Student Number……..

2022 Higher School Certificate
Trial Examination
Physics

General Instructions

- Working time 3 hours
- Reading time - 5 minutes
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- Write your student number on the exam and multiple-choice answer sheet.
- A data sheet, formulae sheets and periodic table are provided at the back of this paper

Total marks: 100

Section I – 20 marks

Attempt Questions 1-20 (pages 2-10)

- Allow about 35 minutes for this part

Section II - 80 marks

- Attempt Questions 21-31 (pages 11-27)
- Allow about 2 hours and 25 minutes for this part
- For all questions involving calculations in this section show relevant working

Section I
20 marks
Attempt Questions 1-20
Allow about 35 minutes for this part

Use the multiple-choice answer sheet provided for Questions 1-20

1. When a 12 kg rock is placed onto scales on the planet X the reading is 160 N. What is the ratio of the surface gravity on planet X over surface gravity on planet earth?

(A) 1.36

(B) 4.28

(C) 13.3

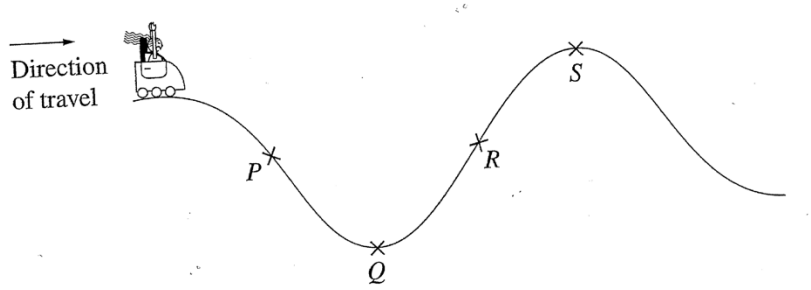
(D) 16.3

2 A student spins a cork of mass m on the end of a string so that it produces vertical circular motion with radius r. The speed is the minimum speed needed to maintain a circle.

What is the tension T, and the velocity v at the top of the circle?

	Tension at top	*Velocity at top*
(A)	$T = mv^2/r + mg$	$v = \sqrt{(gr)}$
(B)	$T = mv^2/r + mg$	$v = gr$
(C)	$T = mv^2/r - mg$	$v = \sqrt{(gr)}$
(D)	$T = mv^2/r - mg$	$v = gr$

3 The diagram below shows a roller coaster.



At which position is the normal force and the centripetal force acting in the same direction?

(A) Position P

(B) Position Q

(C) Position R

(D) Position S

4 A 200 kg satellite that orbits Earth at an altitude of 300 km. The satellite is travelling with a velocity of 27 800 km h^{-1}. The radius of the Earth is 6 380 km.

What is the gravitational force acting on this satellite?

(A) 1 794 N

(B) 1 966

(C) 1 794 000 N

(D) 1 966 000 N

5 Sheryl the sky diver is falling downward when she opens her parachute. What is the direction of her velocity vector and the direction of the acceleration vector just after opening her parachute and before she reaches the terminal speed?

(A) $\boldsymbol{V}$ is down, $\boldsymbol{a}$ is up

(B) $\boldsymbol{V}$ is down, $\boldsymbol{a}$ is down

(C) $\boldsymbol{V}$ is up, $\boldsymbol{a}$ is up

(D) $\boldsymbol{V}$ is up, $\boldsymbol{a}$ is down

6 Which of the following is **not** a component of a DC generator?

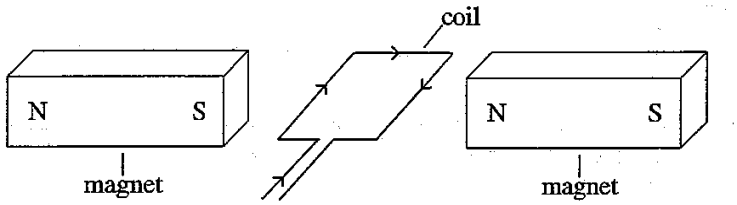
(A) Field coils

(B) Armature coil

(C) Split ring commutator

(D) Slip ring commutator

7 The following current carrying coil is set up between two magnets placed 10 cm apart. The two magnets are then flipped around (N becomes S), and their separation is increased by 2 cm. What happens to the torque on the coil?



(A) Torque is same direction and the magnitude is reduced

(B) Torque is same direction and the magnitude is unchanged

(C) Torque is opposite direction and the magnitude is reduced

(D) Torque is opposite direction and the magnitude is unchanged

8 An ideal transformer is used to convert an input of 800 V to an output current of 24 A. There are 5 700 turns in the primary coils and 460 turns in the secondary.

What is the current on the primary?

(A) 1.94 A

(B) 3.81 A

(C) 13.8 A

(D) 64.6 A

9 Thompson carried out an experiment with a modified form of cathode ray tube, where charged particles are injected into a region perpendicular to a magnetic field. He measured the charge to mass ratio *q/m*. What does the new charge to mass ratio become if the particle velocity is doubled, the charge is doubled, and magnetic field strength is tripled?

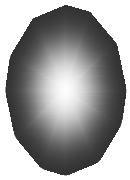
(A) 0.66 *q/m*

(B) 1.33 *q/m*

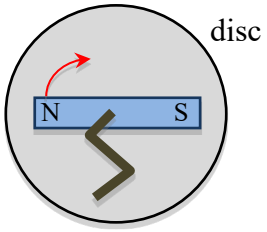
(C) 1.66 *q/m*

(D) 1.75 *q/m*

10 A rocket is traveling past an asteroid at a speed of 0.85c in the direction shown below. Which picture below correctly shows how the asteroid will appear to the travellers aboard the rocket?

(A)	(B)	(C)	(D)
			

11 The device below shows an aluminum disk and crank driven magnet set up on the same axle. When the crank handle is turned, the poles of the magnet spin across the surface of the disc which is free to move. What occurs if the turning speed is increased?



(A) The disk rotates more slowly due to the back emf

(B) The disk rotates more quickly due to the greater emf and eddy currents

(C) The disk rotates more slowly due to increased frictio

(D) The disk rotates more quickly due to the magnetic force on a current.

12 A group of students carried out an experiment to examine how the temperature of a certain light bulb varies with the voltage, using 6 different voltage settings. Which of the alterations below will make the experimental results less valid here?

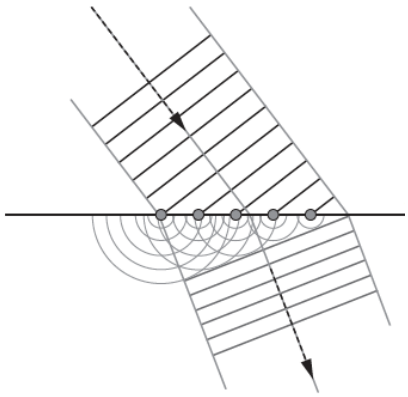
(A) Using different voltage settings in the same voltage range

(B) Using different light globes for the same voltage settings

(C) Using the same amount of room lighting for all voltage settings

(D) Carrying out more trial measurements at each voltage setting and averaging

13 A beam of light crosses from medium 1 to medium 2 as shown. What happens to the frequency and the speed of the light beam as it crosses?



(A) Frequency increases, speed increases

(B) Frequency increases, speed decreases

(C) Frequency remains unchanged, speed decreases

(D) Frequency increases, speed remains unchanged

14 Which statement is correct about the description of particles from the Standard Model?

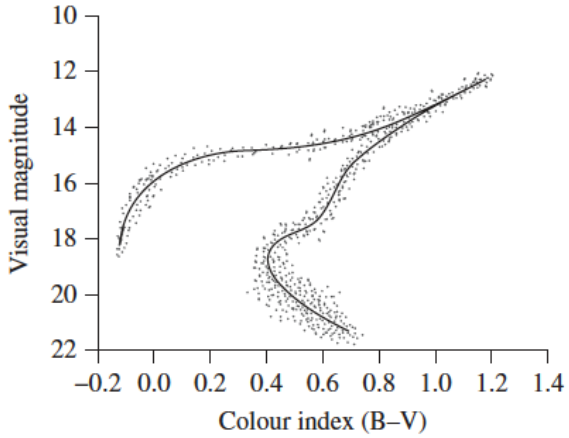
(A) Electrons are leptons, and they are made of smaller particle

(B) Protons are hadrons, and they are not made smaller particle

(C) Photons are bosons and are not made of smaller particles

(D) Neutrons are leptons and are made of smaller particles

15 The diagram below shows the HR diagram for a certain group of stars. What happens to the colour and the brightness of a typical star in this group after it passes through its red giant stage?



(A) The colour becomes more blue and the brightness decreases

(B) The colour becomes more blue and the brightness increases

(C) The colour becomes more red and the brightness increases

(D) The colour becomes more red and the brightness decreases

16 A nucleus of U-246 undergoes alpha decay and then beta decay. What is the end product?

(A) U- 243

(B) Pa- 243

(C) Th- 244

(D) Th- 245

17 The force acting between two-point charges Q and q separated by distance r is *F*. What does the force become when the separation distance is tripled, and the size of each charge is doubled?

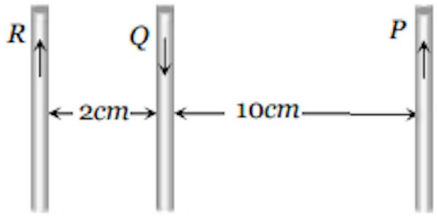
(A) 4/3 *F*

(B) 2/3 *F*

(C) 4/9 *F*

(D) 2/9 *F*

18 Three long parallel wires P, Q, R are sitting near each other as shown. The currents are measured as P = 2 A, Q = 4 A, R = 6 A. What is the net force on P from R and Q?



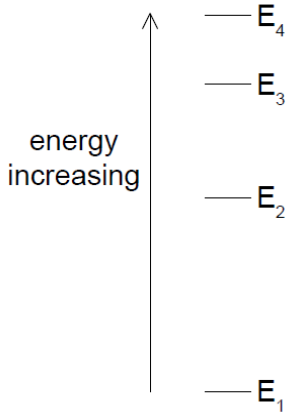
(A) 36 μN right

(B) 36 μN left

(C) 4 μN left

(D) 4 μN left

19 The energy levels for a certain atom are shown below to scale. A photon of wavelength λ is emitted because of a transition from E_3 to E_2. Which transition leads to the emission of a photon of a redder wavelength?



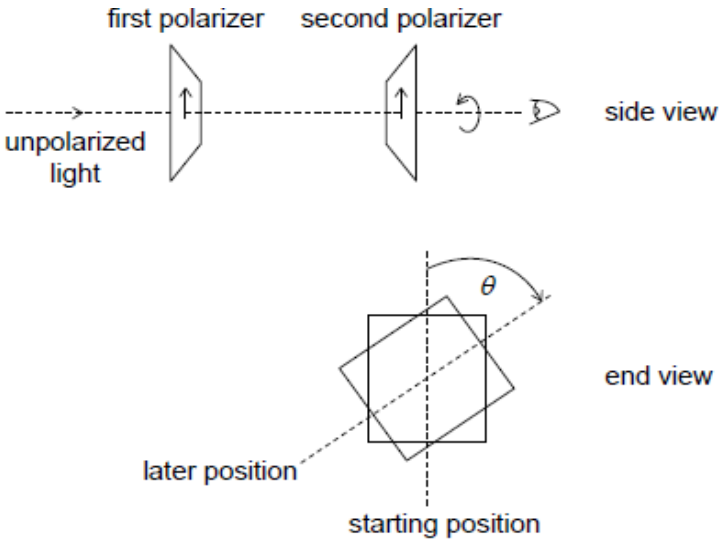
(A) E_4 to E_1

(B) E_3 to E_1

(C) E_2 to E_3

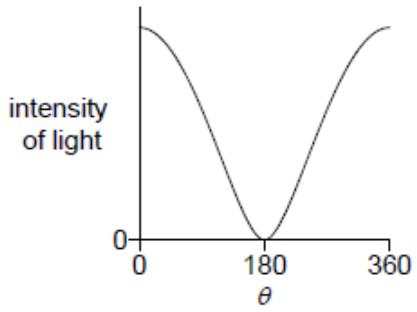
(D) E_4 to E_3

20 A beam of unpolarized light is incident on two polarizers. The axes of polarization of both polarizers are initially parallel. The second polarizer is then rotated through 360° as shown.

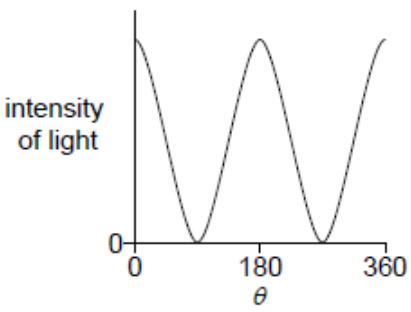


Which graph shows the variation of intensity with angle θ for the light leaving the second polarizer?

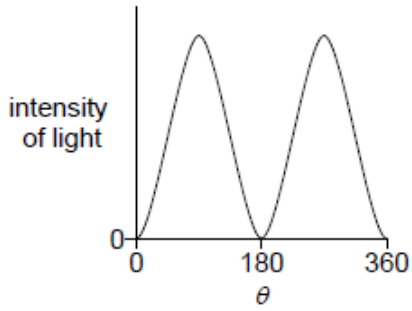
A.



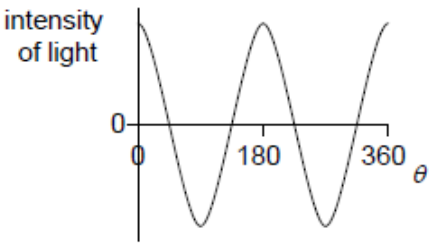
B.



C.



D.



Section II - 80 marks
Attempt Questions 21-31
Allow about 2 hours and 25 minutes for this part

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
Extra writing space is provided on pages 28-29. If you use this space, clearly indicate which question you are answering.

Question 21 (6 marks)

A student pushes a tennis ball off a building that is 8.6 m high. The ball's initial velocity is horizontal, and is given by u. The ball lands on the ground at a point that is 4.8 m horizontally out from its launch position. Assume that air resistance is negligible.

(a) Calculate the time it takes the ball to reach the ground. **1**

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(b) Calculate the final velocity of the ball. **3**

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(c) Explain how the final velocity and range of the ball changes if air resistance is acting. **2**

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Question 22 (9 marks)

A projectile launcher is set up on the top of 10 km high platform on the surface of the moon. The initial speed of the projectile can be varied, and the projectile is launched horizontally.

(a) Describe how the shape of the projectile's path changes as the initial speed is increased. **2**

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(b) The mass of the moon is 7.35×10^{22} kg and the radius of the moon is 1740 km. Calculate the initial speed required in order for the projectile to achieve a circular orbit. **2**

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(c) Explain whether or not the projectile is able to escape from the moon if the launch speed in part (b) is now doubled. **2**

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Question 22 continues on the next page

Question 22 (continued)

(d) Draw a labeled diagram in the space provided to compare the path of the projectile in circular orbit {part (b)} and escape {part (c)}. Draw the force vector to indicate the gravitational force on the projectile during orbit. **3**

Question 23 (6 marks)

A small 870 g mass is whirled around in a horizontal circle at one end of a 0.85 m length of string, forming a cone shape with angle θ to the vertical. The string when hanging vertically will just support a load of 44 N without breaking.

(a) Draw the force diagram, in the space provided for the spinning mass, showing the vectors and their vertical and horizontal components. **3**

(b) Calculate the angle θ and the maximum speed in rad.s^{-1} for the mass before the string breaks. **3**

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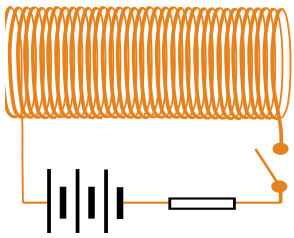
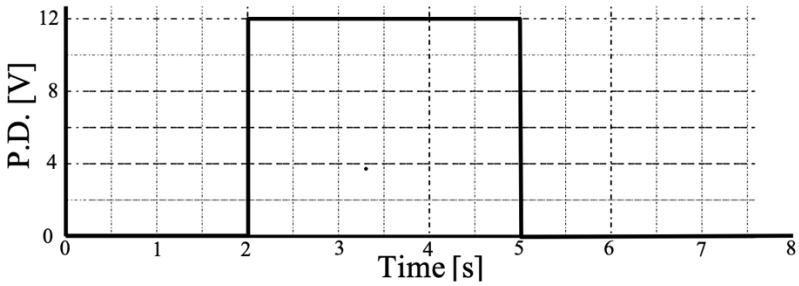
Question 24 (7 marks)

The diagram below shows a coil connected to a 12-volt battery. The switch is initially open, then at 2.0 s it is closed, and it stays closed until t = 5.0 s when it is opened again. A graph of V against t is shown below.





(a) According to the graph, at what time(s) does the magnetic field inside the coil have maximum strength? Justify your answer. **2**

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(b) The above graph does not accurately represent the production of back emf induced in the coil here. Explain when you would expect the induced back emf in the coil to be greatest and why this occurs. **3**

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(c) Calculate the emf induced across the coil if there are 220 turns, the flux changes from 0.004 T to 0.032 T in a time of 26 ms and the coil radius is 3.1 cm. **2**

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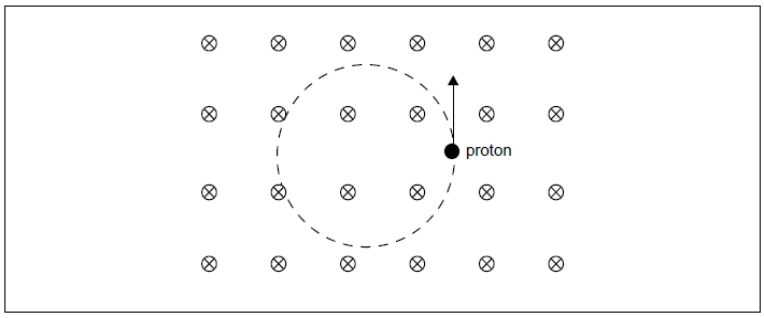
Question 25 (7 marks)

A proton is moving in a region of uniform magnetic field. The magnetic field is directed into the plane of the paper. The arrow shows the velocity of the proton at one instant and the dotted circle gives the path followed by the proton. The speed of the proton is 2.0×10^6 ms^{-1} and the magnetic field strength B is 0.35 T.



(a) Explain why the path of the proton is a circle. **2**

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(b) Calculate the radius of the path. **2**

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Question 25 continues on the next page

Question 25 (continued)

(c) Calculate the time for one complete revolution in microseconds. **2**

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(d) Calculate the work done by the magnetic field on the charge. **1**

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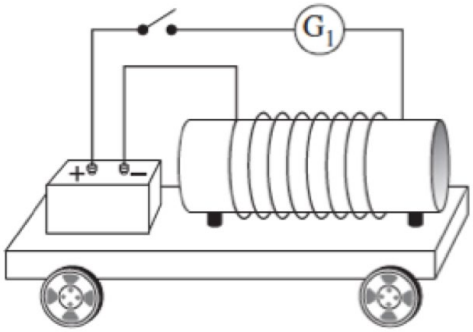
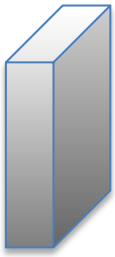
Question 26 (7 marks)

A solenoid is mounted on a car as shown. The solenoid is connected to a galvanometer, and the also connected to an open switch and a battery. The car is sitting near a metal block that is free to slide, and the total mass of the car is twice that of the block. The galvanometer reads current and swings to indicate current direction.



car



metal block

(a) The switch on car 1 is suddenly closed. Explain what happens to the current and the magnetic field in the solenoid, and in the metal block, as the car starts moving. Justify your response. **4**

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Question 26 continues on the next page

Question 26 (continued)

(b) The mass of the car is 4.0 kg and the block is 2.0 kg, and the initial speed of car is 1.5 ms^{-1}. Calculate the velocity of the car and its acceleration just after the interaction, assuming that interaction occurred over a time of 83 ms, and that there are no friction losses. **3**

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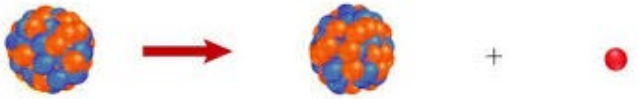
Question 27 (7 marks)

A certain atom undergoes radioactive decay. The reactant and product of a certain nuclear transformation are shown below.

Reactant: $^{131}_{53}I$ **Product**: $^{131}_{54}Xe$ and a beta particle



(a) Explain what occurs in the decay process, referring to all the particles involved. Include the nuclear equation showing the decay. **4**

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(b) The half-life of I-131 is 8 days. If the original sample contained 56 g of iodine 131, work out the decay constant and the amount of iodine which remains after 14 days, and state what has happened to the temperature. **3**

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Question 28 (5 marks)

Bohr, Rutherford and de Broglie each had a different model of the atom.

(a) Describe how Bohr's atomic model was similar to Rutherford's, and how it involved both classical features and quantum features. **2**

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(b) de Broglie used the concept of matter waves. Calculate the velocity and the wavelength of a nonrelativistic electron which has a kinetic energy of 3.3 eV. **3**

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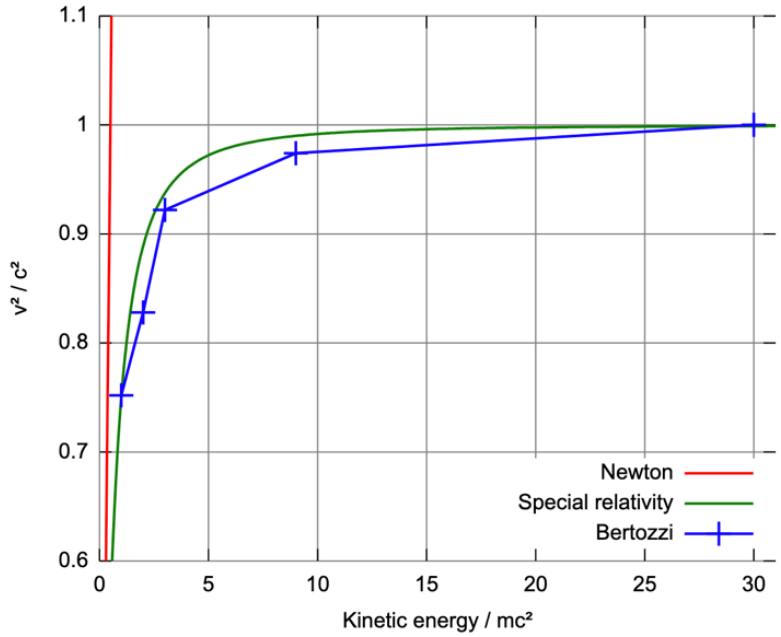
Question 29 (7 marks)

The Bertozzi experiment involved firing electrons at a metal plate. He measured the velocities and the amount of heat energy that was produced on the plate. The diagram below shows how the particle kinetic energy changes with the particle velocity. The red line shows what would happen if Newton's laws were obeyed. The blue line shows the experimental results.



(a) Show that particle kinetic energy can be expressed as $KE = p^2/2m$. **1**

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(b) Describe what occurs to the particles' KE here. **2**

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Question 29 continues on the next page

Question 29 (continued)

(c) Can the results here be used as evidence for the theory of relativity? Explain. **4**

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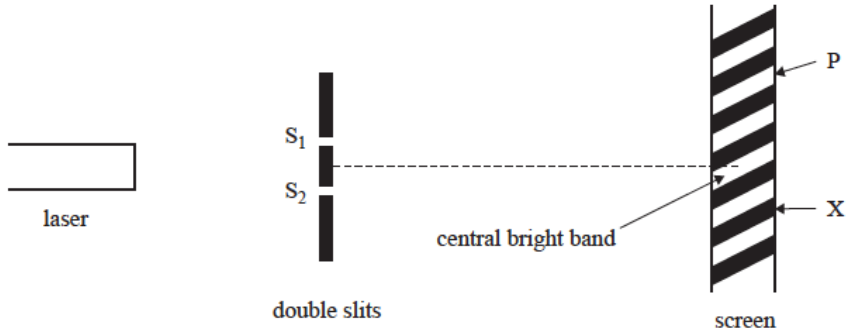
Question 30 (8 marks)

Some physics students conduct an experiment by using a laser and double slits in a darkened room, as shown below. X is a dark band, and P is a bright band. The path difference $S_1X - S_2X$ is measured to be 726 nm.



(a) Describe how the dark band forms at X. **2**

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(b) Calculate the wavelength of the laser. **2**

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Question 30 continues on the next page

(c) Describe what occurs to the pattern of light and dark bands if the screen is brought in closer to the double slit. **2**

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(d) Calculate the path difference to P in wavelengths and in meters. **2**

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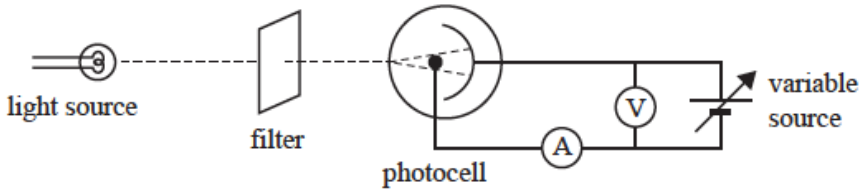
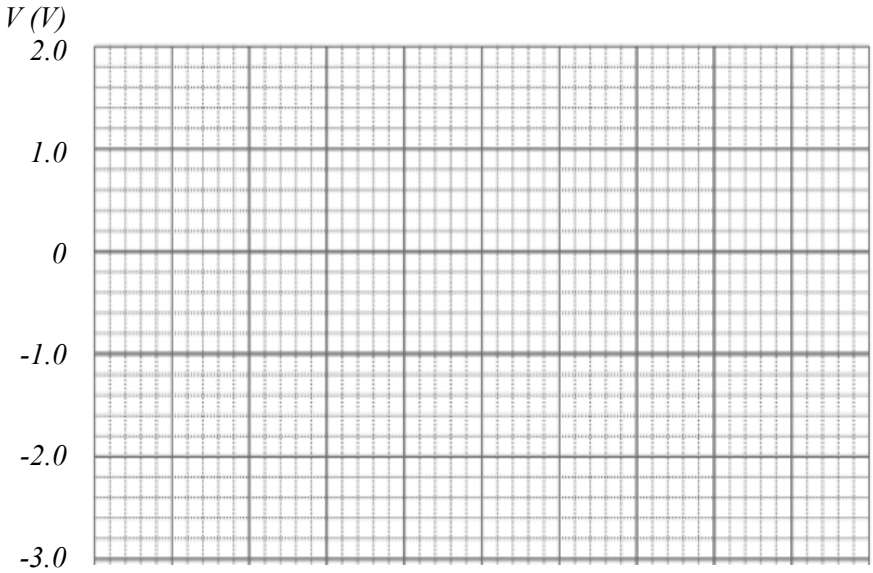
Question 31 (11 marks)

Amy carries out a photoelectric effect experiment. Electrons from a light source travel through a filter onto a photocell. The filters are changed so as to shine a particular wavelength onto the photocell. The variable voltage is increased until the current just goes to zero, and then recorded. Amy repeats this process for different frequencies.



Frequency (Hz)	Voltage (V)
6.0×10^{14}	0.16
7.0×10^{14}	0.52
7.5×10^{14}	0.72
8.0×10^{14}	0.88
9.0×10^{14}	1.35

(a) Plot a graph of the results here. Use the range from zero to $9x10^{14}$ Hz. **3**



Question 31 continues on the next page

Question 31 (continued)

(b) Explain how the stopping voltage is related to the electrons' kinetic energy. **2**

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(c) Use the graph to determine the work function in eV, as well as Plank's constant. **2**

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(d) For each frequency, Amy doubles the intensity of the incident light. Describe how the new graph compares with the original graph. Do these two graphs support the wave model or particle model of light? Justify your answer. **4**

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END OF EXAM

Extra writing space (if needed)

Please clearly state which question you are answering.

If you still need more space, please ask for extra writing paper.

Extra writing space (if needed)

Please clearly state which question you are answering.

If you still need more space, please ask for extra writing paper.

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Student Number:……..

PHYSICS – MULTIPLE-CHOICE ANSWER SHEET

ATTEMPT ALL QUESTIONS

Question	**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 ⬭
	16	A ⬭	B ⬭	C ⬭	D ⬭
	17	A ⬭	B ⬭	C ⬭	D ⬭
	18	A ⬭	B ⬭	C ⬭	D ⬭
	19	A ⬭	B ⬭	C ⬭	D ⬭
	20	A ⬭	B ⬭	C ⬭	D ⬭

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} ms^{-1}
Electric Permittivity constant, ε_0	8.854×10^{-12} A^2 s^2 $kg^{-1}m^{-3}$
Magnetic permittivity 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
I 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

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

$$v = u + at$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Waves and thermodynamics

$$v = f\lambda$$

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

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

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

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

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

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

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

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

$$I_1r_1^2 = I_2r_2^2$$

$$Q = mc\Delta T$$

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

Electricity & 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

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.

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