
 - i. There is a reading on the voltmeter. [3]
 - ii. The reading varies in magnitude. [2]
- c. Use the graph above to determine the frequency (in Hz) of the oscillation of the magnet [3]

(10)

QUESTION 13

The diagram below represents a generator as viewed from above.



- Identify whether the generator represented above is an **a.c** or **d.c** generator. Give a reason for your answer. [2]
- When the coil is in the position shown in the diagram, side AB rotates OUT of the page. Determine the polarity of the magnets marked X and Y. [2]
- Draw a sketch graph to show how the induced voltage changes over time for a single rotation of the coil. **Start your graph** for the coil position shown in the diagram. [3]

(7)

QUESTION 14

Transformers play an important role in industry and in our homes. 15 000 V is required for a picture to be formed on a television screen. Our domestic power supply in South Africa is 240 V.

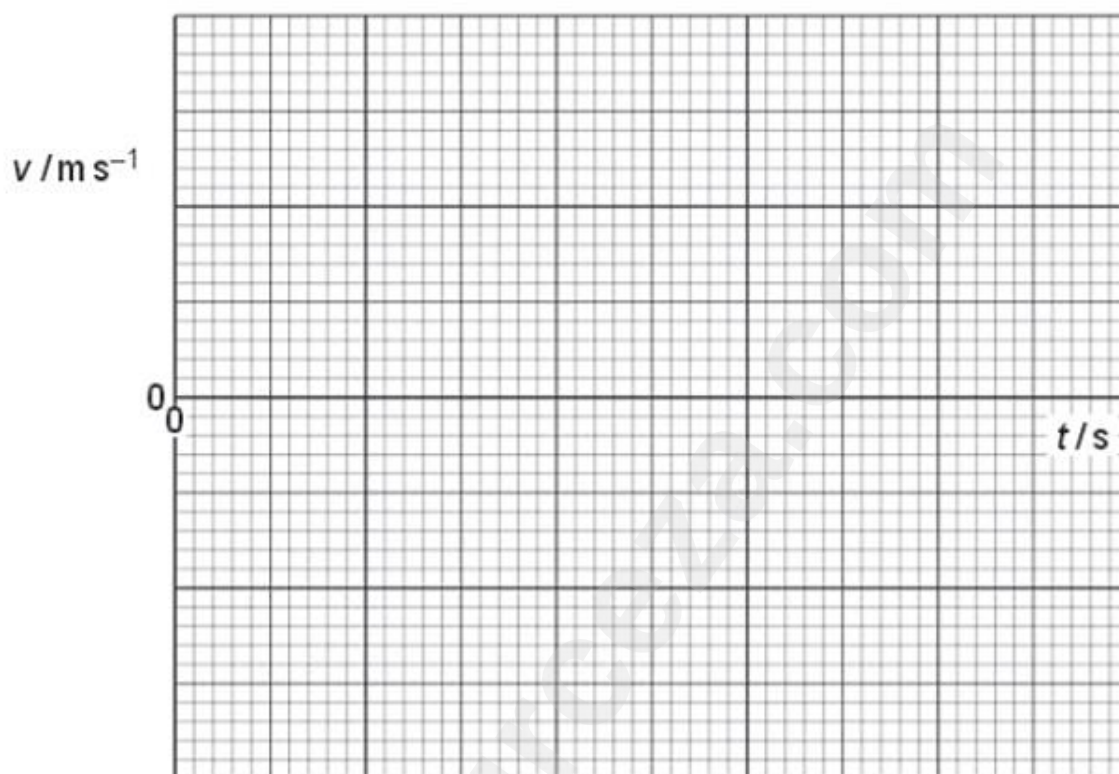
- a. State whether a step-up or step-down transformer is used in a television? [1]
- b. There are 400 windings on the primary coil of a TV transformer. How many windings are on the secondary coil? [3]
- c. Assuming a 100% efficient transformer, calculate the current in the primary coil, given that the television draws 2,5 A of current. [3]

(7)

TOTAL MARKS = 200

ANSWER SHEET: PHYSICS PRELIM 2020

QUESTION 5.C



Graph grid for Question 7 on following page

QUESTION 7 (b)

