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ST BENEDICT'S

SUBJECT	Physical Science Preliminary Examination Paper 1	DATE	20 September 2021
GRADE	12	MARKS	200
EXAMINER	Mrs Govender	MODERATORS	Mr du Toit Mr McCoy
NAME		DURATION	3 hours
CLASS			
LOW ORDER	50%	HIGH ORDER	50%

INSTRUCTIONS

1. This question paper consists of 15 pages, an Answer Sheet of 3 pages and a Data Sheet of 2 pages. Please make sure that your question paper is complete.
2. Answer ALL the questions.
3. Read the questions carefully.
4. Use the data and formulae whenever necessary.
5. **Start each question on a new page.**
6. Show your working in all calculations.
7. Units need not be included in the working of calculations, but appropriate units should be shown in all answers.
8. Express all answers to **TWO** decimal places unless told otherwise.
9. It is in your own interest to write legibly and to present your work neatly.

Question	1	2	3	4	5	6	7	8	9	Total
Total	20	24	22	22	25	26	27	21	13	200

QUESTION 1**20 MARKS**

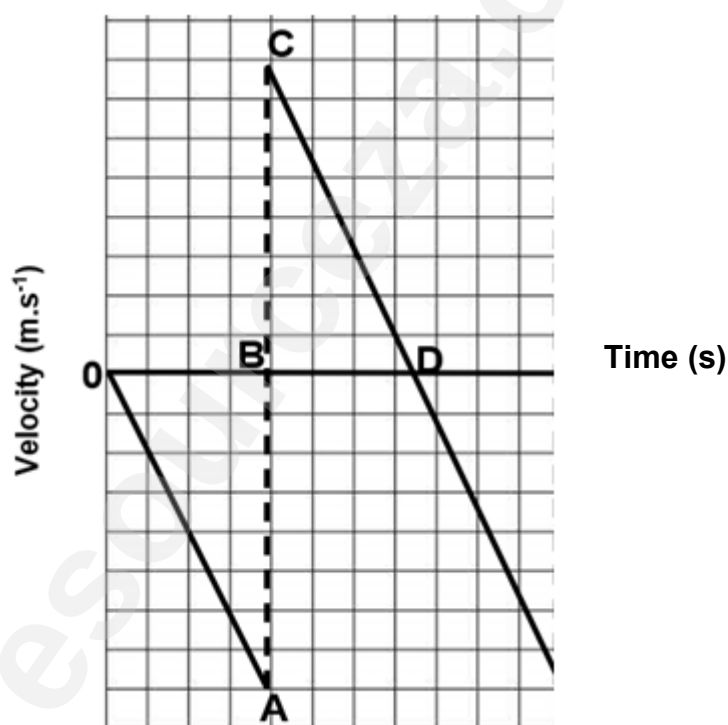
Answer the following multiple-choice questions on your separate ANSWER SHEET.
Make a cross (X) in the box corresponding to the letter which you consider to be the most correct.

1.1 Which of the following pairs of physical quantities contains ONLY vector quantities?

- A. Work, power
- B. Potential difference, impulse
- C. Resistance, impulse
- D. Impulse, weight

(2)

1.2 Yuri drops a golf ball from a certain height above the ground that bounces a few times as it hits the ground. The velocity-time graph below shows the motion of the ball from the time it is dropped. Ignore the effects of air friction.



In relation to the velocity-time graph for the bouncing golf ball shown above, which statement below is correct?

	Down Direction	Maximum Height
A.	positive	C
B.	positive	D
C.	negative	C
D.	negative	D

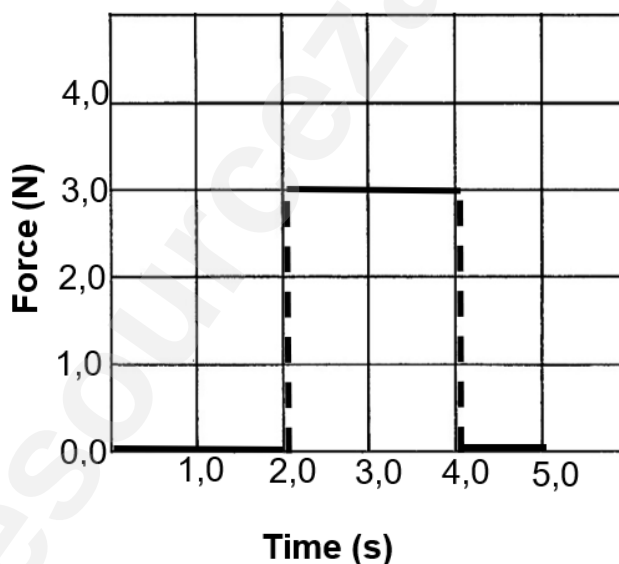
(2)

- 1.3 Formula one driver, Charles Leclerc accelerates his Ferrari uniformly from rest. After travelling a distance, d , in a straight line in t seconds, the Ferrari has a velocity v . At what distance and time during the motion did Leclerc reach a velocity of $\frac{1}{2}v$?

	Distance	Time
A.	$d/4$	$t/2$
B.	$d/2$	$t/2$
C.	$d/2$	$t/4$
D.	$d/4$	$t/4$

(2)

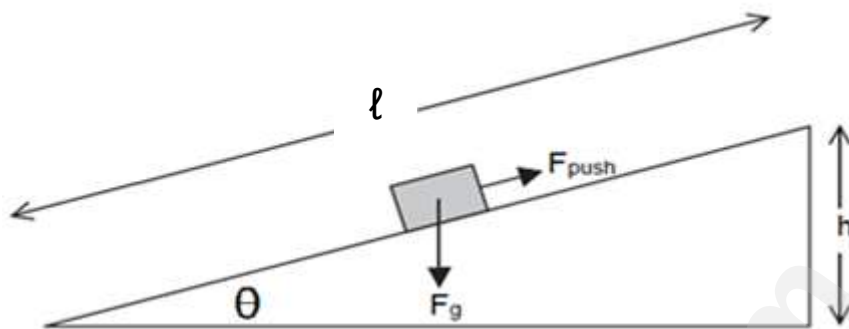
- 1.4 A 3 kg mass moving in a straight line with an initial velocity of 4 m.s^{-1} forward, is acted on by a net force as shown in the graph below. What is the speed (in m.s^{-1}) of the mass at 5 s?



- A. 2
B. 6
C. 8
D. 9

(2)

- 1.5 A student uses a force, F_{push} , to push a block up a frictionless slope of length, ℓ .



Then net work by the student can be calculated using:

- A. $F_{\text{push}} \times h$
- B. $(F_{\text{push}} - F_g \sin \theta) \times \ell$
- C. $F_g \times h$
- D. $F_g \times \ell$

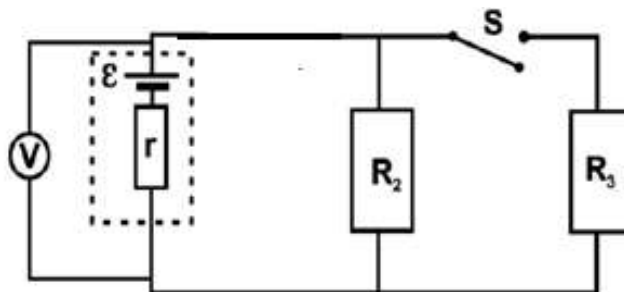
(2)

- 1.6 At a point during freefall an object has a velocity of $v \text{ m.s}^{-1}$. At this same point the object's kinetic energy is a third of its potential energy. The height of the object at this point can be calculated using

- A. $\frac{3v^2}{2g}$
- B. $\frac{2g}{3v^2}$
- C. $\frac{6g}{v^2}$
- D. $\frac{v}{6g}$

(2)

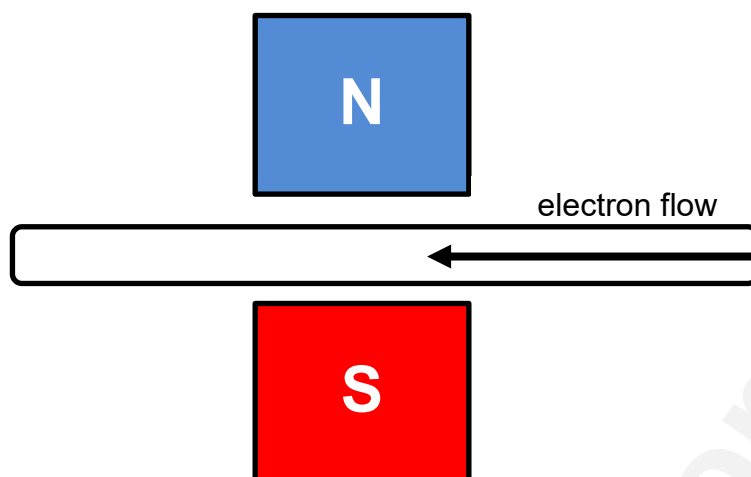
- 1.7 If **switch S**, in the circuit below, is closed, what happens to the rate of energy conversion in **R_2** ?



- A. It decreases
- B. It increases
- C. It remains the same
- D. It registers as 0 W

(2)

- 1.8 A current-carrying conductor is placed in a permanent magnetic field as shown below.

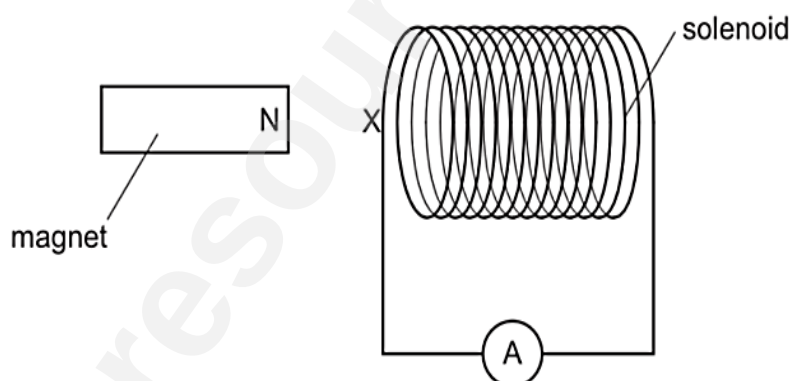


In which direction will the conductor experience an electromagnetic force?

- A. Up
- B. Down
- C. Out of the page
- D. Into the page

(2)

- 1.9 Mr du Toit connects a solenoid in series with a sensitive ammeter. He places the North pole of a magnet next to one end of the solenoid, marked X.



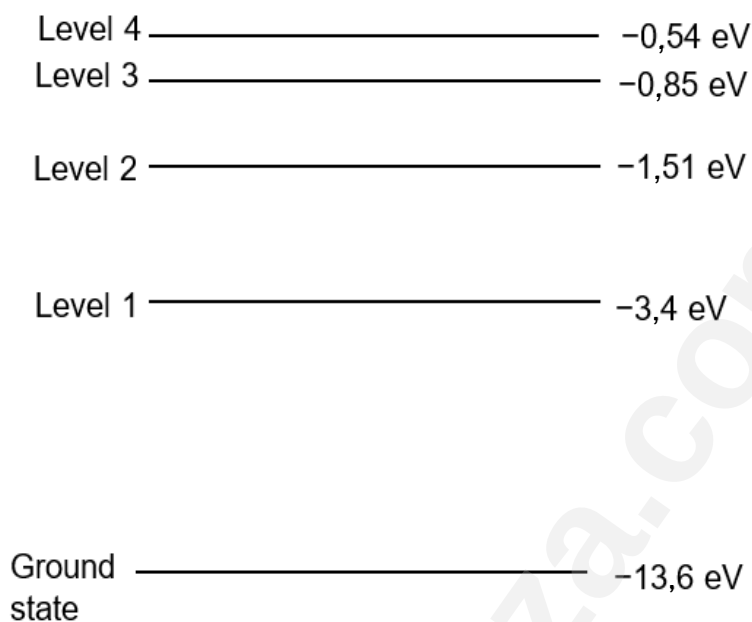
Mr du Toit pushes the North pole of the magnet towards X, then he pulls the magnet away from X. The ammeter deflects in both instances.

Which type of magnetic pole is induced at X during the two instances?

	As the North pole moves towards X	As the North pole moves away from X
A.	N pole	N pole
B.	N pole	S pole
C.	S pole	N pole
D.	S pole	S pole

(2)

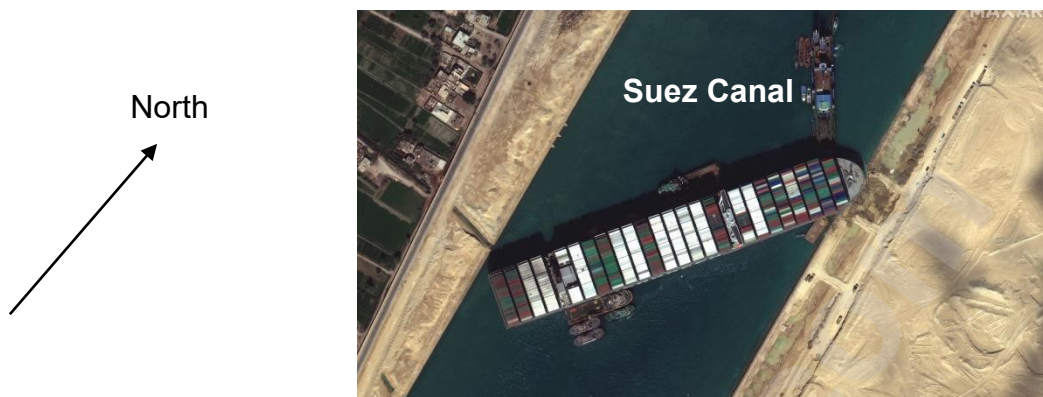
- 1.10 The diagram shows an energy level diagram for a hydrogen atom. Electrons with energy 13,0 eV collide with atoms of hydrogen in their ground state. What is the number of different wavelengths of electromagnetic radiation that could be emitted when the atoms de-excite?



- A. 0
- B. 3
- C. 6
- D. 7

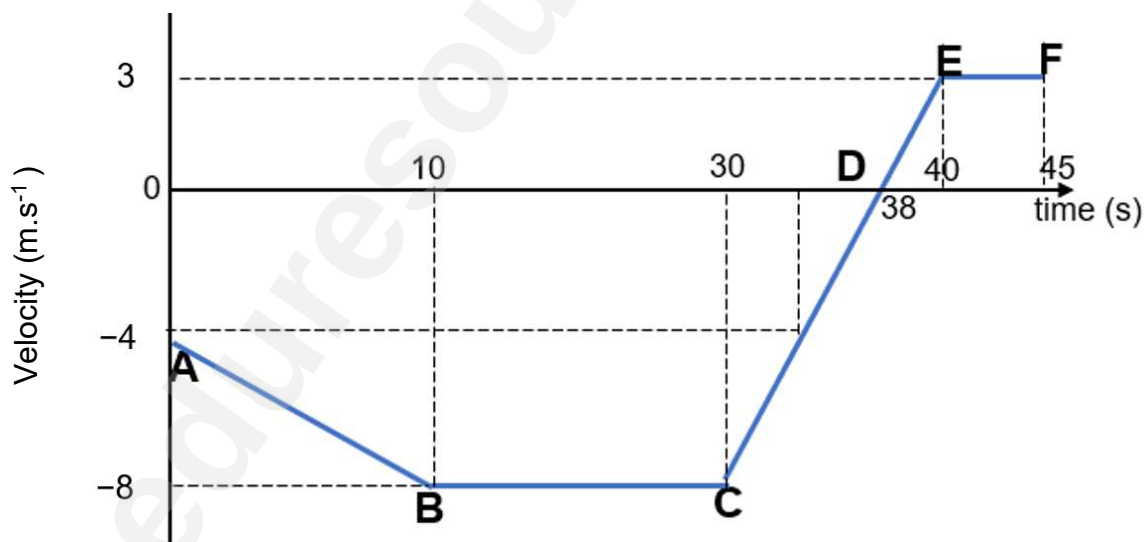
(2)

- 2.1 A massive ship, the *Ever Given*, recently blocked off the Suez Canal. *Ever Given* was travelling due North at a velocity of $42,20 \text{ km.h}^{-1}$ and was grounded due to a strong wind that caused a current of $12,87 \text{ km.h}^{-1}$ to flow in a direction at 60° West of South.



- 2.1.1 Define *resultant vector*. (2)
- 2.1.2 Convert $42,20 \text{ km.h}^{-1}$ to m.s^{-1} . (1)
- 2.1.3 Determine the magnitude of the resultant velocity west in km.h^{-1} . (2)
- 2.1.4 Determine the magnitude of the resultant velocity north in km.h^{-1} . (3)
- 2.1.5 Hence, determine the overall resultant velocity. (4)

- 2.2 The following velocity-time graph shows the motion of a tug boat that was deployed to free the *Ever Given*. The tug boat was initially travelling South in a straight line.



- 2.2.1 Define *acceleration*. (2)
- 2.2.2 During which time interval is the tugboat moving south while accelerating north? (2)
- 2.2.3 The displacement of the tugboat at D is 252 m south. Calculate the final displacement of the tugboat at F. (4)
- 2.2.4 A partially completed position time graph has been reproduced on the ANSWER SHEET. Complete the graph of the motion of the tugboat from B to F on the ANSWER SHEET. (4)

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QUESTION 3: “I SEE GRAPH PAPER- YOU MUST BE PLOTTING SOMETHING”
22 MARKS

The three science teachers at Bennies decided to take the boys outside onto the cricket field to carry out an investigation to confirm the value of gravitational acceleration (g). The top cricketer at Bennies, Ryan Maxl, was asked to throw a cricket ball vertically upwards many times. Mr McCoy uses light gates to measure the initial velocity (u) of the ball. The boys used the Hudl Technique app on their phones to determine the maximum height reached by the ball each time. Mrs Govender helped the boys to collate the data.

- 3.1 State the instantaneous velocity and the acceleration of the ball when it reaches the maximum height. (2)

Mr du Toit recorded the results in the table below:

Initial velocity (m.s^{-1})	Initial velocity squared ()	Maximum Height (m)
4	16	3
10	100	5
14	196	10
20	400	20
28	784	40
32	1024	52

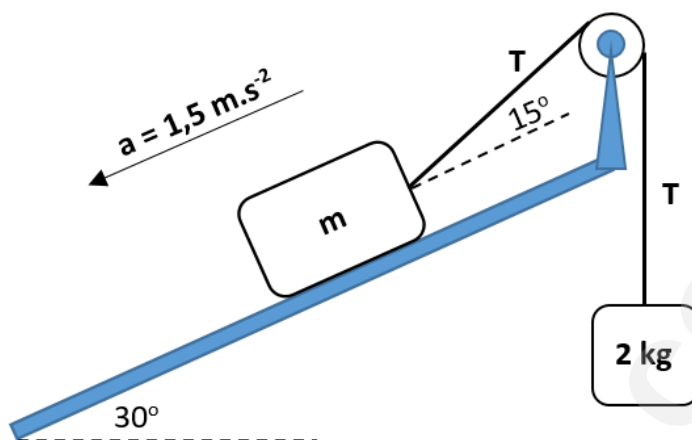
- 3.2 Provide a unit of measurement for the initial velocity squared. (1)
- 3.3 Write down a simplified equation to show the relationship between the square of the initial velocity, u^2 , and the maximum height reached by the ball. (2)
- 3.4 This question must be answered on the ANSWER SHEET. Plot a line of best fit graph of the maximum height reached by the ball versus the initial velocity squared. (6)
- 3.5 Use the graph to determine the gradient of the line of best fit. Indicate, clearly, the values used on the line of best fit. (4)
- 3.6 Use the gradient calculated in question 3.5 to determine the gravitational acceleration (g). (2)
- 3.7 Calculate the percentage accuracy of the value calculated in **3.6**. (3)
- 3.8 Why is there a difference between the calculated value and the theoretical value? (2)
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QUESTION 4: “FRICTION ANNOYS ME, IT’S SUCH A DRAG”

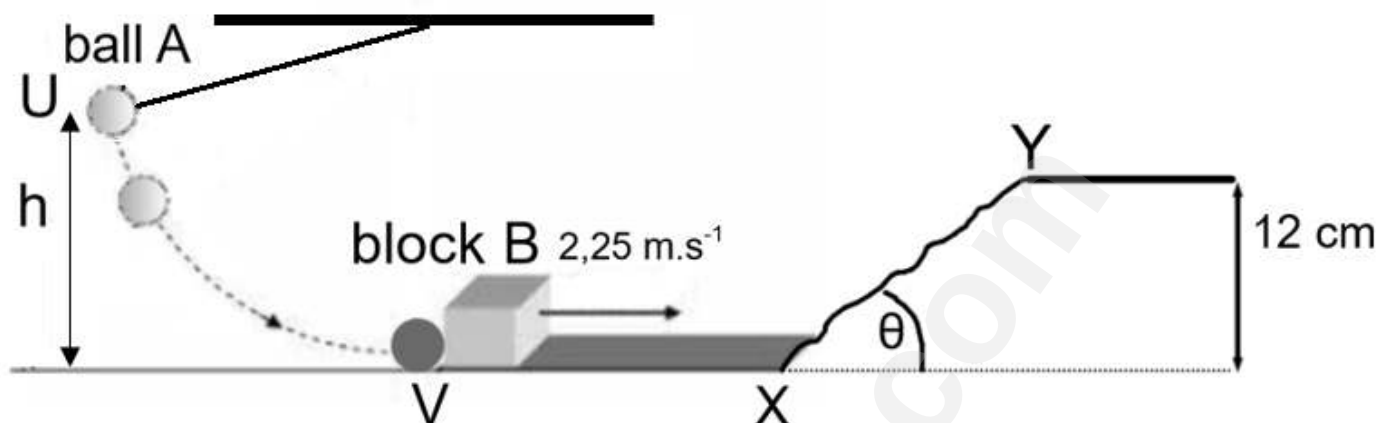
22 MARKS

Block **m** is connected to a string that runs over a frictionless pulley to another block of mass 2 kg. The slope makes an angle of 30° to the horizontal and the string connects to block **m** with an angle of 15° to the surface of the slope and the acceleration at this angle is $1,5 \text{ m}\cdot\text{s}^{-2}$. The kinetic friction between the surface and block **m** is 4 N. Any effects of air resistance may be ignored.



- 4.1 State *Newton's Second Law* of motion. (2)
- 4.2 Determine the magnitude of the tension, **T**, in the string. (3)
- 4.3 Draw a labelled free-body diagram of all the forces acting on block **m**. (4)
- 4.4 Determine the mass of the block, **m**. (5)
- 4.5 Calculate the co-efficient of kinetic friction between the surface and block **m**. (5)
- 4.6 How would the kinetic frictional force acting block **m** be affected if the block was wider (i.e., had a bigger contact area with the table surface). The mass of the block and all other forces remain the same.
Only write it will INCREASE, DECREASE or REMAIN THE SAME. (1)
- 4.7 Support your answer in question 4.6 with a statement regarding friction. (2)

Ball **A** with mass of 1,5 kg is released from a height, h , at point **U** and collides with block **B** with a mass of 3 kg at the bottom of its swing at point **V**. Immediately after the collision ball **A** moves at $0,5 \text{ m.s}^{-1}$ to the left and block **B** moves $2,25 \text{ m.s}^{-1}$ to the right. Air resistance is negligible.

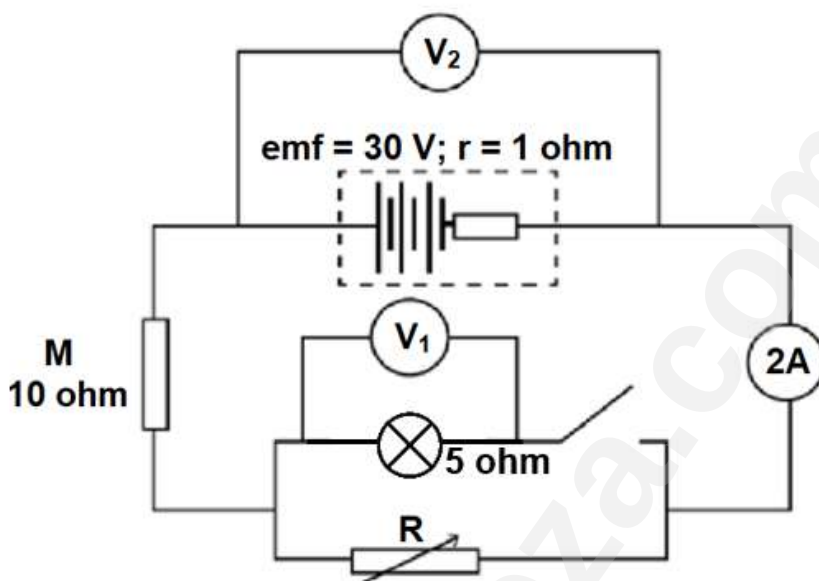


- 5.1 State the *law of conservation of linear momentum*. (2)
- 5.2 Calculate the speed of ball **A** before the collision at the bottom of its swing. (5)
- 5.3 Sketch a graph to represent the mechanical energy of ball **A** as it swings from **U** to **V**. You do not need to show any values. (2)
- 5.4 Determine the height, h , that ball **A** was released from. (4)
- 5.5 If the collision lasts for 0,01 s, calculate the magnitude of the force exerted by the 1,5 kg ball on the 3 kg block during the collision. (4)

After the collision, block **B** moves on a frictionless surface **VX** and then on a rough incline **XY**. A constant frictional force of 20,2 N acts on the block and causes it to come to rest at point **Y**.

- 5.6 Define the *work-energy theorem*. (2)
- 5.7 Calculate the distance from X to Y. (6)

A circuit consists of a battery with an **emf** of 30 V and an internal resistance of 1 Ω . A motor **M**, a variable resistor which can be set at different values, **R**, a 5 Ω resistor and a switch **S** are connected as shown in the diagram below.



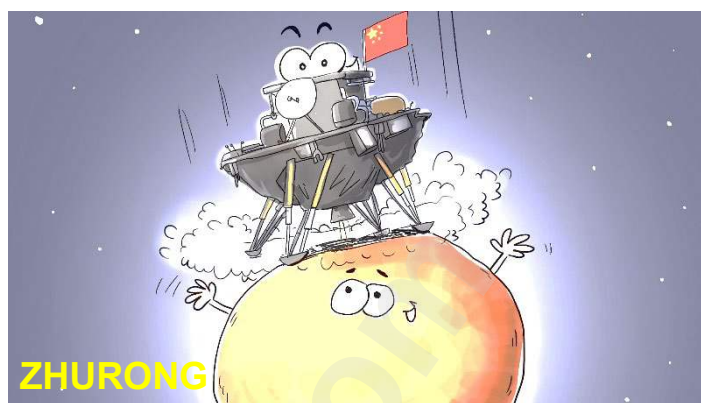
The reading on the ammeter is 2 A with the switch **open**:

- 6.1 Define *current*. (1)
- 6.2 Calculate the power dissipated in the motor, **M**. (3)
- 6.3 Calculate the resistance at which the rheostat, **R** is set. (4)
- 6.4 Sketch a graph to show the relationship between the power dissipated in the motor **M** and the current flowing through the resistor. (2)
- 6.5 Calculate the cost (in cents) of using the motor for 45 minutes in a town where the price of electricity is R 1,70 per kWh. (3)

The switch is now closed and the rheostat is adjusted so that its resistance is 2 Ω .

- 6.6 Calculate the new reading on the ammeter. (4)
- 6.7 Calculate the reading on the voltmeter V_1 . (4)
- 6.8 The 10 Ω motor is removed from the circuit and replaced with a connecting wire. Use equations to explain the effect on the brightness of the 5 Ω light bulb. (5)

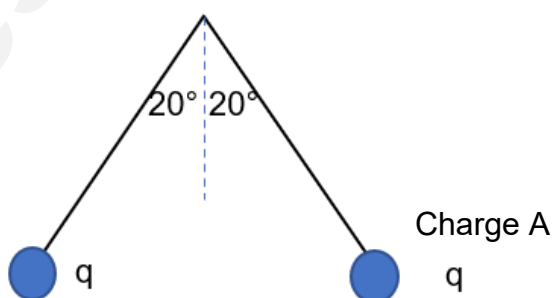
7.1 Currently there are two active rovers on Mars, NASA's Perseverance and China's Zhurong as shown in the picture below.



Mars has a mass of $6,42 \times 10^{23}$ kg and Perseverance has a mass of 1025 kg. The gravitational field strength on the surface of the earth is $9,8 \text{ N.kg}^{-1}$.

- 7.1.1 Define the term *gravitational field strength*. (2)
- 7.1.2 The gravitational field strength on the surface of Mars is 38% of the value on Earth. Determine the radius of Mars. (5)
- 7.1.3 The two rovers are 1800 km apart on the surface of Mars and the force between them is $5,1 \times 10^{-18} \text{ N}$.
 - a. Calculate the mass of Zhurong. (3)
 - b. Explain, without a calculation, how the weight of Perseverance on Mars would compare to its weight on another planet with half the mass and double the radius of Mars. (3)

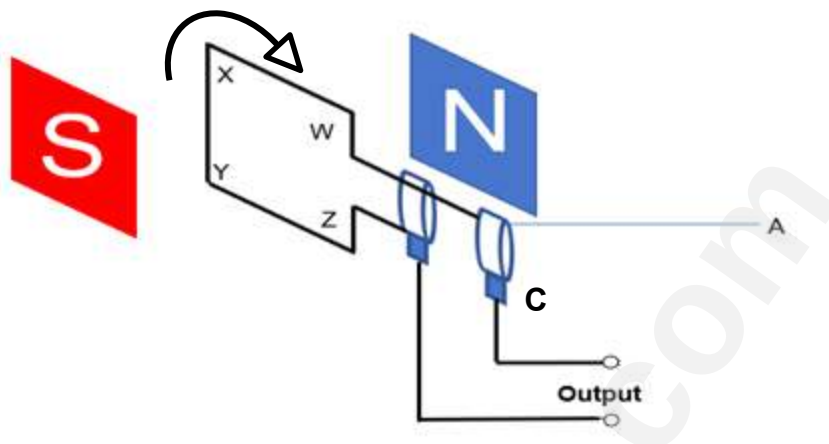
7.2 Two 5 g point charges are charged equally, q , and suspended on two long threads. The charges repel each other as shown in the diagram. Each thread is 1,0 m long.



- 7.2.1 Draw a fully labelled free body diagram for the charge labelled A. (3)
- 7.2.2 Prove that the charge on each charge (q) is equal to $4,45 \times 10^{-6} \text{ C}$. (6)
- 7.3 Define the *magnitude of electric field at a point*. (2)
- 7.4 Calculate the magnitude of the electric field of A if a charge is placed 0,5 nm away from charge A. (3)

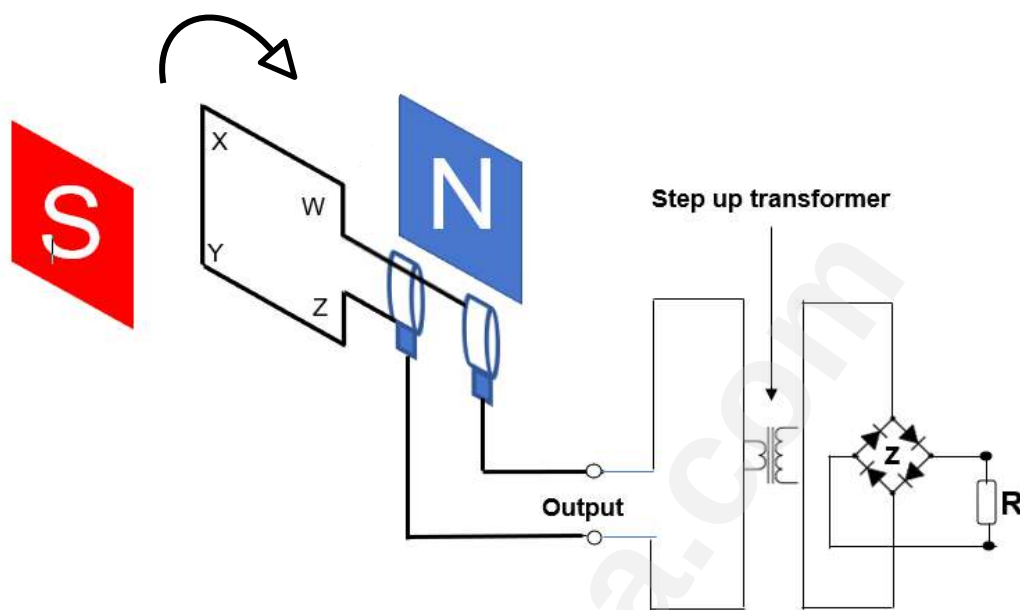
QUESTION 8: WHAT THE FLUX!

The diagram below represents the emergency AC generator that was part of the *Ever Given ship*. The coil is in the vertical position. A components is labelled A and the output potential of the generator is 200 V and 30 Hz.



- 8.1 Is flux density a vector quantity? Explain your answer. (2)
- 8.2 Refer to a formula to explain whether the flux through the coil is a maximum or zero in the position shown. (2)
- 8.3 Write down the name of component A. (1)
- 8.4 The coil is rotated from the vertical position towards the horizontal position, as shown in the diagram (clockwise when viewed from C). Use the letters given on the coil to indicate the direction of the current flow in the coil while it is being rotated. (2)
- 8.5 State *Faraday's Law of electromagnetic induction*. (2)
- 8.6 Use an appropriate equation to explain why the induced emf in the coil increases if the coil is rotated faster. (3)
- 8.7 Starting from the position shown in the diagram, sketch a graph on the ANSWER SHEET of the output emf versus time for ONE complete revolution of the coil. (3)

- 8.8 A step-up transformer is now connected to the output of the AC generator and the output voltage is now doubled.

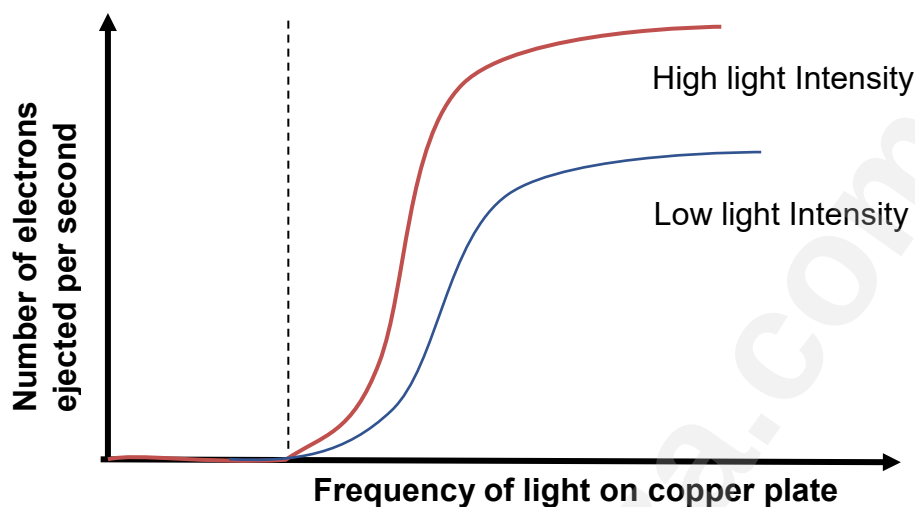


- 8.8.1 Name the components that form the bridge rectifier (Z). (1)
- 8.8.2 State the function of the bridge rectifier. (2)
- 8.8.3 On the same set of axes used in 8.7, use a dotted line to show the combined effect of the transformer and the use of a bridge rectifier on the output emf. (3)

QUESTION 9: LIGHT HAS NO MASS - OTHERWISE IT WOULD BE CALLED HEAVY

13 MARKS

A copper plate is illuminated with UV radiation of wavelength 150 nm. The work function of copper is 5,0 eV. The diagram below shows how the number of electrons ejected from copper metal is affected by UV radiation of two different light intensities.



- 9.1 Provide a definition for the physical quantity represented by the dotted line labelled A. (2)
- 9.2 Calculate the maximum kinetic energy of the ejected electrons in eV. (5)
- 9.3 Compare the two graphs above in terms of the number of electrons ejected per second. Explain your answer. (2)
- 9.4 On the **same set of axes**, sketch a graph of the maximum kinetic energy of an ejected electron as a function of intensity of light:
 - 9.4.1 below the threshold frequency (Label this A on your graph) and; (2)
 - 9.4.2 above the threshold frequency (Label this B on your graph). (2)

END OF EXAMINATION

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EXAMINATION DATA SHEET FOR THE PHYSICAL SCIENCES (PHYSICS)

TABLE 1 PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Acceleration due to gravity	g	$9,8 \text{ m}\cdot\text{s}^{-2}$
Speed of light in a vacuum	c	$3,0 \times 10^8 \text{ m}\cdot\text{s}^{-1}$
Universal gravitational constant	G	$6,7 \times 10^{-11} \text{ N}\cdot\text{m}^2\cdot\text{kg}^{-2}$
Coulomb's constant	k	$9,0 \times 10^9 \text{ N}\cdot\text{m}^2\cdot\text{C}^{-2}$
Magnitude of charge on electron	e	$1,6 \times 10^{-19} \text{ C}$
Mass of an electron	m_e	$9,1 \times 10^{-31} \text{ kg}$
Planck's constant	h	$6,6 \times 10^{-34} \text{ J}\cdot\text{s}$
1 electron volt	eV	$1,6 \times 10^{-19} \text{ J}$

TABLE 2 PHYSICS FORMULAE

MOTION

$v = u + at$ or $v_f = v_i + a\Delta t$	$s = \left(\frac{v+u}{2}\right)t$ or $\Delta x = \left(\frac{v_f+v_i}{2}\right)\Delta t$
$v^2 = u^2 + 2as$ or $v_f^2 = v_i^2 + 2a\Delta x$	$s = ut + \frac{1}{2}at^2$ or $\Delta x = v_i\Delta t + \frac{1}{2}a(\Delta t)^2$

FORCE AND MOMENTUM

$F_{net} = ma$	$F_{net} = \frac{\Delta p}{\Delta t}$ or $F_{net}\Delta t = m\Delta v$	$J = \Delta p = mv - mu$ or $J = \Delta p = mv_f - mv_i$
$p = mv$	$F_g = mg$	$F_{fs}^{max} = \mu_s F_N$ $F_{fk} = \mu_k F_N$

WORK, ENERGY AND POWER

$W = Fs$ or $W = F\Delta x$ or $W = F\Delta x \cos \theta$	$P = \frac{W}{t}$	$P = Fv$
$E_p = mgh$	$E_k = \frac{1}{2}mv^2$	$W_{net} = \Delta E_K$
efficiency = $\frac{\text{power}_{out}}{\text{power}_{in}} \times 100$		

GRAVITATIONAL AND ELECTRIC FIELDS

$F = G \frac{m_1 m_2}{r^2}$	$g = \frac{F}{m}$	$g = G \frac{M}{r^2}$
$F = k \frac{q_1 q_2}{r^2}$	$E = \frac{F}{q}$	$E = \frac{kQ}{r^2}$

ELECTRIC CIRCUITS

$I = \frac{q}{t}$	$V = \frac{W}{q}$
$R = \frac{V}{I}$	$emf = I(R_{ext} + r)$ or $emf = V_{load} + V_{internal\ resistance}$
$R_s = R_1 + R_2 + \dots$	$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$
$P = \frac{W}{t} \quad \text{or} \quad W = Pt$	
$W = VIt \quad \text{or} \quad W = I^2 R t \quad \text{or} \quad W = \frac{V^2}{R} t$	
$P = VI \quad \text{or} \quad P = I^2 R \quad \text{or} \quad P = \frac{V^2}{R}$	

ELECTRODYNAMICS

$\Phi = BA \cos \theta$	$emf = -\frac{N \Delta \Phi}{\Delta t}$	$F = IB \ell \sin \theta$
$V_p I_p = V_s I_s$	$\frac{N_s}{N_p} = \frac{V_s}{V_p}$	

PHOTONS AND ELECTRONS

$c = f \lambda$	$E = hf$ or $E = \frac{hc}{\lambda}$	
$E = W_0 + E_{K(\max)}$	$W_0 = hf_0$	$E_{K(\max)} = \frac{1}{2} m v_{\max}^2$