JAMES RUSE AGRICULTURAL HIGH SCHOOL

2024

HALF YEARLY

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used
- A data sheet, formulae sheet and Periodic Table are provided

Total marks: 100

Section I – 20 marks (pages 2–13)

- Attempt Questions 1–20
- Allow about 35 minutes for this section

Section II – 80 marks (pages 19–42)

- Attempt Questions 21–36
- Allow about 2 hours and 25 minutes for this section

Section I

Attempt Questions 1–15
Allow about 20 minutes for this part

Use the multiple-choice answer sheet (page 21) for Questions 1–15

The answer sheet can be torn off. Leave it, separate, on your desk at the end of the exam

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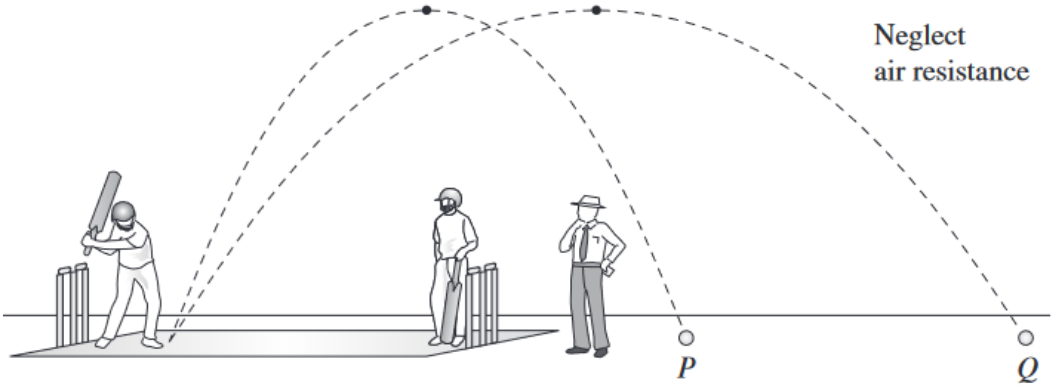
1 The picture shows a game of cricket



The picture shows two consecutive shots by the batsman. Both balls reach the same maximum height above the ground but ball Q travels twice as far as ball P.

Which of the following is different for balls P and Q?

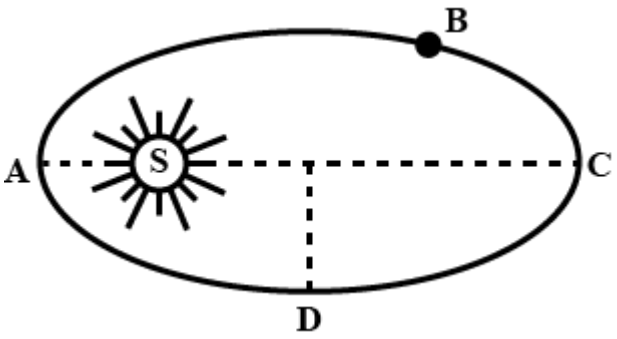
A. Time of flight
B. Initial velocity
C. Gravitational force
D. Gravitational acceleration

2 The Earth planet has mass M and radius R. Due to its mass, it has a gravitational field around it. Select the most correct answer about acceleration due to gravity.

	Formula for acceleration due to gravity	Direction of acceleration due to gravity
A.	$F = \frac{GMm}{R^2}$	Towards the centre
B.	$g = \frac{GM}{R^2}$	Towards the centre
C.	W = m x g	Away from the centre
D.	F = m x a	Away from the centre

3

A planet is moving in an elliptical orbit around the sun (S) as shown in the diagram below.



Which of the following statements about the planet is true?

A. Its total energy is the same in Position A and D.
B. Its potential energy is the same in Position A and D.
C. Its potential energy decreases moving from Position A to D.
D. Its kinetic energy increases moving from Position A to D

4 An aeroplane is flying horizontally over level ground. It has an altitude of 490 m and a velocity of 100 ms^{-1}. As the aeroplane passes directly above a cross marked on the ground, an object is released from the aeroplane.

How far away from the cross will this object land?

A. 490 m
B. 1000 m
C. 10 000 m
D. 49 000 m

5 Four model rockets are launched with the velocity components shown in the table. Which rocket was launched 30 degrees to the horizontal?

Rocket	Horizontal component of velocity (m/s)	vertical component of velocity (m/s)
A.	22	50
B.	32	40
C.	42	20
D.	52	30

6 The table gives information about two satellites of a planet.

Satellite	Radius of orbit (km)	Orbital period (days)
P	10000	2.0
Q	40000	T

What is the orbital period of satellite Q?

A. 1.4 days
B. 4.0 days
C. 16 days
D. 32 days

7 A spaceship at a distance r metres from the centre of a star experiences a gravitational force of x newtons. The spaceship moves half the distance towards the star.

What is the gravitational force acting on the spaceship when it is at this new location?

A. $\frac{x}{2}$ newtons
B. x newtons
C. 2x newtons
D. 4x newtons

8 The table shows the values of acceleration due to gravity on the surface of Earth and on the surface of Mars.

Planet	Acceleration due to gravity (m/s/s)
Earth	9.8
Mars	3.7

A person weighs 490 N on the surface of the Earth.
Select the correct answer

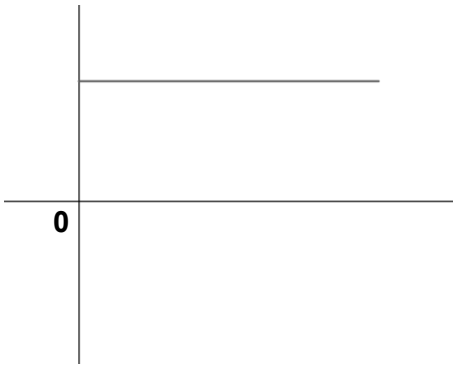
	Mass (Kg)	Weight (N)
A	100	370
B	50	185
C	50	490
D	100	185

9 The initial velocity required by a space probe to just escape the gravitational pull of a planet is called **escape velocity.**
Which of the following quantities does not affect the magnitude of the escape velocity?

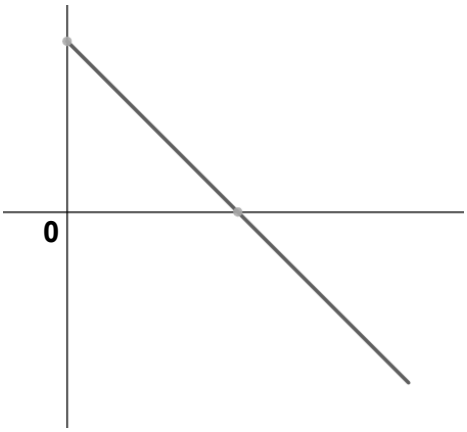
A. Mass of the planet
B. Radius of the planet
C. Mass of the space probe
D. Universal gravitation constant

10 A ball is thrown at an angle of 45 degrees from the ground. If upwards is considered positive, select the **acceleration – time graph** that describes the vertical motion.

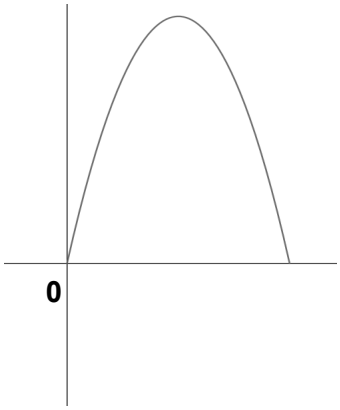
A.



C.



B.

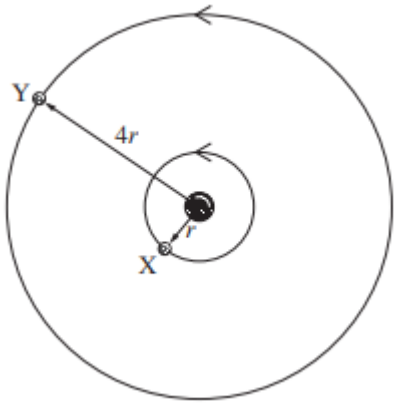


D.

11 Which of the following best describes Galileo's analysis of projectile motion?

A. A projectile launched with enough velocity would escape Earth's gravity.
B. A projectile would travel in a straight line unless acted upon by an external force.
C. A projectile would travel in a parabolic path because it has a constant vertical velocity and constant horizontal acceleration
D. A projectile would travel in a parabolic path because it has a constant horizontal velocity and constant vertical acceleration.

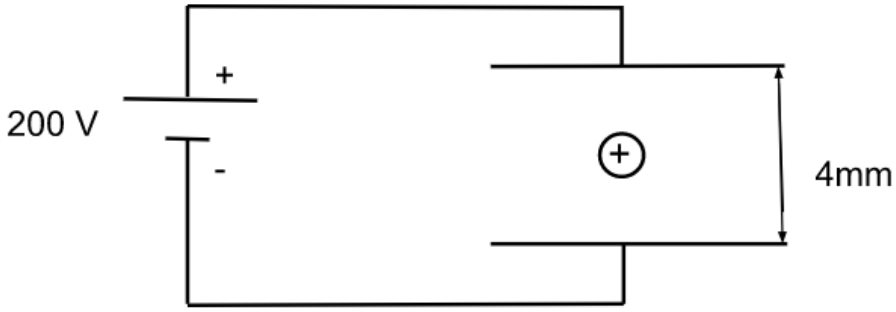
12 Two planets, X and Y, travel around a star in the same direction, in circular orbits. Planet X completes ONE revolution about the star in time T.
The radii of the orbits (X:Y) are in ratio1:4.



How many revolutions does the planet Y make about the star during the same time?

A. 1/8 revolution
B. 1/4 revolution
C. 4 revolutions
D. 8 revolutions

13 A pair of parallel plates has a potential difference of 200 V across them as shown below. A positive charge of magnitude is 5 mC is placed exactly in the middle of plates which are 4 mm apart.



Select the most correct answer from the following options.

	Work done the charge	Direction of charge movement
A	0.5 J	Downward
B	0.5 N	Downward
C	1.5 J	Upward
D	0.5 J	Upward

14 Which choice correctly describes the Input power (P) and output power of REAL transformers?

	Step-up transformer		**Step-down transformer**	
	Input Power	Output Power	Input Power	Output Power
A.	P	< P	P	< P
B.	P	> P	P	> P
C.	P	P	P	P
D.	P	< P	P	P

15 A 100 Kg satellite orbits the Earth in a circular orbit and after many revolutions, it drops down to a lower orbit. Ignore atmospheric friction or drag. Which statement about this satellite is correct?

A. Its kinetic energy decreases and potential energy increases.
B. Its kinetic energy increases and potential energy increases.
C. Its kinetic energy increases, potential energy decreases and mechanical energy remains constant.
D. Its kinetic energy decreases, potential energy increases and mechanical energy remains constant

END OF SECTION I
CONTINUE TO THE PAGE 9 FOR SECTION II

This page has been left blank intentionally
Section 2 begins on the next page

NESA NUMBER: _____

2022

HIGHER SCHOOL CERTIFICATE
HALF YEARLY EXAMINATION

Physics

Section II
Answer Booklet

55 marks
Attempt Questions 16–26
Allow about 1 hours 40 minutes for this section

Instructions

- Write your NESA ID where requested
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in question involving calculations
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Please turn over

Question 16 (8 marks)

A stone is projected upwards at an angle of 30 to the horizontal from the top of a vertical cliff. Given that the initial velocity of the stone is 15 m/s and that it hits the horizontal ground below the cliff 2 seconds later, calculate:

(a) The horizontal distance travelled by the stone from the foot of the cliff. **2**

(b) The height of the cliff **2**

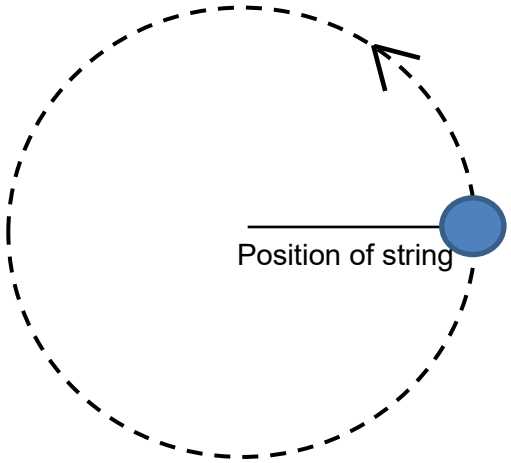
(c) The velocity of the stone just before it hits the ground **3**

(d) If the same experiment were to be conducted on Mars, which has an acceleration due to gravity of $3.7\ ms^{-2}$, how would the range be different on Mars as compared to that on Earth? **1**

Question 17 (6 marks)

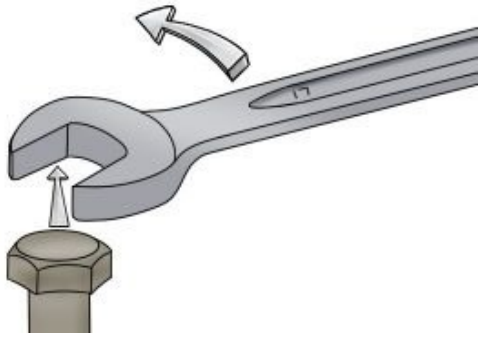
(a) A 2.5kg rock attached to a 1.5m string spins in a horizontal circle. It completes 100 revolutions in 1 minute. **3**
Calculate the tension force in the string.

(b) **Annotate** the diagram below and **explain** in words what would happen to the motion of the rubber bob if the string breaks at the position shown in the diagram. The rubber bob is undergoing uniform horizontal circular motion anticlockwisely. **3**



Question 18 (4 marks)

Mr. Moraleda is able to apply a maximum force of 85N. He tries to use a 32cm long spanner to turn a stuck nut, which requires 25Nm of torque to turn.



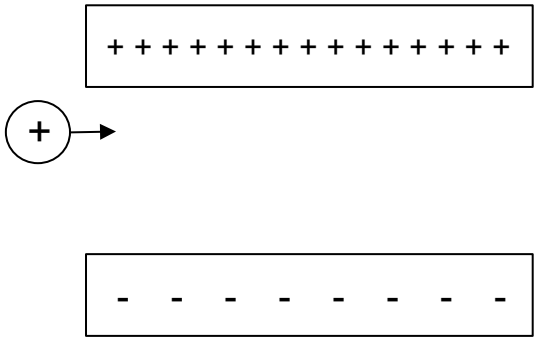
(a) **Explain** whether Mr. Moraleda would be able to turn the nut if he applied his maximum force at the optimum angle. **2**

(b) Outline a technical solution that can help Mr. Moraleda to turn another stuck nut which requires 40Nm of torque to undo. **2**

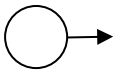
NESA NUMBER: _____

Question 19 (5 marks)

Proton launched horizontally into an electric field



A ball launched horizontally from a certain height above the ground



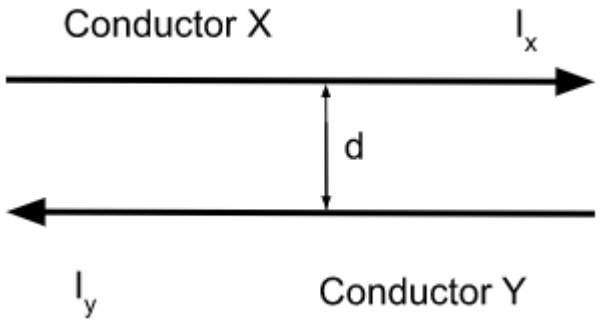
Ground
(Uniform gravitational field)

(a) Sketch the trajectories for the proton and the ball on the above diagrams. **1**

(b) Compare and contrast the trajectory of a proton in the electric field above and the trajectory of a projectile launched horizontally in the gravitational field above. **4**

Question 20 (7 marks)

A circuit set up like the diagram below is used to investigate the relationship between force per unit length and distance between two parallel conductors.



The experiment was performed with current in conductor X was FOUR times the current in conductor Y. The table shows the results obtained from carrying out this investigation.

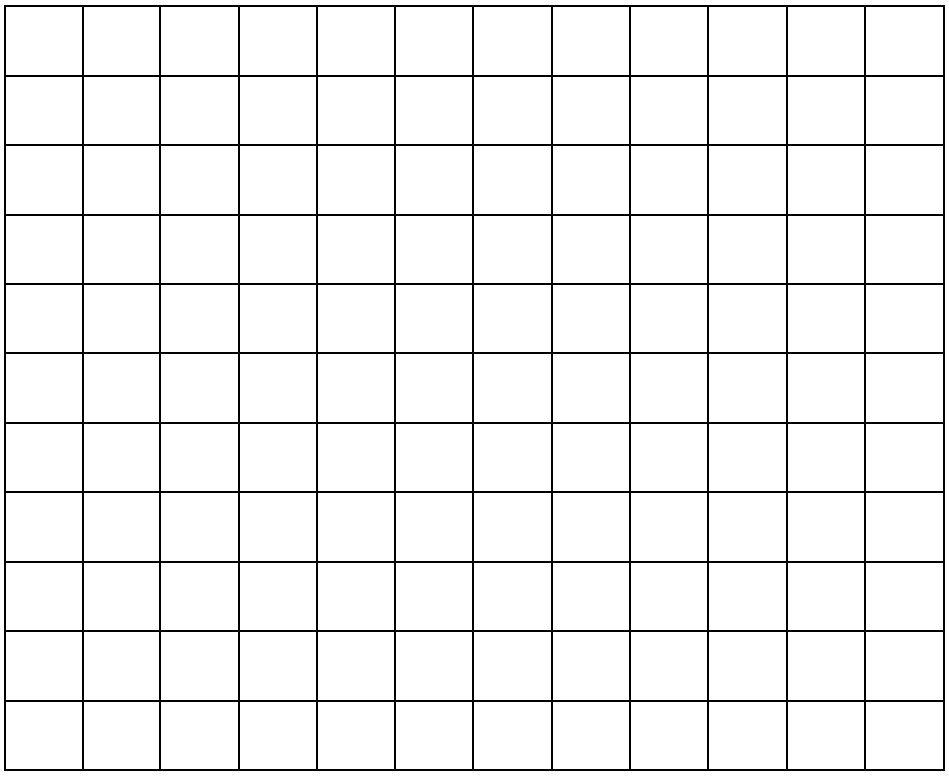
Trial Run	Distance between two conductors d (cm)	1/ distance (1/d) (m^{-1})	Force per unit length $x10^{-6}$ (N/m)
1	2	50	90
2	3	33	60
3	5	20	36
4	10	10	18
5	20	5	9

(a) Identify TWO variables that were needed to be controlled in this experiment. **2**

Question 20 continues on the next page

(Question 20 continued)

(b) Plot a line of best fit graph between force per unit length and 1/distance. **4**



(c) Describe the nature of force between two conductors. **1**

_____

_____

_____

Question 21 (3 marks)

A cyclist is riding around a frictionless circular banked track for two laps. On the first lap, he travels at a speed v. On the second lap, the cyclist ends up at a lower position and his path has a smaller radius than that of the first lap. **3**

Explain the difference in positions for the two laps.

Question 22 (3 marks)

A satellite of mass 500kg is boosted from an orbit of altitude 10000km above the earth to an orbit of altitude 20000km above the earth. The satellite's orbital speed remains the same. **3**

Calculate the work done required to change the orbit of this satellite.

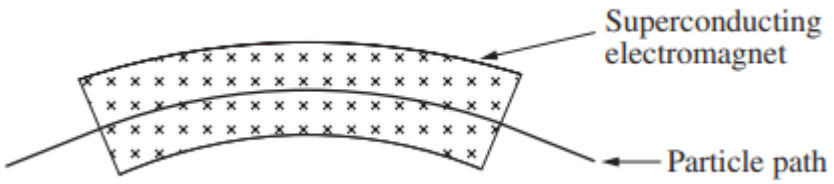
Question 23 (4 marks)

Compare the orbital velocity, orbital period, and the use of low earth orbits and geostationary orbits. **4**

Question 24 on next page

Question 24 (5 marks)

In the Large Hadron Collider (LHC), the particle beams are steered using magnetic fields (directed into the page), as shown.



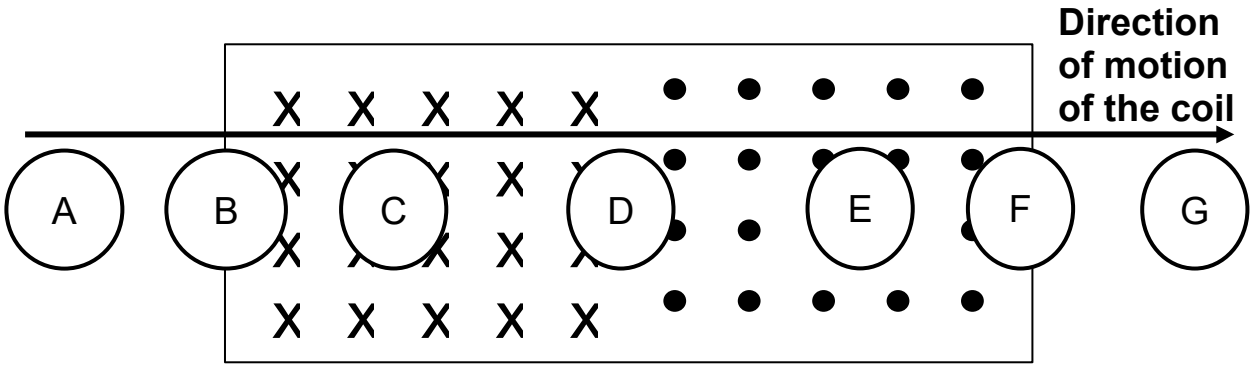
(a) Two particles with the same mass and same speed are travelling through the LHC in opposite directions. **2**

What can be deduced about the charge on the particles?

(b) During a test run, a proton travels with a speed of 1.0×10^7 ms^{-1} around the LHC. The radius of curvature of its path is 4.2 m. Calculate the magnetic field strength. **3**

NESA NUMBER: _____

Question 25 (7 marks)
The diagram below shows seven positions of a metal coil moving at constant speed from left to right through a uniform magnetic field directed firstly into the page, and then out of the page.

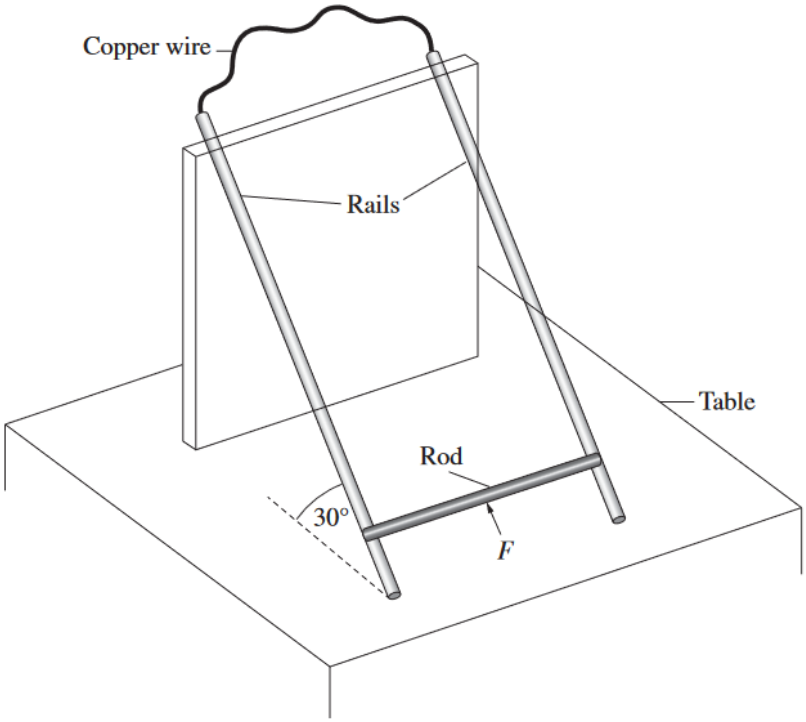


(a) Explain the position(s) of the coil when there will be current induced in the coil. **3**

(b) Explain the direction of all of the induced current(s) in the locations identified above, using principle(s) of Physics. **4**

Question 26 (3 marks)
A metal rod sits on a pair of parallel metal rails, 15 cm apart, that are connected by a copper wire. The rails are at 30° to the horizontal.

The apparatus is in a uniform magnetic field of 0.8 T which is upward, perpendicular to the table.



A force, F, is applied parallel to the rails to move the rod at a constant speed along the rails. The rod is moved a distance of 30 cm in 2.5 s.

(a) Calculate the change in magnetic flux through the circuit while the rod has moved a distance of 30 cm. **2**

(b) Label on the diagram above, the direction of induced current flowing through the copper wire, using an arrow. **1**

NESA NUMBER: _____

2023 Physics HSC Half Yearly Examination

Section I –Multiple Choice Answer Sheet

15 marks
Attempt Questions 1 – 15
Allow about 20 minutes for this section.

You may tear this page, and the data sheets off to help complete the questions.
Leave this page separate on your desk at the end of the exam.

Select the alternative A, B, C, or D that best answers the question. Fill in the response circle completely.

1	A ○	B ○	C ○	D ○
2	A ○	B ○	C ○	D ○
3	A ○	B ○	C ○	D ○
4	A ○	B ○	C ○	D ○
5	A ○	B ○	C ○	D ○
6	A ○	B ○	C ○	D ○
7	A ○	B ○	C ○	D ○
8	A ○	B ○	C ○	D ○
9	A ○	B ○	C ○	D ○
10	A ○	B ○	C ○	D ○
11	A ○	B ○	C ○	D ○
12	A ○	B ○	C ○	D ○
13	A ○	B ○	C ○	D ○
14	A ○	B ○	C ○	D ○
15	A ○	B ○	C ○	D ○

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number	79
Symbol	Au
Standard Atomic Weight	197.0
Name	Gold

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.38 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.61 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.96 Molybdenum	43 Tc Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanoids	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.9 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89–103 Actinoids	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium	113 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.1 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

Standard atomic weights are abridged to four significant figures.

Elements with no reported values in the table have no stable nuclides.

Information on elements with atomic numbers 113 and above is sourced from the International Union of Pure and Applied Chemistry Periodic Table of the Elements (November 2016 version).

The International Union of Pure and Applied Chemistry Periodic Table of the Elements (February 2010 version) is the principal source of all other data. Some data may have been modified.

Physics

DATA SHEET

Charge on electron, q_e	-1.602×10^{-19} C
Mass of electron, m_e	9.109×10^{-31} kg
Mass of neutron, m_n	1.675×10^{-27} kg
Mass of proton, m_p	1.673×10^{-27} kg
Speed of sound in air	340 m s^{-1}
Earth's gravitational acceleration, g	9.8 m s^{-2}
Speed of light, c	3.00×10^{8} m s^{-1}
Electric permittivity constant, ε_0	8.854×10^{-12} A^2 s^4 kg^{-1} m^{-3}
Magnetic permeability constant, μ_0	$4\pi \times 10^{-7}$ N A^{-2}
Universal gravitational constant, G	6.67×10^{-11} N m^2 kg^{-2}
Mass of Earth, M_E	6.0×10^{24} kg
Radius of Earth, r_E	6.371×10^{6} m
Planck constant, h	6.626×10^{-34} J s
Rydberg constant, R (hydrogen)	1.097×10^{7} m^{-1}
Atomic mass unit, u	1.661×10^{-27} kg 931.5 MeV/c^2
1 eV	1.602×10^{-19} J
Density of water, ρ	1.00×10^{3} kg m^{-3}
Specific heat capacity of water	4.18×10^{3} J kg^{-1} K^{-1}
Wien's displacement constant, b	2.898×10^{-3} m K

FORMULAE SHEET

Motion, forces and gravity

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

$$\Delta U = mg\Delta h$$

$$P = \frac{\Delta E}{\Delta t}$$

$$\sum \frac{1}{2}mv^2_{\text{before}} = \sum \frac{1}{2}mv^2_{\text{after}}$$

$$\Delta \vec{p} = \vec{F}_{\text{net}}\Delta t$$

$$\omega = \frac{\Delta \theta}{t}$$

$$\tau = r_{\perp}F = rF\sin\theta$$

$$v = \frac{2\pi r}{T}$$

$$U = -\frac{GMm}{r}$$

$$v = u + at$$

$$\vec{F}_{\text{net}} = m\vec{a}$$

$$W = F_{||}s = Fs\cos\theta$$

$$K = \frac{1}{2}mv^2$$

$$P = F_{||}v = Fv\cos\theta$$

$$\sum m\vec{v}_{\text{before}} = \sum m\vec{v}_{\text{after}}$$

$$a_{\text{c}} = \frac{v^2}{r}$$

$$F_{\text{c}} = \frac{mv^2}{r}$$

$$F = \frac{GMm}{r^2}$$

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

Waves and thermodynamics

$$v = f\lambda$$

$$f = \frac{1}{T}$$

$$d\sin\theta = m\lambda$$

$$n_{\text{x}} = \frac{c}{v_{\text{x}}}$$

$$I = I_{\text{max}}\cos^2\theta$$

$$Q = mc\Delta T$$

$$f_{\text{beat}} = \left| f_2 - f_1 \right|$$

$$f' = f\frac{\left(v_{\text{wave}} + v_{\text{observer}}\right)}{\left(v_{\text{wave}} - v_{\text{source}}\right)}$$

$$n_1\sin\theta_1 = n_2\sin\theta_2$$

$$\sin\theta_{\text{c}} = \frac{n_2}{n_1}$$

$$I_1r_1^2 = I_2r_2^2$$

$$\frac{Q}{t} = \frac{kA\Delta T}{d}$$

Electricity and magnetism

$$E = \frac{V}{d}$$

$$V = \frac{\Delta U}{q}$$

$$W = qV$$

$$W = qEd$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$B = \frac{\mu_0 NI}{L}$$

$$\Phi = B_{||}A = BA\cos\theta$$

$$\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$$

$$\frac{V_\mathrm{p}}{V_\mathrm{s}} = \frac{N_\mathrm{p}}{N_\mathrm{s}}$$

$$\vec{F} = q\vec{E}$$

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

$$I = \frac{q}{t}$$

$$V = IR$$

$$P = VI$$

$$F = qv_\perp B = qvB\sin\theta$$

$$F = lI_\perp B = lIB\sin\theta$$

$$\frac{F}{l} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{r}$$

$$\tau = nIA_\perp B = nIAB\sin\theta$$

$$V_\mathrm{p} I_\mathrm{p} = V_\mathrm{s} I_\mathrm{s}$$

Quantum, special relativity and nuclear

$$\lambda = \frac{h}{mv}$$

$$K_\mathrm{max} = hf - \phi$$

$$\lambda_\mathrm{max} = \frac{b}{T}$$

$$E = mc^2$$

$$E = hf$$

$$\frac{1}{\lambda} = R\left(\frac{1}{n_\mathrm{f}^2} - \frac{1}{n_\mathrm{i}^2}\right)$$

$$t = \frac{t_0}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$$

$$l = l_0\sqrt{\left(1 - \frac{v^2}{c^2}\right)}$$

$$p_\mathrm{v} = \frac{m_0 v}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$$

$$N_\mathrm{t} = N_0 e^{-\lambda t}$$

$$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$$