STUDENT NUMBER: _____

North Sydney Boys High School
Year 12 Physics 2025
Assessment Task 3

General Instructions

- Reading time – 5 minutes.
- Working time – 135 minutes.
- Board approved calculators may be used.
- Write using a black pen.
- Write your student number at the top of every separate page.
- Use the multiple-choice answer sheet provided at the end and may be separated.
- A NESA data and formula sheet is provided at the end and may be separated.

Total Marks – 80

Part A - 15 marks

- Attempt Questions 1–15.
- Allow about 25 minutes for this part.

Part B - 65 marks

- Attempt Questions 16–23.
- Allow about 110 minutes for this part.

PART A /15	
PART B /65	
Total Mark /80	
KU /57	
WS /23 (Q16, Q20 & Q23)	

This paper MUST NOT be removed from the examination room.

Part A – 15 marks

Choose the most correct answer. Use the multiple-choice answer sheet for Questions 1–15

1. During a game of paintball, player X shoots a paintball, which has a velocity of 80 m s^{-1}, horizontally from a height of 10 m towards player Y, who is positioned 25 m away. What is the horizontal velocity of the paintball just before impact?

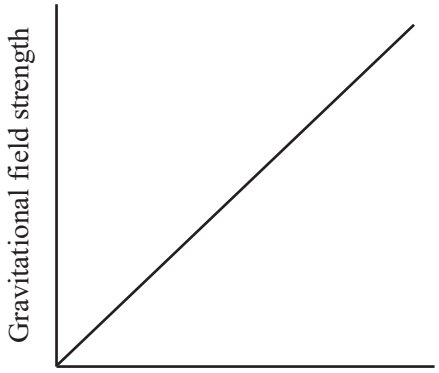
   A. 8.0 m s^{-1}

   B. 8.2 m s^{-1}

   C. 80 m s^{-1}

   D. 800 m s^{-1}

2. A Physics student plotted the graph shown for a planet of mass M.



   Which of the following could be an appropriate title for the *x*-axis and the expression for the gradient of the line?

   A. Distance from the centre of the planet. Gradient = GM

   B. Inverse square of the distance from the centre of the planet. Gradient = GM

   C. Square of distance from the surface of the planet. Gradient = GM

   D. Mass of the planet. Gradient = G/r

3. The Moon is located 3.84×10^8 m from Earth and has a mass of 7.35×10^{22} kg. Earth has a mass of 6.0×10^{24} kg. If a 1.00 kg object is located midway between Earth and the Moon, what is the object's acceleration due to gravity?

   A. 1.07×10^{-2} m s^{-2} towards Earth

   B. 1.07×10^{-2} m s^{-2} towards the Moon

   C. 1.18×10^{-2} m s^{-2} towards Earth

   D. 1.32×10^{-4} m s^{-2} towards the Moon

4. A satellite is currently in a low Earth orbit of 850 km and must be brought down to a lower orbit of 650 km.
In order to be stable in the lower orbit, the speed of the satellite would need to

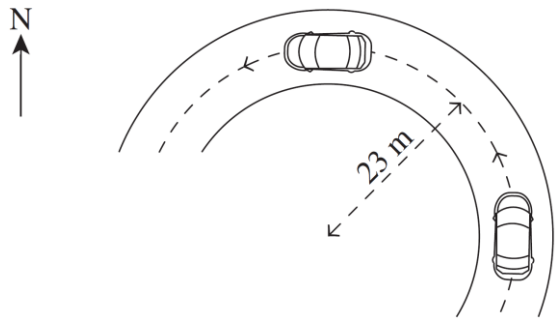
A. increase by 105 m s^{-1}.

B. decrease by 105 m s^{-1}.

C. increase by 3115 m s^{-1}.

D. decrease by 3115 m s^{-1}.

5. An instructor at a driving school demonstrated driving around a bend in a vehicle of mass 2200 kg, as shown in the diagram.



The instructor was initially driving north at a speed of 10.5 m s^{-1} and then maintained a constant speed of 10.5 m s^{-1} as they continued around the bend.
The magnitude of the frictional force between the road and the car's wheels, under different conditions, is shown in the table below.

Condition	*Frictional force (N)*
dry	9500
heavy rain	8000
chemical spill on road (oily residue)	6500

Based on this information, under which conditions would it be safe to drive around the bend?

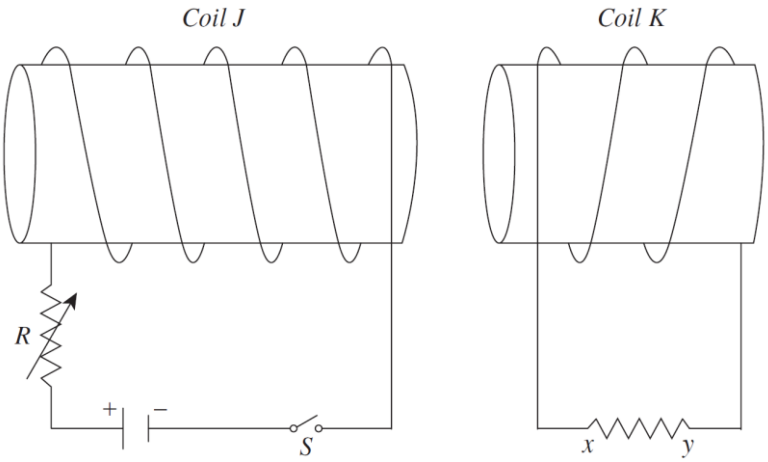
A. dry only.

B. none of the conditions.

C. dry and heavy rain only.

D. all of the conditions.

6. The apparatus shown in the diagram below is used in an experiment to demonstrate Lenz's law.



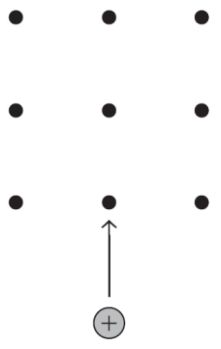
In the experiment, the following sequence of changes is made to the apparatus:

i. Switch S is opened after having been closed for a long period of time.
ii. Switch S is closed after having been open for a long period of time.
iii. The resistance of R decreases while switch S remains closed.

Which row of the table identifies the direction of the current in resistor x-y after each change?

	I	*II*	*III*
A.	*x* to *y*	*x* to *y*	*x* to *y*
B.	*x* to *y*	*y* to *x*	*y* to *x*
C.	*y* to *x*	*y* to *x*	*y* to *x*
D.	*y* to *x*	*x* to *y*	*y* to *x*

7. The diagram below shows a proton being fired with a velocity of 1200 m s^{-1} into a uniform magnetic field of 3.00 T. The magnetic field is directed out of the page.



What is the acceleration of the proton as it enters the field?

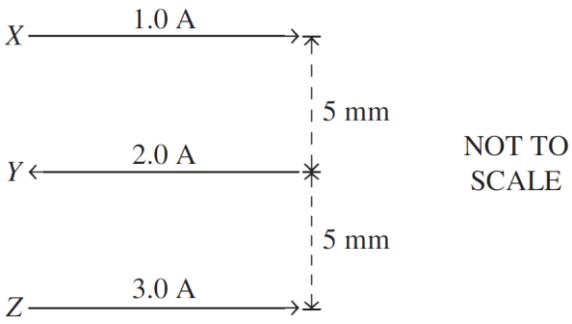
A. 5.77×10^{-16} m s^{-2} to the right

B. 5.77×10^{-16} m s^{-2} to the left

C. 3.45×10^{11} m s^{-2} to the right

D. 3.45×10^{11} m s^{-2} to the left

8. Three parallel current-carrying wires, X, Y and Z, are shown. The current in wire Y is flowing in the opposite direction to the currents in wires X and Z.



What is the magnitude of the net force acting on wire X?

A. 2×10^{-5} N m^{-1} up

B. 2×10^{-5} N m^{-1} down

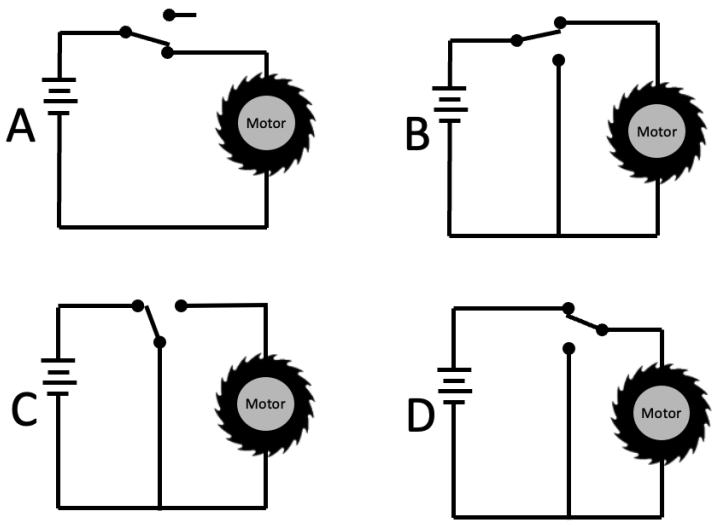
C. 8×10^{-5} N m^{-1} up

D. 8×10^{-5} N m^{-1} down

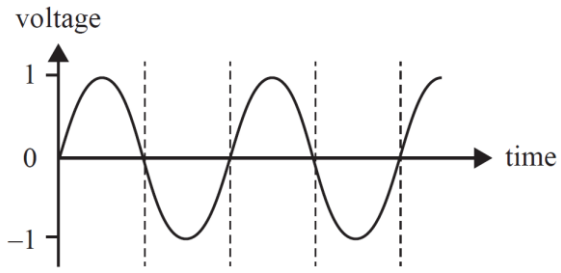
9. A circular saw consists of a DC electric motor connected to a circular saw blade, which continues to spin for a while after the switch is opened. To make the blade slow more quickly (and reduce the chance of accidental injury) a manufacturer proposes using electromagnetic braking when the switch is in the "off" position.

Which circuit would operate the saw in the "on" position and slow the saw more quickly using electromagnetic braking in the "off" position?

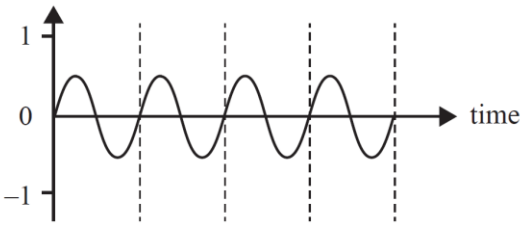
In all options below, the switch is drawn in the "on" position.

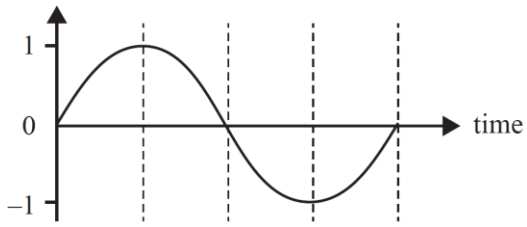


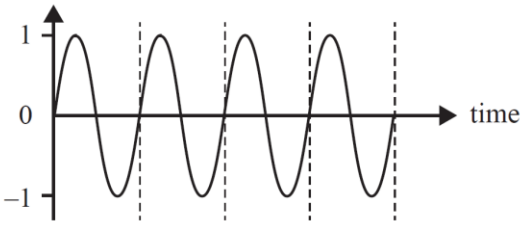
10. The coil of an AC generator completes 50 revolutions per second. A graph of output voltage versus time for this generator is shown below.

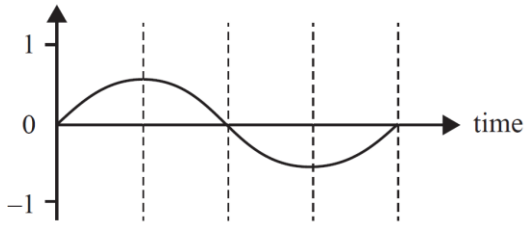


Which one of the following graphs best represents the output voltage if the rate of rotation is changed to 25 revolutions per second?

A.


B.


C.


D.


11. Polarisation is a property of

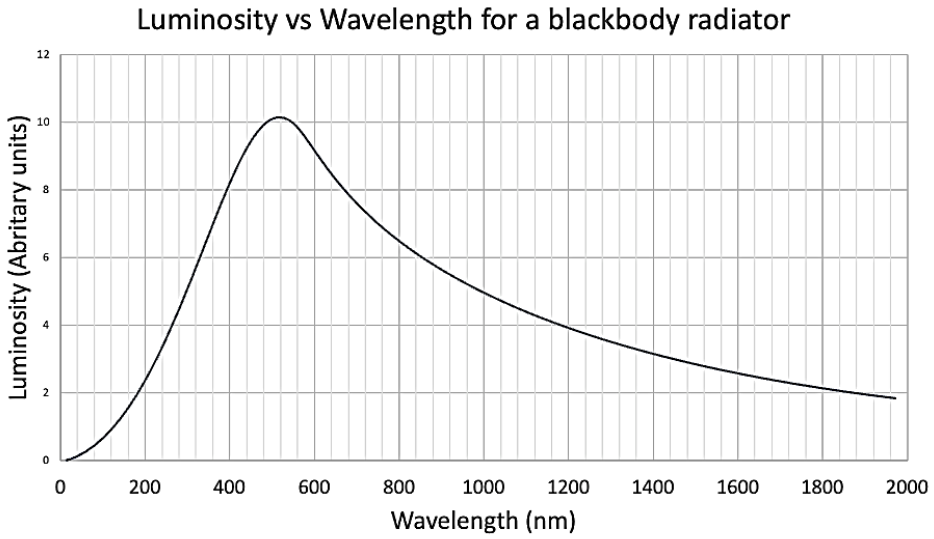
A. all types of waves.

B. only sound waves.

C. only transverse waves.

D. only longitudinal waves.

12. The light emitted from a hot black body object was measured and presented in the graph.



Which option is the best estimate of the temperature of this object?

A. 4500 K.

B. 5200 K.

C. 5600 K.

D. 7200 K.

13. Which statements identify Maxwell's contribution to our understanding of light?

L	provided a unifying framework for electricity and magnetism.
M	demonstrated that energy in light is quantised $E = hf$.
N	predicted that changing electric and magnetic fields can propagate as waves.
O	conducted experiments to measure the speed of light.
P	predicted that gravity could bend light.
Q	predicted a theoretical speed for the propagation of light in a vacuum.

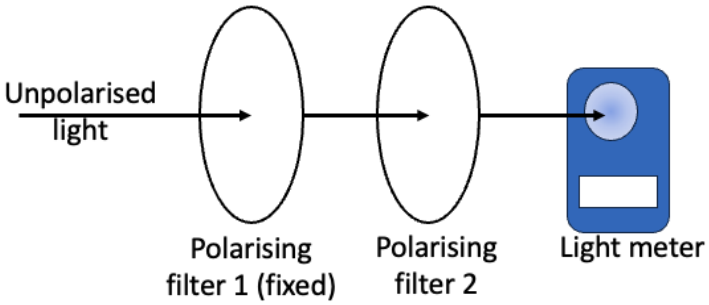
A. L, M, Q

B. L, N, O

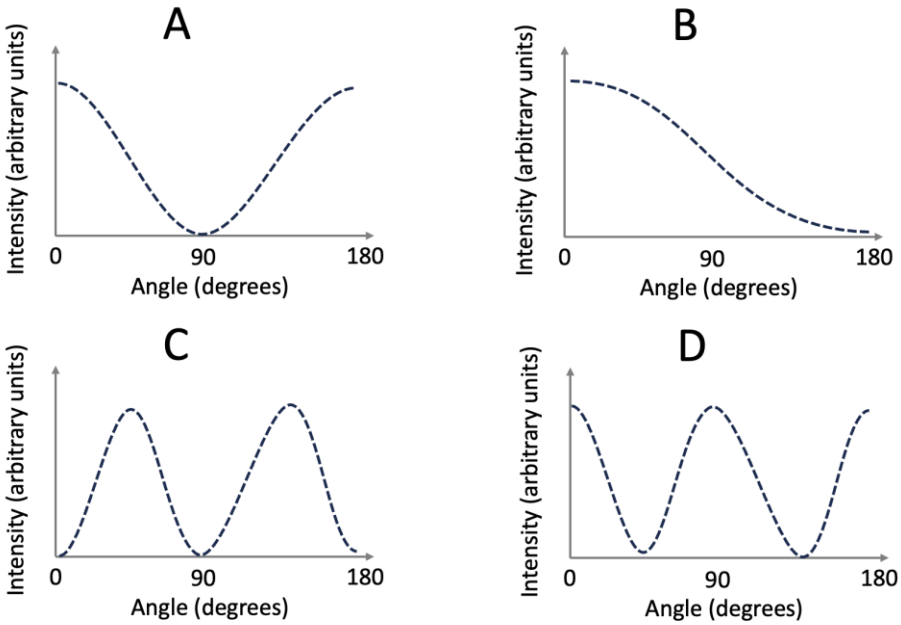
C. M, O, P

D. L, N, Q

14. Two polarising filters and a light meter were set up as shown. Filter 2 was rotated so that the light meter read a maximum and this position was marked as 0 degrees.



Filter 2 was then rotated about the polarising axis through 180 degrees. Which option best graphs the intensity that would be measured by the light meter during this rotation?



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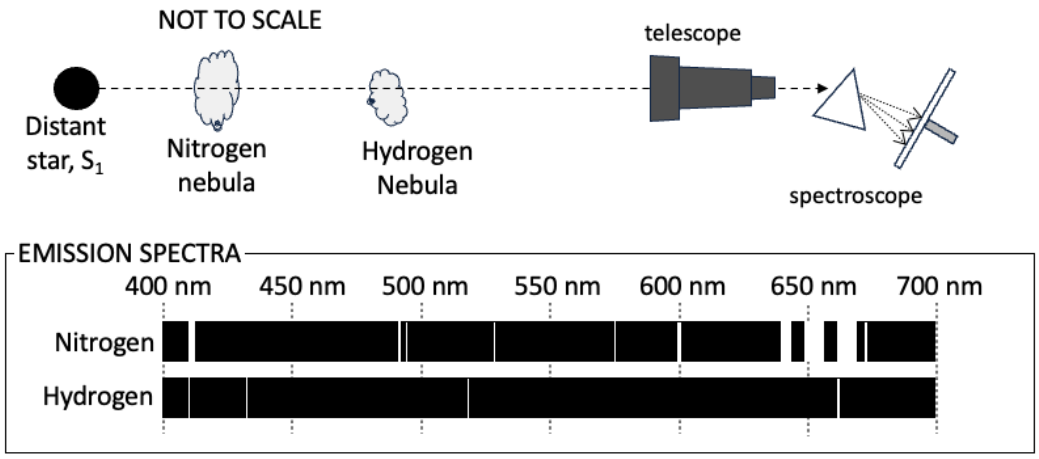
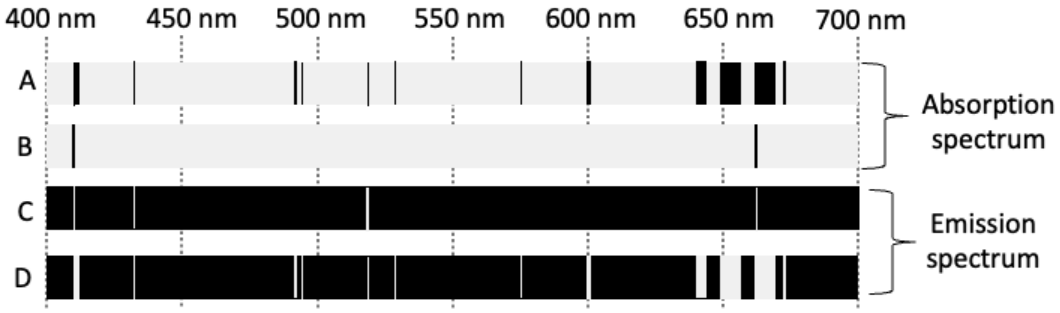
15. Light from a distance main sequence star (S_1) travels through two nebulae and is collected by a telescope and split into its spectrum. The diagram contains further information.



Which option best describes what would be observed?

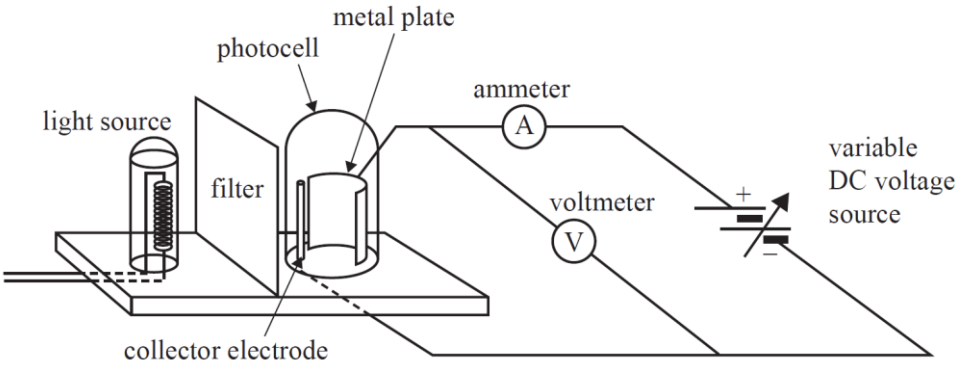


Part B – 65 marks

Write your answers in the spaces provided.

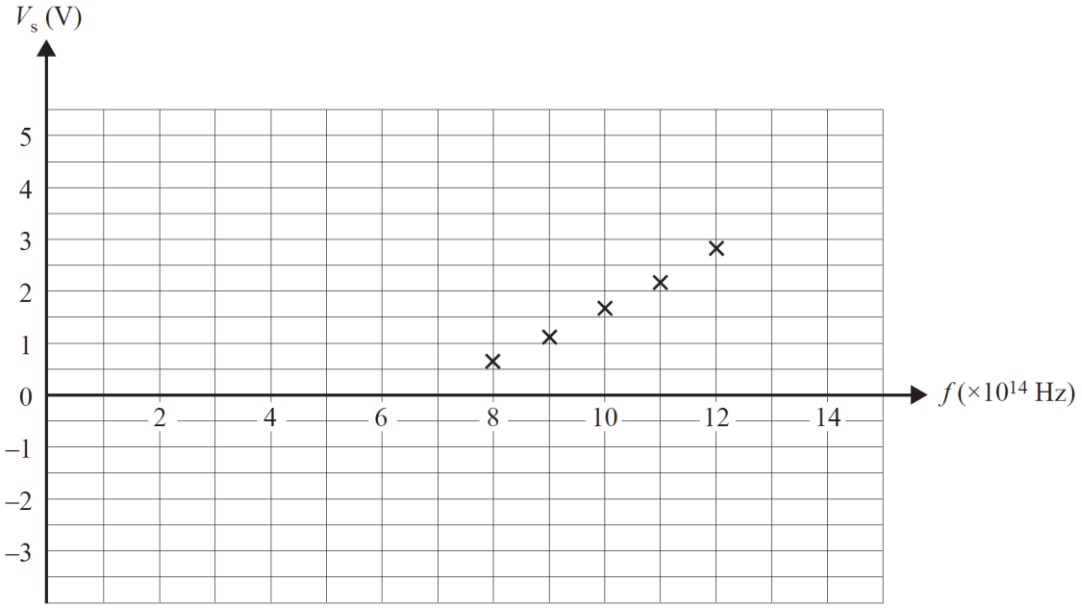
Question 16 (6 marks)

To investigate the photoelectric effect, Sam and Kim set up an experiment. The apparatus is shown in the figure below.



With the light source on and a filter in place, Sam and Kim measure the maximum kinetic energy of emitted photoelectrons by gradually changing the collector voltage until the current measured by the ammeter just falls to zero.

They record this voltage (the stopping voltage) for each frequency of the incident light and plot their results in a graph of stopping voltage, V_s, versus frequency, f ($\times 10^{14}$ Hz), of the incident light, as shown below.



With 6.0×10^{14} Hz light, the ammeter always shows zero. Sam wants to repeat the experiment for this frequency with a much brighter light source and wants to expose the metal to the light for much longer. Kim says photoelectrons will never be ejected with this frequency of light.

(a) What explanation might Sam give to support his opinion that by waiting longer and using a brighter light source, photoelectrons could be ejected from the metal with light of a frequency of 6.0×10^{14} Hz?

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(b) Use the graph with suitable construction to calculate Planck's constant in eVs.

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(c) Determine the work function of the metal from the graph in eV.

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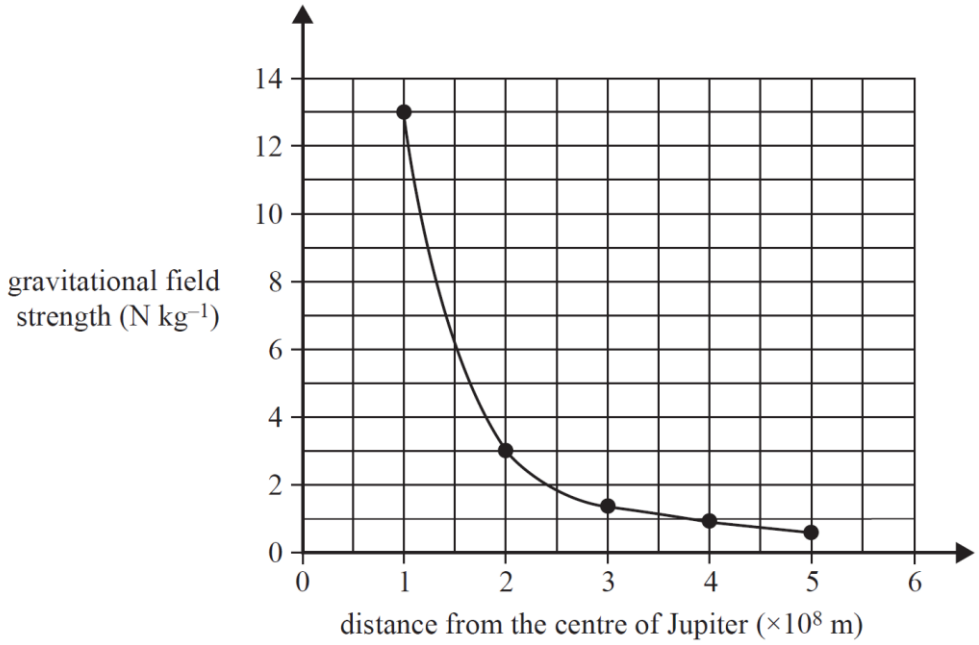
Question 17 (8 marks)

The spacecraft *Juno* has been put into orbit around Jupiter. The table below contains information about the planet Jupiter and the spacecraft *Juno*. The next figure shows gravitational field strength (N kg^{-1}) as a function of distance from the centre of Jupiter.

Mass of Jupiter	1.90×10^{27} kg
Radius of Jupiter	7.00×10^{7} m
Mass of spacecraft *Juno*	1500 kg



(a) Determine the gravitational force acting on *Juno* by Jupiter when *Juno* is at a distance of 2.0×10^{8} m from the centre of Jupiter. 2

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(b) Use the graph above to determine the magnitude of the change in gravitational potential energy of the spacecraft *Juno* as it moves from a distance of 2.0×10^{8} m to a distance of 1.0×10^{8} m from the centre of Jupiter. 3

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(c) Europa is a moon of Jupiter. It has a circular orbit of radius 6.70×10^8 m around Jupiter. Calculate the period of Europa's orbit. 3

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Question 18 (10 marks)

Physics students studying interference set up a double-slit experiment using a 610 nm laser, as shown in Figure 1 below. The light power output of the laser is 5.03×10^{-3} J s^{-1}.

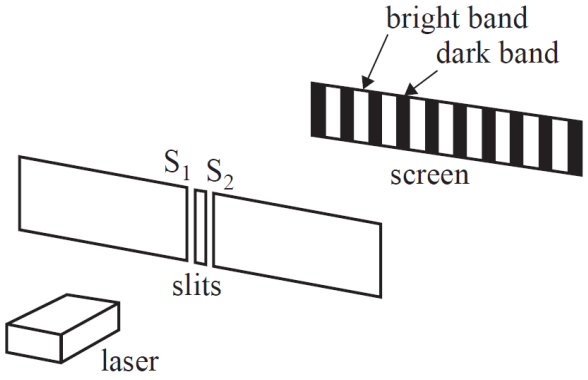

Figure 1

(a) Calculate the number of photons leaving the laser each second.

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A section of the interference pattern observed by the students is shown in Figure 2 below. There is a bright band at point C, the centre point of the pattern.

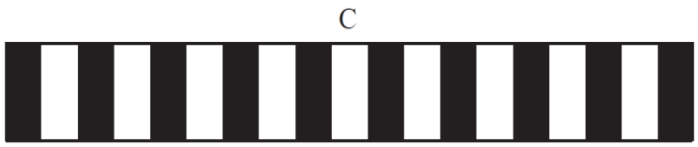

Figure 2

(b) Explain why point C is in a bright band rather than in a dark band.

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(c) Another point on the pattern to the right of point C (on the screen) is further from slit S_1 than slit S_2 by a distance of 2.14×10^{-6} m. Mark this point on Figure 2 by writing an X above the point. You must use a calculation to justify your answer.

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(d) The centre-to-centre distance from C to X is 0.05 m on the screen. If the perpendicular distance of the slits to the screen is 2 m, find the slit separation distance between S_1 and S_2 using small angle approximation.

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Question 19 (7 marks)

A 2 metre long rod of negligible thickness is in its rest frame, S′. The rod makes an angle 30° with its x′ axis. The lower end of the rod is at the origin of the S′ frame. The rod moves (translates) with a speed of 85% of that of light along the horizontal direction in the x axis (parallel to x′) of an S frame.

(a) Determine the length of the rod as measured by a stationary observer in the S frame.

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(b) Determine the angle θ the rod makes with the x axis in the S frame.

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(c) How will the rod appear to the stationary observer in the S frame?

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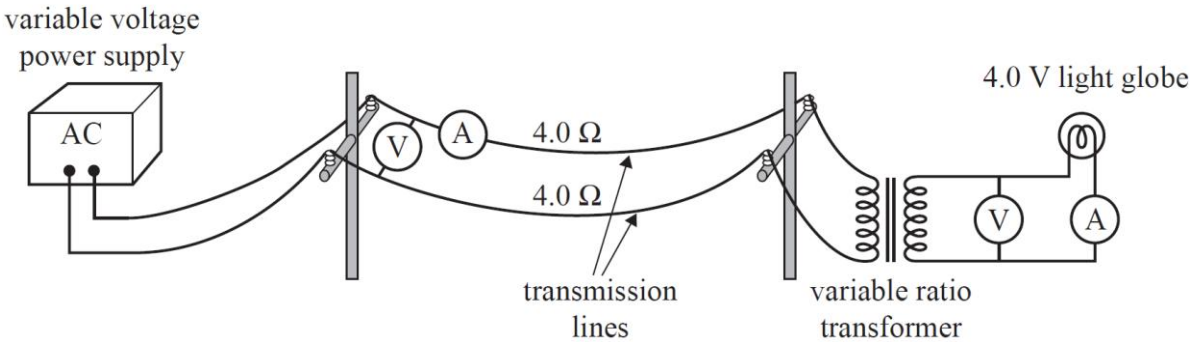
Question 20 (12 marks)

A Physics class is investigating power loss in transmission lines.

The students construct a model of a transmission system. They first set up the model as shown in the figure below. The model consists of a variable voltage AC power supply, two transmission lines, each of 4.0 Ω (total resistance = 8.0 Ω), a variable ratio transformer, a light globe and meters as needed. The purpose of the model is to operate the 4.0 V light globe.

A variable ratio transformer is one in which the ratio of turns in primary windings to turns in secondary windings can be varied. The resistance of the connecting wires can be ignored.



In their first experiment, the transformer is set on a ratio of 4:1 and the current in the transmission lines is measured to be 3.0 A. The light globe is operating correctly, with 4.0 V across it.

(a) Calculate the power dissipated in the light globe.

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(b) Calculate the voltage output of the power supply.

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(c) Calculate the total power loss in the transmission lines.

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(d) In a second experiment, the students set the variable of the transformer at 8:1 and adjust the variable voltage power supply so that the light globe operates correctly, with 4.0 V across it. Calculate the total power loss in the transmission line in the second experiment.

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(e) Suggest two reasons why high voltages are often used for the transmission of electric power over long distances.

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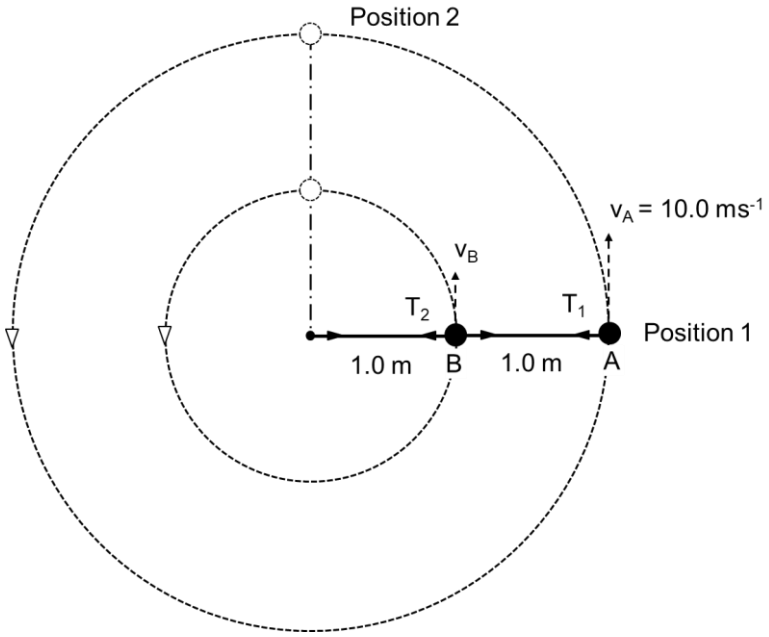
Question 21 (12 marks)

In the figure below, Ball A is attached to one end of a mass-less string of length 1.0 m while the other end is attached to an identical ball B. A second similar string of length 1.0 m is attached to ball B as shown. Each ball has a mass of m = 0.2 kg. This arrangement is held by hand at the free end of the string from ball B and is whirled around in a *vertical* circle. Both balls always move co-linear to each other as a system as shown. Air resistance can be ignored.



(a) At position 1, the speed of mass A is 10.0 ms^{-1}. Calculate tensions T_1 and T_2.

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(b) Using energy conservation or otherwise, calculate tension T_1 at position 2.

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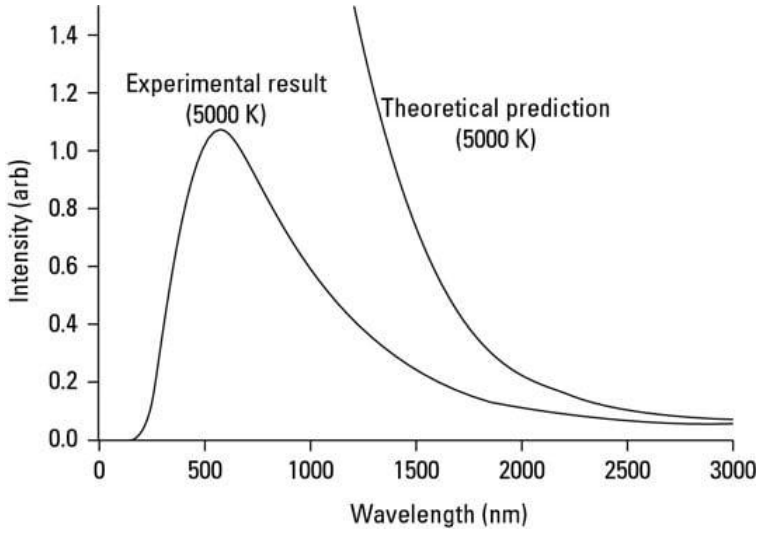
Question 22 (5 marks)

The figure below shows experimental result of a Blackbody radiation spectrum at 5000 K and the corresponding theoretical prediction curve also known as the ultraviolet catastrophe. Explain the basis of the ultraviolet catastrophe and how Planck reinterpreted its features to fit with experimental results obtained from Blackbody radiation spectra.



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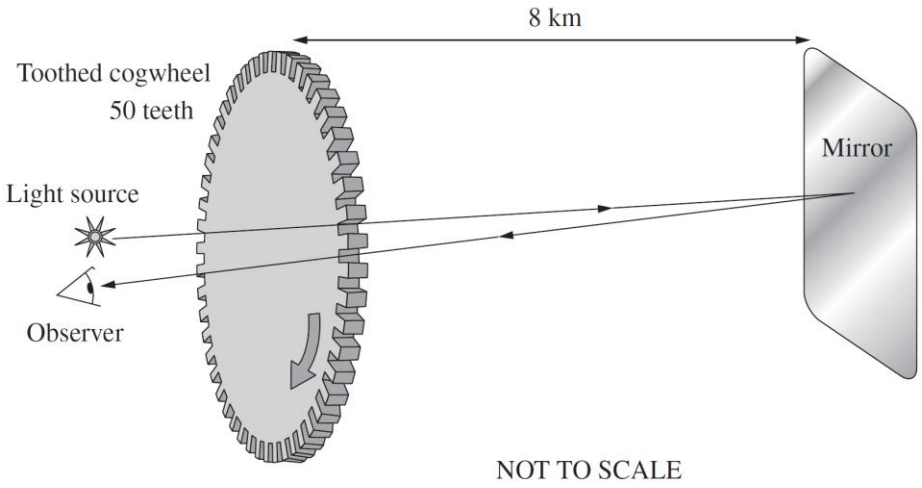
Question 23 (5 marks)

In the 1840s, French physicist, Hippolyte Fizeau performed an experiment to measure the speed of light. He shone an intense light source at a mirror 8 km away and broke up the light beam with a rotating cogwheel. He adjusted the speed of rotation of the wheel until the reflected light beam could no longer be seen returning through the gaps in the cogwheel.

The diagram below shows a similar experiment. The cogwheel has 50 teeth and 50 gaps of the same width.



Explain why specific speeds of rotation of the cogwheel will completely block the returning light. Support your answer with calculations.

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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

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

$$v = u + at$$

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

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

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

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

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

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

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

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

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

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

$$a_c = \frac{v^2}{r}$$

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

$$F_c = \frac{mv^2}{r}$$

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

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

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

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

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

Waves and thermodynamics

$$v = f\lambda$$

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

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

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

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

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

$$n_x = \frac{c}{v_x}$$

$$\sin\theta_c = \frac{n_2}{n_1}$$

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

$$I_1 r_1^2 = I_2 r_2^2$$

$$Q = mc\Delta T$$

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

FORMULAE SHEET (continued)

Electricity and magnetism

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

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

$$W = qV$$

$$W = qEd$$

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

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

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

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

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

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

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

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

$$V = IR$$

$$P = VI$$

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

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

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

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

$$V_p I_p = V_s I_s$$

Quantum, special relativity and nuclear

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

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

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

$$E = mc^2$$

$$E = hf$$

$$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

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

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

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

$$N_t = N_0 e^{-\lambda t}$$

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

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

STUDENT NUMBER: _____

North Sydney Boys High School
Science Faculty
Year 12 Physics 2025
Assessment Task 3

MULTIPLE CHOICE ANSWER SHEET

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** ☐