Student Number

Pymble Ladies' College

2022
TRIAL EXAMINATION

Physics

General Instructions

Reading time - 5 minutes

Working time - 3 hours

Write using black pen

Draw diagrams using pencil

Board-approved calculators may be used

A data sheet, formulae sheets and Periodic Table are provided

Write your Student Number at the top of this page and the multiple choice answer sheet.

Extra writing space is provided at the end of the paper. If you use this, please indicate clearly which question you are answering.

Total marks – 100

This paper has two parts, Part A and Part B

Part A – 20 marks
- Attempt Questions 1–20
- Allow about 35 minutes for this part
- Use the answer sheet provided

Part B – 80 marks
- Attempt Questions 21–33
- Allow about 2 hours and 25 minutes for this part

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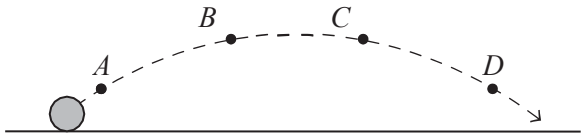
PART A

Part A – 20 marks
Attempt Questions 1–20
Allow about 35 minutes for this part
Use the multiple-choice answer sheet for Questions 1–20, provided separately at the back of this exam.

Question 1

A field hockey player scoops the ball up and over opposing players to pass to their teammate further up the field. The ball moves from position *A* to position *D*, as shown in the diagram.

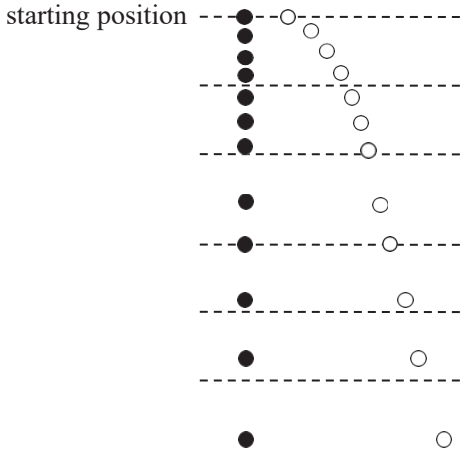


At which position(s) would the acceleration of the ball be vertically downward?

A. *D* only
B. *C* and *D* only
C. *B*, *C* and *D* only
D. *A*, *B*, *C* and *D*

Question 2

Two balls were simultaneously released from the same starting position. The black ball was dropped from rest and the white ball was projected horizontally, as shown in the diagram. The dashed lines represent equal distance intervals.



Which row of the table identifies the relative motions of the balls?

	X position of the balls	*Y position of the balls*	*Y velocities of the balls*	*X velocities of the balls*	*Y acceleration of the balls*
A.	different	same	same	different	same
B.	same	same	same	same	same
C.	different	different	different	different	different

D.

different	same	same	different	different

Question 3

A National Aeronautics and Space Administration (NASA) scientist uses a simulator to model the surface gravity of four different bodies in the Solar System. The surface gravity of each body is shown in the table.

Body	*Surface gravity (m s $^{-2}$)*
Ceres	5.55
Icarus	0.38
Hermes	4.97
Pallas	2.49

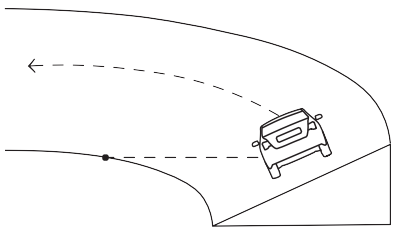
In the first simulation, the scientist throws a small cube with a mass of 450 g upwards. The cube initially travels at a speed of 6.5 m s^{-1} and reaches a maximum height of 8.5 m.

Which body is the scientist simulating?

A. Ceres
B. Icarus
C. Hermes
D. Pallas

Question 4

A road has a curve of radius 63 m and is banked at an angle of 12°. The diagram shows a car approaching the curve in wet, slippery conditions.



Assuming that there is no friction, calculate the maximum speed at which the car can safely make the turn.

A. 6.07 km h^{-1}
B. 11.5 km h^{-1}
C. 36.5 km h^{-1}
D. 41.2 km h^{-1}

Question 5

What will be produced when white light is passed through a gaseous sample of an element and examined with a spectrometer?

A. an absorption spectrum that is shown as a series of dark lines on a coloured background

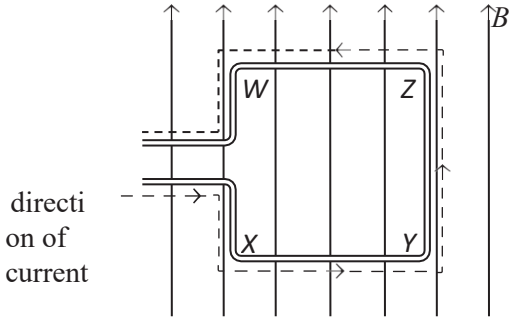
B. an emission spectrum that is shown as a series of coloured lines on a dark background

C. an absorption spectrum that is shown as a series of coloured lines on a dark background

D. an emission spectrum that is shown as a series of dark lines on a coloured background

Question 6

Consider the current-carrying loop.



How is torque created in the current-carrying loop?

A. There is a force on *WZ* out of the page and a force on *XY* into the page.

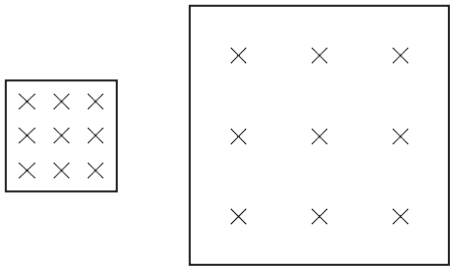
B. There is a force on *WZ* into the page and a force on *XY* out of the page.

C. There is a force on *WZ* out of the page and a force on *XY* out of the page.

D. There is a force on *WZ* into the page and a force on *XY* into the page.

Question 7

A Physics teacher drew two magnetic fields and asked their students to explain the difference between the magnetic flux of each field. The two magnetic fields are shown in the diagram.



Which of the following statements is correct?

A. The two magnetic fields show the same amount of flux, and the smaller magnetic field shows less flux density.

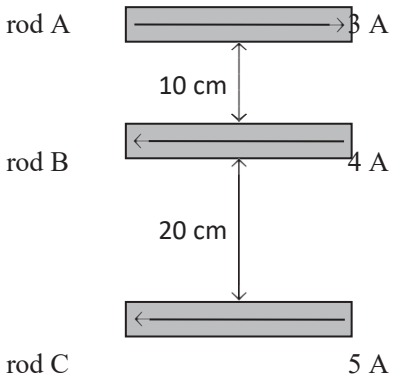
B. The two magnetic fields show different amounts of flux, and the smaller magnetic field shows less flux density.

C. The two magnetic fields show different amounts of flux, and the smaller magnetic field shows greater flux density.

D. The two magnetic fields show the same amount of flux, and the smaller magnetic field shows greater flux density.

Question 8

The diagram shows a set-up that uses three rods (A–C), each carrying a current in the direction indicated by the arrows.



What is the magnitude and direction of the force per unit length on rod C?

A. 1×10^{-5} N m^{-1} down

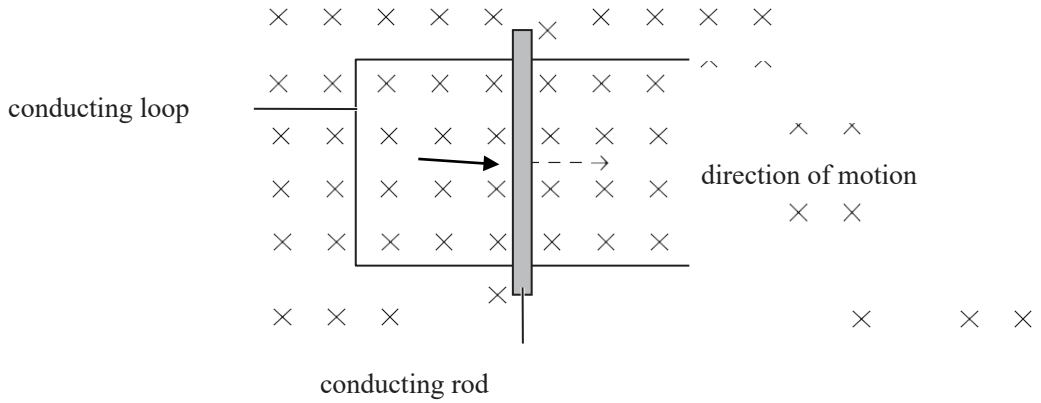
B. 1×10^{-5} N m^{-1} up

C. 3×10^{-5} N m^{-1} up

D. 3×10^{-5} N m^{-1} down

Question 9

A conducting rod slides along a metal conducting loop, as shown in the diagram.

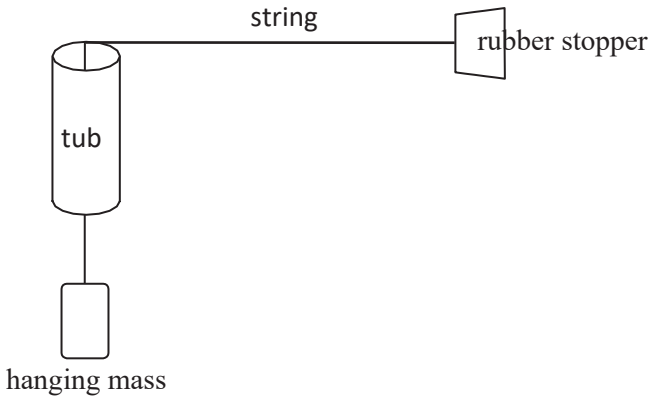


Which row of the table is correct?

	Direction of force on the conducting rod	*Direction of induced current in the rod*	*Direction of current around the conducting loop*
A.	to the left	up the rod	anticlockwise
B.	to the left	down the rod	clockwise
C.	to the right	up the rod	anticlockwise
D.	to the right	down the rod	clockwise

Question 10

A student carries out an investigation to find the relationship between the centripetal force, rotational speed and radius of an object moving in a uniform, circular motion. The student attaches a rubber stopper to a hanging mass using a string that passes through a tube and swings the rubber stopper around the tube, as shown in the diagram. As the rubber stopper is swung, the hanging mass rises and falls depending on the rotational speed of the stopper. When the hanging mass neither rises nor falls, the radius of the stopper's path is measured.



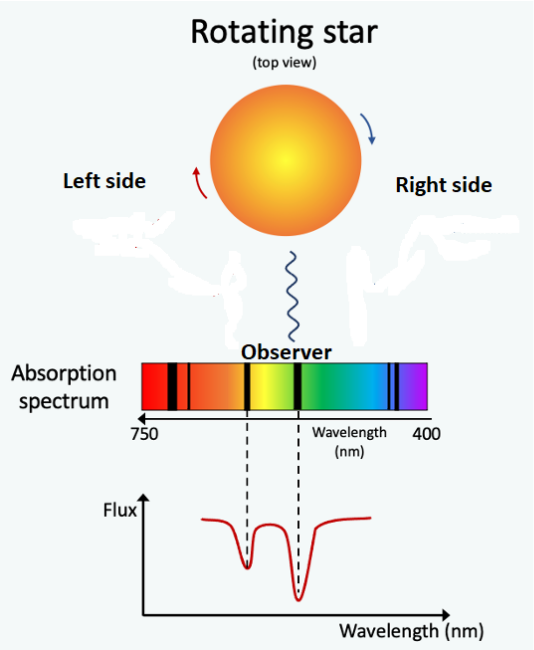
Which row of the table identifies the variables for this investigation?

	Independent variable	*Dependent variable*	*Controlled variables*
A.	hanging mass	length of string	mass of rubber stopper, rotational speed
B.	rotational speed	length of string	hanging mass, rotational speed
C.	mass of rubber stopper	rotational speed	hanging mass, length of string
D.	rotational speed	radius of stopper path	mass of rubber stopper, length of string

Question 11

As a star rotates, the observed atomic absorption bands appear broader. Consider the statement about this relationship and choose the correct terms in the table below corresponding to X, Y and Z.

> When a star is rotating relatively to an observer, as shown on the diagram, light received from the left side of the photosphere is ***X*** while the light received from the right side of the photosphere is **Y**. The **Z** it rotates, the wider the absorption band will appear in its spectrum.

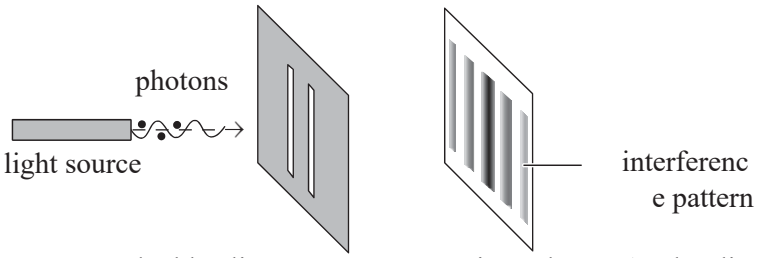


Which row of the table completes the statement?

	X	*Y*	*Z*
A.	blue-shifted	red-shifted	faster
B.	red-shifted	blue-shifted	faster
C.	blue-shifted	red-shifted	slower
D.	red-shifted	blue-shifted	slower

Question 12

Young performed an experiment where photons were beamed through a double-slit onto a screen, as shown in the diagram.



The following changes were made,

Change 1: The slit separation is changed.

Change 2: The distance between the double-slit and the screen is increased.

Which row of the table identifies what will occur after each change?

	Change 1	*Change 2*
A.	If the slit separation increases, the spacing between the bright bands decreases.	The spacing between the bright bands decreases.
B.	If the slit separation increases, the spacing between the bright bands decreases.	The spacing between the bright bands increases.
C.	If the slit separation increases, the spacing between the bright bands increases.	The spacing between the bright bands increases.
D.	If the slit separation decreases, the spacing between the bright bands increases.	The spacing between the bright bands decreases.

Question 13

Most stars have at least one planet orbiting them. Two planets, Psi and Tri, have been observed to orbit a star. Psi has an orbital path with a radius that is four times smaller than the radius of Tri's orbital path.

Which of the following statements about Psi and Tri is correct?

A. Tri would take 8 times longer than Psi to make a full orbit of the star.

B. Psi would take 8 times longer than Tri to make a full orbit of the star.

C. Tri would take 64 times longer than Psi to make a full orbit of the star.

D. Psi would take 64 times longer than Tri to make a full orbit of the star.

Question 14

An ideal transformer is used to convert an input of 800 V to an output current of 24 A. There are 5700 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

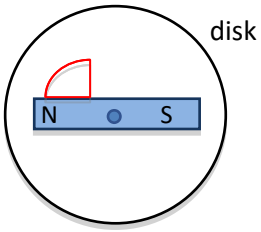
Question 15

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)
			

Question 16

The device below shows an aluminum disk and a magnet set up on the same axle. The disk and magnet are free to turn relatively to each other on the axle. The magnet is turning relative to the disk. What occurs if the angular velocity of the magnet 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 friction

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

Question 17

If light had a pure wave nature, which observation from investigations into the photoelectric effect would occur?

(A) The energy transfer from the light source to the metal would occur continuously therefore there would be a delay in the initial emission of photoelectrons.

(B) The energy transfer from the light source to the metal would occur discretely therefore the initial emission of photoelectrons would be nearly instantaneous.

(C) The energy transfer from the light source to the metal would occur continuously therefore interference pattern would be observed on the metal.

(D) The energy transfer from the light source to the metal would occur discretely therefore interferences pattern would be observed on the metal.

Question 18

A non-ideal step-down transformer has a primary voltage of 33 kV and a primary current of 200A. The secondary voltage is 11 kV with a secondary current of 460A.

The transformer's efficiency is closest to:

(A) 90%

(B) 75%

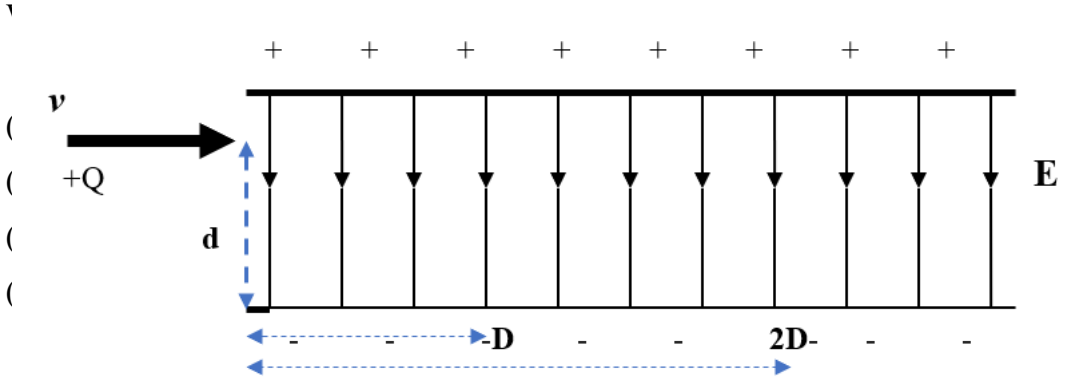
(C) 50%

(D) 33%

Question 19

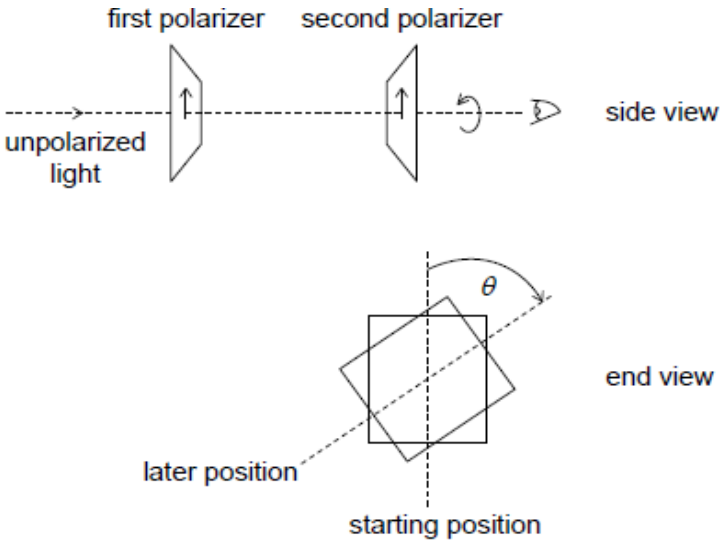
A charged particle +Q enters a region of uniform electric field E between two parallel plates, as shown.
The particle's speed before entering is ***v***.

The apparatus is in a vacuum and the experiment is being performed in weightless conditions.
The charged particle travels a horizontal distance **D** before striking the charged plate.



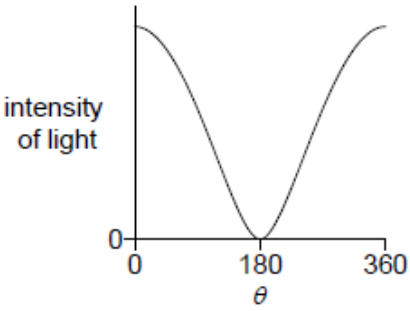
Question 20

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.



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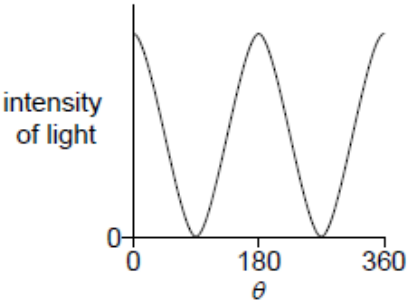

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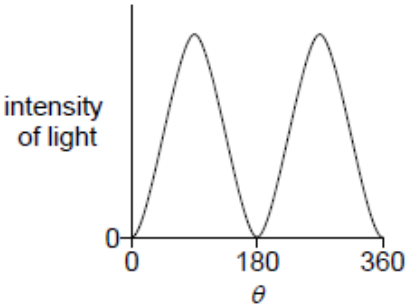
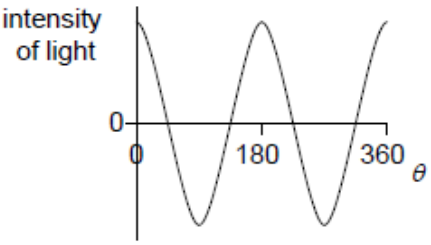


D.



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Part B – 80 marks

Attempt Questions 21–33

Allow about 2 hours and 25 minutes for this part.

Show all relevant working in questions involving calculations.

Write your Student Number at the top of this page.

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering

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Marks

Question 21 (5 marks)

By applying the law of conservation of energy to the relationship between gravitational potential energy and kinetic energy, explain how the escape velocity from a distance *r* from the centre of mass of a planet is given by: $\sqrt{\frac{2GM}{r}}$ where M is the mass of the planet. **5**

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Marks

Question 22 (5 marks)

Two projectiles are launched with the same initial speeds and angles to the horizontal. Projectile **A** has a mass of **m**, while projectile **B** has a mass of **2m**.

(a) Explain why the two projectiles will have the same range. **2**

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(b) Both projectiles were launched again, this time with the same angles to the horizontal but with different initial speeds.

Projectile **B** remains in flight for twice as long as projectile **A** over level ground.

How many times further does projectile **B** travel compared to projectile **A**? **3**

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Marks

Question 23 (4 marks)

Outline a procedure to investigate how the external magnetic field and the current impact the **direction** of the force on a straight current-carrying wire.

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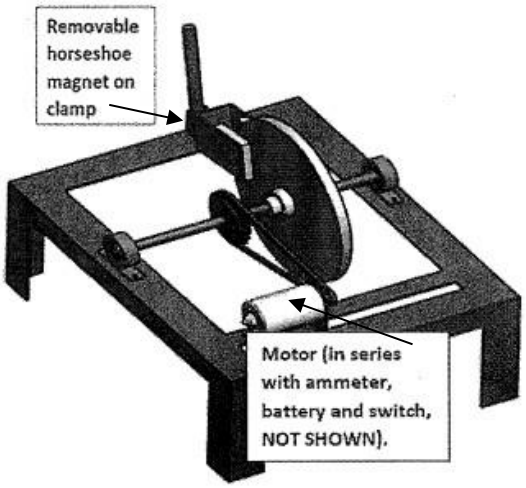
Marks

Question 24 (7 marks)

A student sets up an aluminium disc which is able to rotate in the vertical plane. The axle of the disc has a pulley wheel turned by a motor in series with the ammeter, battery and switch. A clamp with the horseshoe magnet can be attached so that a horizontal magnetic field passes through one part of the disc.



The student observes the current and the speed of the disc rotation, before and after the magnet is attached.
When the magnet is in place, the current through the ammeter is greater and the speed of rotation of the disc is lower.

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Account for each observation.

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Question 24 (Continued)

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Marks

Question 25 (6 marks)

Using two specific examples, explain how the interaction of electricity and magnetism and their respective fields is responsible for various phenomena studied in the Physics course.

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Marks

Question 26 (6 marks)

Observations of black body radiation could not be explained using a wave model of light.

(a) Discuss how Planck's contribution to the explanation of radiation from a black body led to a change in the model of light. **4**

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(b) Determine the peak wavelength of a star with a photosphere of temperature 7000 K. **2**

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Marks

Question 27 (4 marks)

The Hafele-Keating experiment involved flying extremely precise atomic clocks onboard aircraft in different directions around the world and comparing the times on the clocks to the time on clocks that remained on Earth.

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Explain how the Hafele-Keating experiment supported an aspect of special relativity as proposed by Einstein.

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Marks

Question 28 (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 q to the vertical. The string when hanging vertically will just support a load of 44 N without breaking.

3

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

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(b) Calculate the angle q and the maximum angular speed in rad.s^{-1} of the mass before the string breaks.

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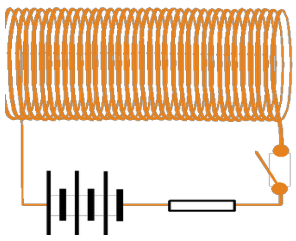
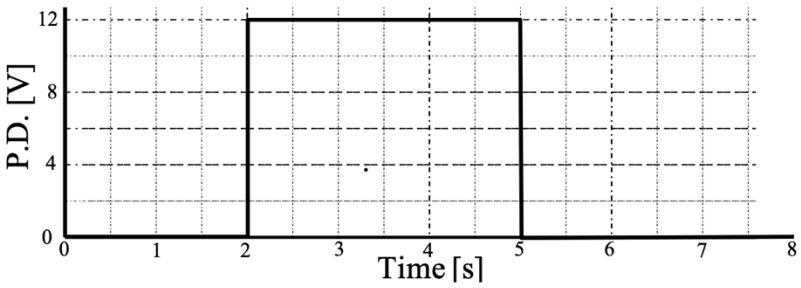
Question 29 (7 marks)

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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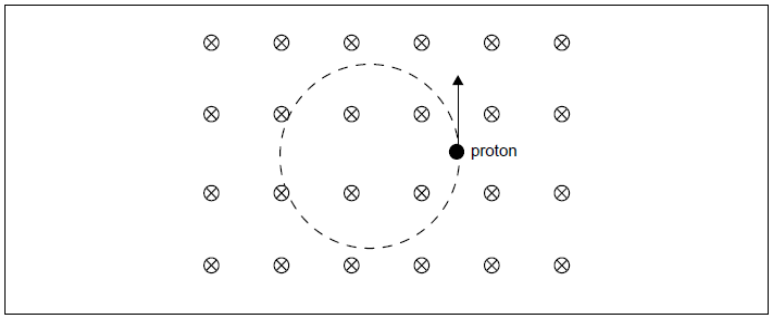
Question 30 (7 marks)

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 30 continues on the next page

Question 30 (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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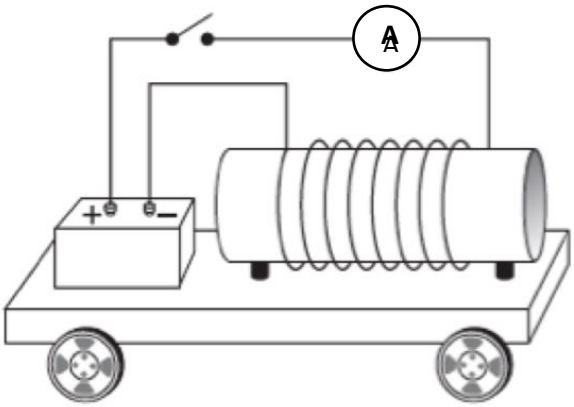
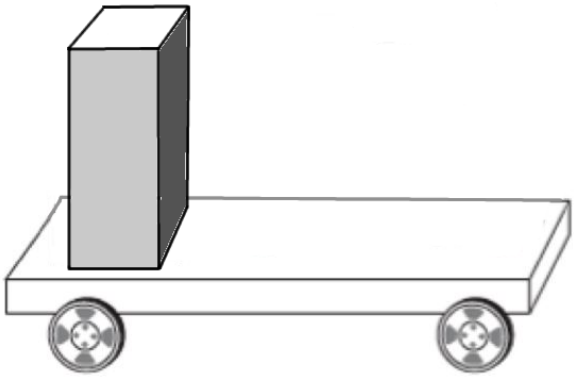
Question 31 (7 marks)

A solenoid is mounted on trolley 1 as shown below. The solenoid is connected to an ammeter, an open switch and a battery. The solenoid is sitting near a copper block that is on trolley 2. Both trolleys are free to roll.
The mass of trolley 1 is 4.0 kg and the mass of trolley 2 is 2.0 kg.



trolley 1- with solenoid



trolley 2 – with copper block

The switch is closed and this causes trolley 1 to start moving at 1.5 ms^{-1}.

Describe and explain the motion of the two carts. Include a quantitative analysis. **7**

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Question 31 (continued)

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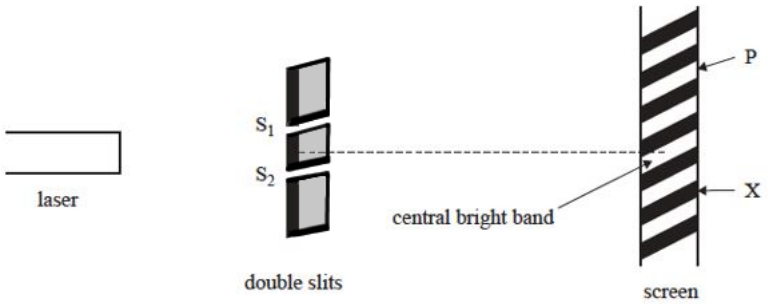
Question 32 (4 marks)

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 distance between slit 1 and X is given by S_1X
The distance between slit 2 and X is given by S_2X.

The path length difference between $S_1X - S_2X$ is measured to be 726 $x10^{-9}$m.



(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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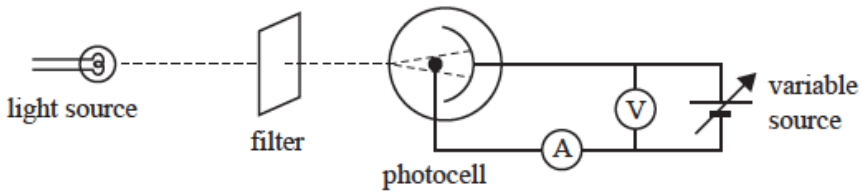
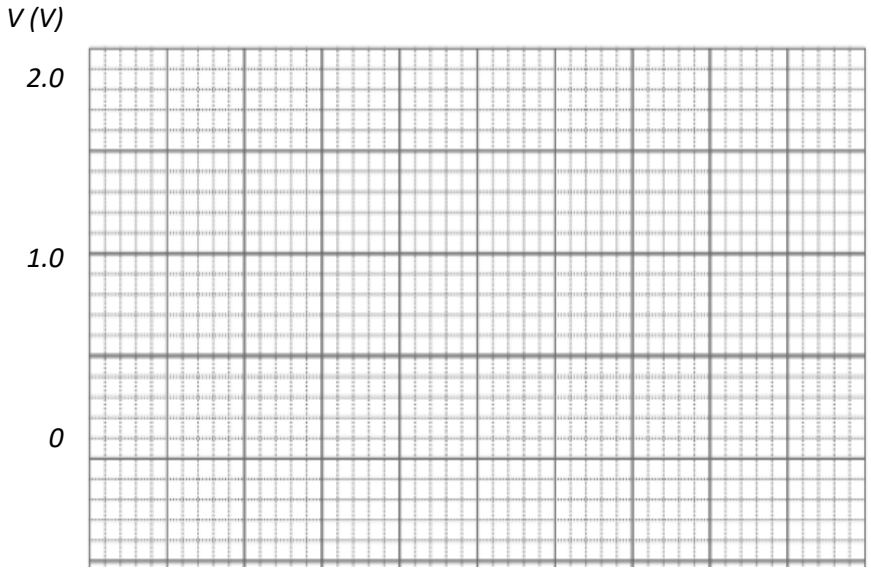
Question 33 (12 marks)

Amy carried out a photoelectric effect experiment. Electrons from a light source travelled through a filter onto a photocell. The filters were changed to shine a particular wavelength onto the photocell. The variable voltage was increased until the photocurrent just went to zero, and then recorded as the stopping voltage. Amy repeated this process for different frequencies.



Frequency (Hz)	Stopping 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) Using the range from zero to $9x10^{14}$ Hz, plot the results on the grid below. **3**



Question 33 continues on the next page

Question 33 (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. **3**

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Question 33 continues on the next page

Question 33 (continued)

(d) Amy repeats the same procedure. This time she doubles the intensity of the incident light and produces a new graph which is identical to the first one. Use the appropriate model of light to account for this observation. **4**

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~ End of Exam ~

Part B extra writing space

If you use this space, clearly indicate which questions you are answering.

Part B extra writing space

If you use this space, clearly indicate which questions you are answering.

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Multiple Choice Answer Sheet

Select the alternative A, B, C or D that best answers the question.

Fill in the response space completely. If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word ***correct*** and drawing an arrow.

Start Here

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 ⬭

Student Number

2022
TRIAL EXAMINATION

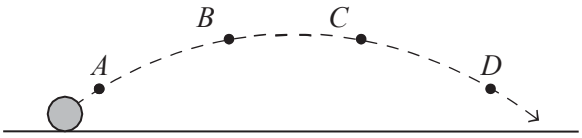
Physics – Marking Guidelines

PART A

Part A – 20 marks
Attempt Questions 1–20
Allow about 35 minutes for this part
Use the multiple-choice answer sheet for Questions 1–20, provided separately at the back of this exam.

Question 1

A field hockey player scoops the ball up and over opposing players to pass to their teammate further up the field. The ball moves from position *A* to position *D*, as shown in the diagram.

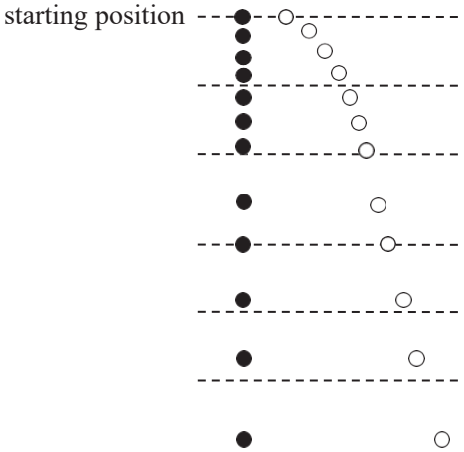


At which position(s) would the acceleration of the ball be vertically downward?

A. *D* only
B. *C* and *D* only
C. *B*, *C* and *D* only
D. *A*, *B*, *C* and *D*

Question 2

Two balls were simultaneously released from the same starting position. The black ball was dropped from rest and the white ball was projected horizontally, as shown in the diagram. The dashed lines represent equal distance intervals.



Which row of the table identifies the relative motions of the balls?

	X position of the balls	*Y position of the balls*	*Y velocities of the balls*	*X velocities of the balls*	*Y acceleration of the balls*
A.	different	same	same	different	same
B.	same	same	same	same	same
C.	different	different	different	different	different

D.

different	same	same	different	different

Question 3

A National Aeronautics and Space Administration (NASA) scientist uses a simulator to model the surface gravity of four different bodies in the Solar System. The surface gravity of each body is shown in the table.

Body	*Surface gravity (m s^{-2})*
Ceres	5.55
Icarus	0.38
Hermes	4.97
Pallas	2.49

In the first simulation, the scientist throws a small cube with a mass of 450 g upwards. The cube initially travels at a speed of 6.5 m s^{-1} and reaches a maximum height of 8.5 m.

Which body is the scientist simulating?

A. Ceres

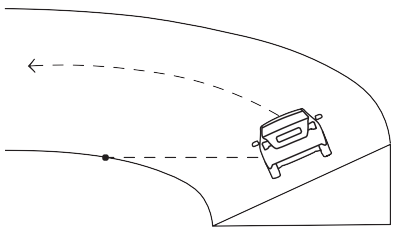
B. Icarus

C. Hermes

D. Pallas

Question 4

A road has a curve of radius 63 m and is banked at an angle of 12°. The diagram shows a car approaching the curve in wet, slippery conditions.



Assuming that there is no friction, calculate the maximum speed at which the car can safely make the turn.

A. 6.07 km h^{-1}

B. 11.5 km h^{-1}

C. 36.5 km h^{-1}

D. 41.2 km h^{-1}

Question 5

What will be produced when white light is passed through a gaseous sample of an element and examined with a spectrometer?

A. an absorption spectrum that is shown as a series of dark lines on a coloured background

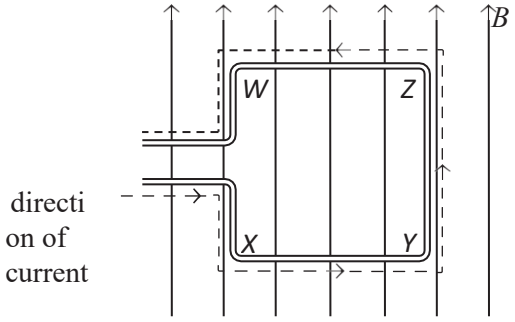
B. an emission spectrum that is shown as a series of coloured lines on a dark background

C. an absorption spectrum that is shown as a series of coloured lines on a dark background

D. an emission spectrum that is shown as a series of dark lines on a coloured background

Question 6

Consider the current-carrying loop.



How is torque created in the current-carrying loop?

A. There is a force on *WZ* out of the page and a force on *XY* into the page.

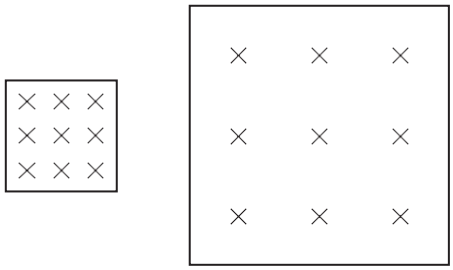
B. There is a force on *WZ* into the page and a force on *XY* out of the page.

C. There is a force on *WZ* out of the page and a force on *XY* out of the page.

D. There is a force on *WZ* into the page and a force on *XY* into the page.

Question 7

A Physics teacher drew two magnetic fields and asked their students to explain the difference between the magnetic flux of each field. The two magnetic fields are shown in the diagram.



Which of the following statements is correct?

A. The two magnetic fields show the same amount of flux, and the smaller magnetic field shows less flux density.

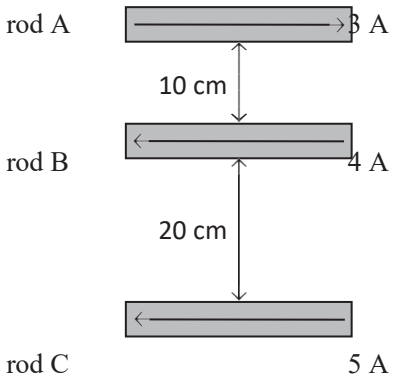
B. The two magnetic fields show different amounts of flux, and the smaller magnetic field shows less flux density.

C. The two magnetic fields show different amounts of flux, and the smaller magnetic field shows greater flux density.

D. The two magnetic fields show the same amount of flux, and the smaller magnetic field shows greater flux density.

Question 8

The diagram shows a set-up that uses three rods (A–C), each carrying a current in the direction indicated by the arrows.



What is the magnitude and direction of the force per unit length on rod C?

A. 1×10^{-5} N m^{-1} down

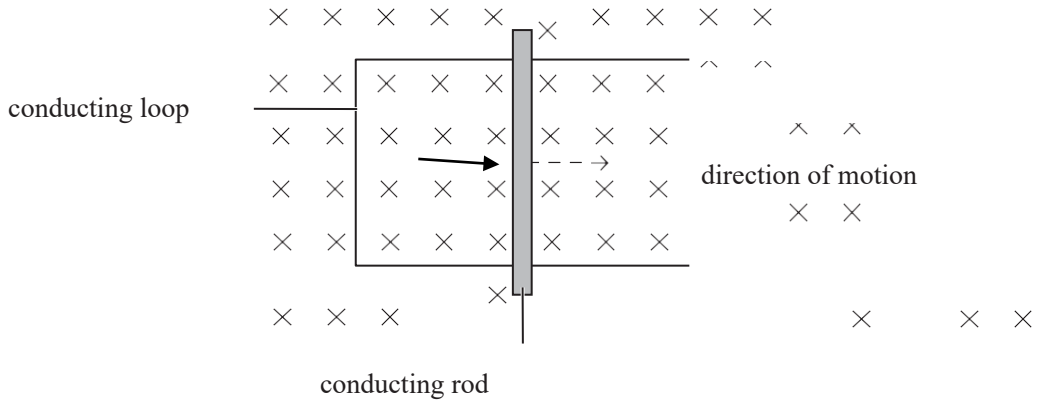
B. 1×10^{-5} N m^{-1} up

C. 3×10^{-5} N m^{-1} up

D. 3×10^{-5} N m^{-1} down

Question 9

A conducting rod slides along a metal conducting loop, as shown in the diagram.

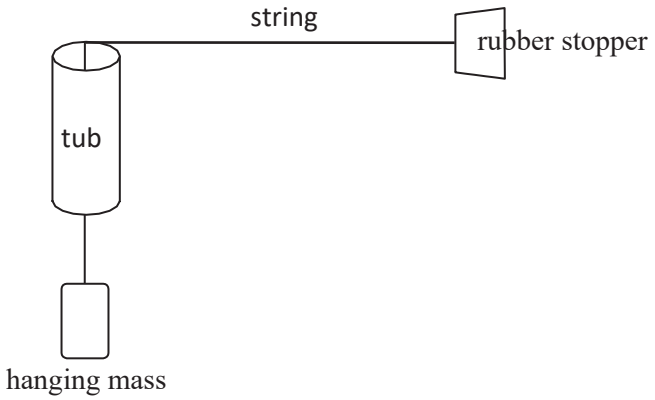


Which row of the table is correct?

	Direction of force on the conducting rod	*Direction of induced current in the rod*	*Direction of current around the conducting loop*
A.	to the left	up the rod	anticlockwise
B.	to the left	down the rod	clockwise
C.	to the right	up the rod	anticlockwise
D.	to the right	down the rod	clockwise

Question 10

A student carries out an investigation to find the relationship between the centripetal force, rotational speed and radius of an object moving in a uniform, circular motion. The student attaches a rubber stopper to a hanging mass using a string that passes through a tube and swings the rubber stopper around the tube, as shown in the diagram. As the rubber stopper is swung, the hanging mass rises and falls depending on the rotational speed of the stopper. When the hanging mass neither rises nor falls, the radius of the stopper's path is measured.



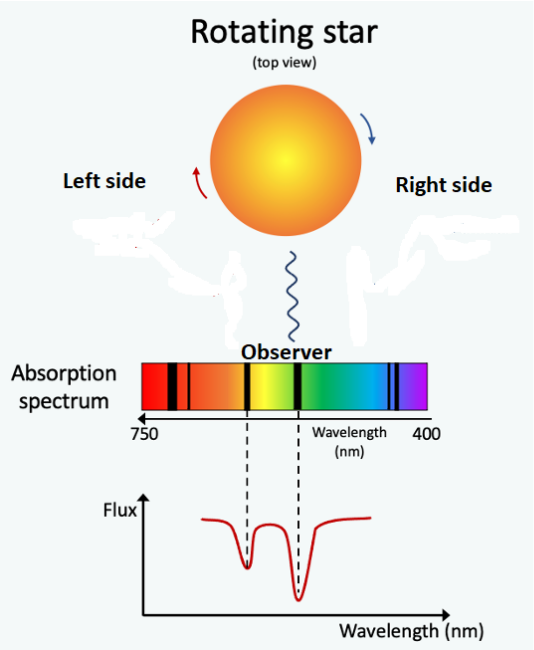
Which row of the table identifies the variables for this investigation?

	Independent variable	*Dependent variable*	*Controlled variables*
A.	hanging mass	length of string	mass of rubber stopper, rotational speed
B.	rotational speed	length of string	hanging mass, rotational speed
C.	mass of rubber stopper	rotational speed	hanging mass, length of string
D.	rotational speed	radius of stopper path	mass of rubber stopper, length of string

Question 11

As a star rotates, the observed atomic absorption bands appear broader. Consider the statement about this relationship and choose the correct terms in the table below corresponding to X, Y and Z.

> When a star is rotating relatively to an observer, as shown on the diagram, light received from the left side of the photosphere is ***X*** while the light received from the right side of the photosphere is **Y**. The **Z** it rotates, the wider the absorption band will appear in its spectrum.

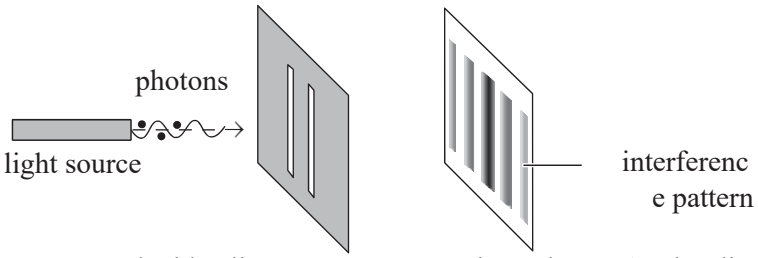


Which row of the table completes the statement?

	X	*Y*	*Z*
A.	blue-shifted	red-shifted	faster
B.	red-shifted	blue-shifted	faster
C.	blue-shifted	red-shifted	slower
D.	red-shifted	blue-shifted	slower

Question 12

Young performed an experiment where photons were beamed through a double-slit onto a screen, as shown in the diagram.



The following changes were made,

Change 1: The slit separation is changed.

Change 2: The distance between the double-slit and the screen is increased.

Which row of the table identifies what will occur after each change?

	Change 1	*Change 2*
A.	If the slit separation increases, the spacing between the bright bands decreases.	The spacing between the bright bands decreases.
B.	If the slit separation increases, the spacing between the bright bands decreases.	The spacing between the bright bands increases.
C.	If the slit separation increases, the spacing between the bright bands increases.	The spacing between the bright bands increases.
D.	If the slit separation decreases, the spacing between the bright bands increases.	The spacing between the bright bands decreases.

Question 13

Most stars have at least one planet orbiting them. Two planets, Psi and Tri, have been observed to orbit a star. Psi has an orbital path with a radius that is four times smaller than the radius of Tri's orbital path.

Which of the following statements about Psi and Tri is correct?

A. Tri would take 8 times longer than Psi to make a full orbit of the star.

B. Psi would take 8 times longer than Tri to make a full orbit of the star.

C. Tri would take 64 times longer than Psi to make a full orbit of the star.

D. Psi would take 64 times longer than Tri to make a full orbit of the star.

Question 14

An ideal transformer is used to convert an input of 800 V to an output current of 24 A. There are 5700 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

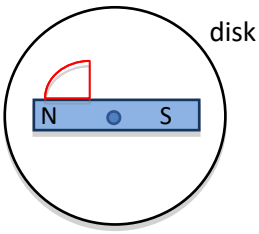
Question 15

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)
			

Question 16

The device below shows an aluminum disk and a magnet set up on the same axle. The disk and magnet are free to turn relatively to each other on the axle. The magnet is turning relative to the disk. What occurs if the angular velocity of the magnet 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 friction

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

Question 17

If light had a pure wave nature, which observation from investigations into the photoelectric effect would occur?

(A) The energy transfer from the light source to the metal would occur continuously therefore there would be a delay in the initial emission of photoelectrons.

(B) The energy transfer from the light source to the metal would occur discretely therefore the initial emission of photoelectrons would be nearly instantaneous.

(C) The energy transfer from the light source to the metal would occur continuously therefore interference pattern would be observed on the metal.

(D) The energy transfer from the light source to the metal would occur discretely therefore interferences pattern would be observed on the metal.

Question 18

A non-ideal step-down transformer has a primary voltage of 33 kV and a primary current of 200A. The secondary voltage is 11 kV with a secondary current of 460A.

The transformer's efficiency is closest to:

(A) 90%

(B) 75%

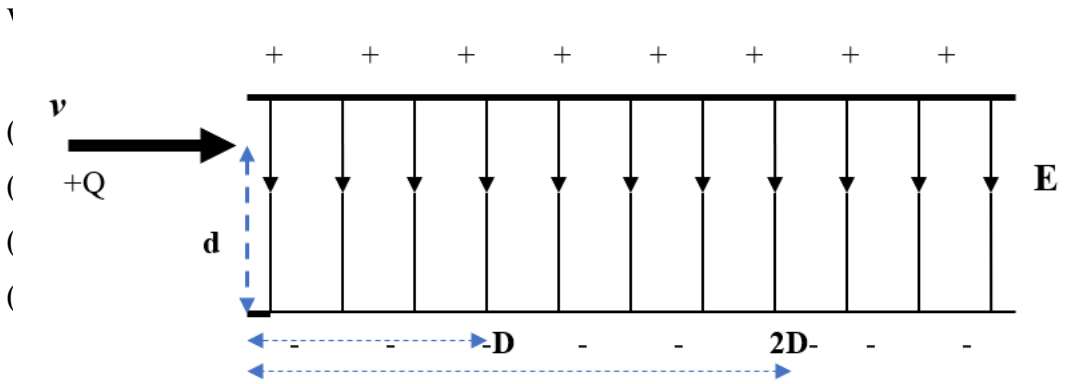
(C) 50%

(D) 33%

Question 19

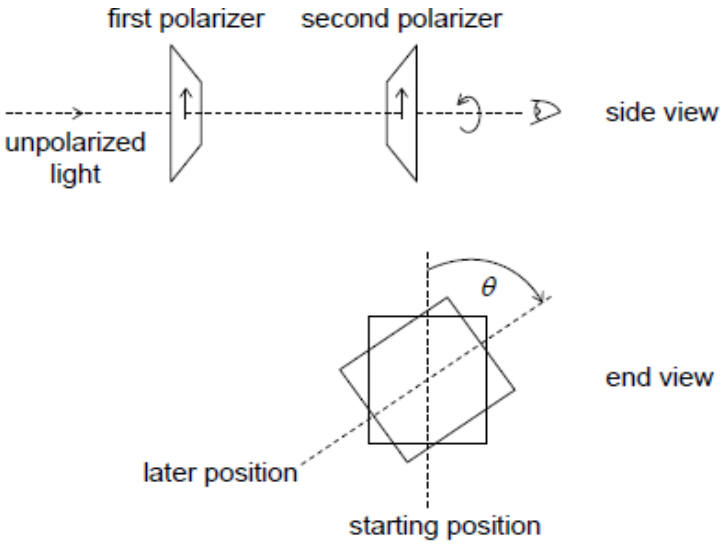
A charged particle +Q enters a region of uniform electric field E between two parallel plates, as shown.
The particle's speed before entering is ***v***.

The apparatus is in a vacuum and the experiment is being performed in weightless conditions.
The charged particle travels a horizontal distance **D** before striking the charged plate.



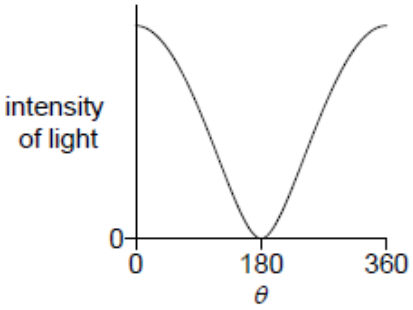
Question 20

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.

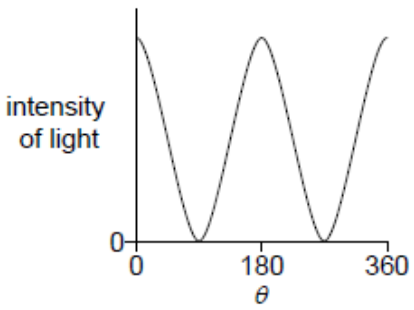


Which graph shows the variation of intensity with angle θ for the light leaving the second polarizer? B

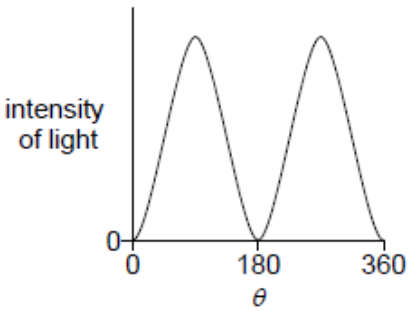
A.



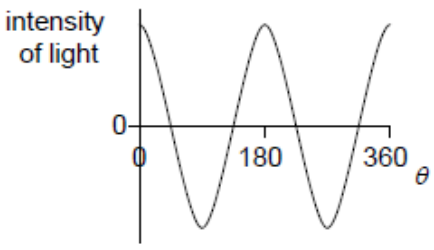
B.



C.



D.



Student number …….

Part B – 80 marks

Attempt Questions 21–33

Allow about 2 hours and 25 minutes for this part.

Show all relevant working in questions involving calculations.

Write your Student Number at the top of this page.

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering

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Marks

Question 21 (5 marks)

By applying the law of conservation of energy to the relationship between gravitational potential energy and kinetic energy, explain how the escape velocity from a distance *r* from the centre of mass of a planet is given by: $\sqrt{\frac{2GM}{r}}$ where M is the mass of the planet. **5**

• Relate escape velocity to the **initial** K needed for K infinitely far away to be equal to 0. • State that the total energy $U(r)+K(r)$ is conserve • Appropriately use the mathematical models $K=\frac{1}{2}mv^2$ and $U=\frac{-GMm}{r}$ and apply the conservation of energy to infer that $\frac{1}{2}mu^2\ \frac{-GMm}{r}=0$ OR $U(r)+K(r)=U(\infty)+K(\infty)=0$ • Derive $v_{escape}=\sqrt{\square}$	5
• State that the total energy $U(r)+K(r)$is conserve • Appropriately use the mathematical models $K=\frac{1}{2}mv^2$ and	4

$U=\frac{-GMm}{r}$ • Apply the conservation of energy to infer that $\frac{1}{2}mu^2\frac{-GMm}{r}=0$ or $U(r)+K(r)=U(\infty)+K(\infty)=0$ • Derive $v_{escape}=\sqrt{\square}$	
• State that the total energy $U(r)+K(r)$ is conserve • Appropriately use the mathematical model $K=\frac{1}{2}mv^2$ • Inappropriately use the model $U=\frac{-GMm}{r}$, by wrongly assuming that $U(r)=0$ • Attempt to apply the conservation of energy to infer that $\frac{1}{2}mu^2$ $\frac{-GMm}{r}=0$ • Derive $v_{escape}=\sqrt{\square}$	3
• Refer to the model $K=\frac{1}{2}mv^2$ • Refer to the model $U=\frac{-GMm}{r}$ • State that $\frac{1}{2}mv^2=\frac{GMm}{r}$ • Derive $v_{escape}=\sqrt{\square}$	2

Question 22 (5 marks) **Marks**

Two projectiles are launched with the same initial speeds and angles to the horizontal. Projectile **A** has a mass of **m**, while projectile **B** has a mass of **2m**.

(a) Explain why the two projectiles will have the same range. **2**

• Apply Newton second law to justify that both projectile have the same acceleration • Same initial velocity + same acceleration (gravity) ∴ same time of flight + same range	2

• Same initial velocity + same acceleration (gravity) ∴ same time of flight + same range	1

(b) Both projectiles were launched again, this time with the same angles to the horizontal but with different initial speeds.
Projectile **B** remains in flight for twice as long as projectile **A** over level ground. **3**

How many times further does projectile **B** travel compared to projectile **A**?

• $t_B = 2t_A$ • $0 = u_{Ay} - g\frac{t}{2} \wedge 0 = u_{By} - 2g\frac{t}{2} \therefore u_{By} = 2u_{Ay}$ • $s_{Ax} = u_{Ax}t \wedge s_{Bx} = 2u_{Bx}t \therefore \frac{s_{Ax}}{s_{Bx}} = \frac{u_{Ax}}{2u_{Bx}}$ • Same angle so $\frac{u_{Ay}}{u_{Ax}} = \frac{u_{By}}{u_{Bx}} \therefore \frac{s_{Ax}}{s_{Bx}} = \frac{u_{Ax}}{2u_{Bx}} = \frac{u_{Ay}}{2u_{By}} = \frac{1}{4}$ • Hence B travels 4 times further	3
• $t_B = 2t_A$ • Any 2 attempts from above	2
• Any 1 attempt from above	1

Marks

Question 23 (4 marks)

Outline a procedure to investigate how the external magnetic field and the current impact the **direction** of the force on a straight current-carrying wire.

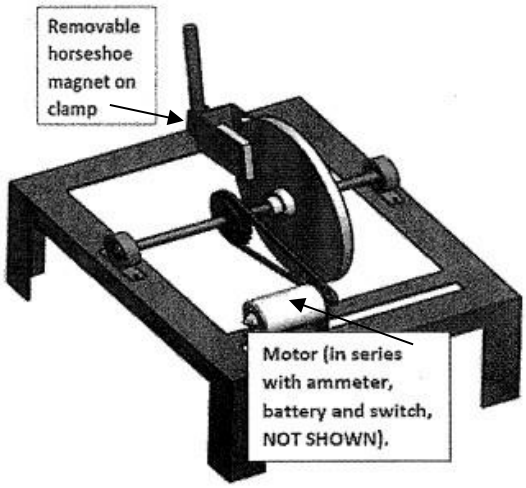
• Describe experimental set up allowing for the observation of the motor effect and more specifically its direction • Describe how the direction of the magnetic field would be reversed. • Describe how the direction of the current would be reversed. • Change one variable at a time	4
• Describe experimental set up allowing for the observation of the motor effect and more specifically its direction • Describe how the direction of the magnetic field would be reversed. • Describe how the direction of the current would be reversed. OR • Any 2 of the above • Change one variable at a time	3
• Any 2 of the above OR • Excellent description of a procedure investigating the direction of the interaction between 2 current carrying wires	2
• Any 1 of the above OR • Satisfactory description of a procedure investigating the direction of the interaction between 2 current	1

4

carrying wires	

Marks

Question 24 (7 marks)
A student sets up an aluminium disc which is able to rotate in the vertical plane. The axle of the disc has a pulley wheel turned by a motor in series with the ammeter, battery and switch. A clamp with the horseshoe magnet can be attached so that a horizontal magnetic field passes through one part of the disc.



The student observes the current and the speed of the disc rotation, before and after the magnet is attached.
When the magnet is in place, the current through the ammeter is greater and the speed of rotation of the disc is lower.

7

Account for each observation.

• Account for BOTH observations
• Apply Lenz's Law to explain that the disc will move slower because
  o induced Eddy current will occur in the disc interacting with the magnet
  o to limit the relative motion of the magnet and the disk.
• Apply Faraday's Law.
  o Recall that in a motor the current interacts with the magnetic field creating a torque forcing the rotor to turn
  o and that the rotation of the rotor in the magnetic field generate a back emf limiting the current
  o proportional to the angular velocity of the motor.
• Link the angular velocity of the motor with the one of the disc.
OR
	7

• Account for BOTH observations
• Apply Lenz's Law to explain that the disc will move slower because
  o induced Eddy current will occur in the disc interacting with the magnet
  o to limit the relative motion of the magnet and the disk.
• Apply Faraday's Law.
  o Recall that in a motor the current interacts with the magnetic field creating a torque forcing the rotor to turn
  o and that the rotation of the rotor in the magnetic field generate a back emf
  o proportional to the angular velocity of the motor.
	6

• Account for BOTH observations • Apply Lenz's Law to explain that the disc will move slower limiting the relative motion of the magnet and the disk. • Apply to Faraday's Law to explain that the back emf will be less if the motor has a lower angular velocity limiting the decrease of the current	4-5
• Account for only ONE observation	2-3

• Apply Lenz's Law to explain that the disc will move slower because o induced Eddy current will occur in the disc interacting with the magnet o to limit the relative motion of the magnet and the disk. OR • Apply Faraday's Law. o Recall that in a motor the current interacts with the magnetic field creating a torque forcing the rotor to turn o and that the rotation of the rotor in the magnetic field generate a back emf proportional to the angular velocity of the motor.	
• Any relevant information	1

Marks

Question 25 (6 marks)

Using two specific examples, explain how the interaction of electricity and magnetism and their respective fields is responsible for various phenomena studied in the Physics course.

6

• Use TWO examples: electromagnetic waves, interaction between two current carrying wires, motor effect, back emf, electric motors, generators, induced current, charged particle in fileds…) • For EACH example describe the electrical factor in terms of field (voltage, emf, back emf). • For EACH example describe the magnetic factor in terms of field. • For EACH example describe the interaction with a cause and effect relationship.	6
• Use TWO examples: electromagnetic waves, interaction between two current carrying wires, motor effect, back emf, electric motors, generators, induced current,…) • For EACH example describe the electrical factor. • For EACH example describe the magnetic factor. • For EACH example describe the interaction with a cause and effect relationship.	5
• Use TWO examples: electromagnetic waves, interaction between	4

two current carrying wires, motor effect, back emf, electric motors, generators, induced current,…) ● For EACH example describe the electrical factor. ● For EACH example describe the magnetic factor. OR ● Use TWO examples ● For only one example, describe the electrical factor in terms of field (voltage, emf, back emf). ● For only one example, describe the magnetic factor in terms of field. ● For only one example describe the interaction with a cause and effect relationship.	
● State TWO examples OR ● Use ONE example ● Describe the electrical factor. ● Describe the magnetic factor.	3
● State ONE example	2
● Any relevant information	1

Marks

Question 26 (6 marks)

Observations of black body radiation could not be explained using a wave model of light.

(a) Discuss how Planck's contribution to the explanation of radiation from a black body led to a change in the model of light. **4**

● Discuss the UV catastrophe in terms of failure of the wave model	4

• Describe Planck contribution:
  ○ Proposed that energy transfer from the black body to the environment was quantised without explaining
  ○ Mathematical model that fit observation
• Identify that Planck's insight led to the particle model of light	

• Describe the UV catastrophe
• Describe Planck contribution:
  ○ Proposed that energy transfer from the black body to the environment was quantised without explaining
  ○ Mathematical model that fit observation
• Identify that Planck's insight led to the particle model of light
	3

• Describe the UV catastrophe • Identify that Planck's insight led to the particle model of light	2
• Any 1 of the above	1

2

(b) Determine the peak wavelength of a star with a photosphere of temperature 7000 K.

• Use $\lambda_{max} = \frac{b}{T}$ • Substitute • Rearrange • Calculate	2
• Use $\lambda_{max} = \frac{b}{T}$	1

Marks

Question 27 (4 marks)

The Hafele-Keating experiment involved flying extremely precise atomic clocks onboard aircraft in different directions around the world and comparing the times on the clocks to the time on clocks that remained on Earth.

4

Explain how the Hafele-Keating experiment supported an aspect of special relativity as proposed by Einstein.

• Identify time dilation as a phenomenon occurring when two frames of reference are moving (fast) relative to each other (inertial)
• Justify the experiment set up:
  ○ High speed planes
  ○ Accurate clocks
• Describe the results and relate them to the theory
	4

• Identify time dilation
• Justify the experiment set up:
  ○ High speed planes
  ○ Accurate clocks
OR
• Identify time dilation
• Describe the results and relate them to the theory
	3

• Identify time dilation
OR
• Justify the experiment set up:
  ○ High speed planes
  ○ Accurate clocks
	2

• Any relevant information	1

Marks

Question 28 (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 q to the vertical. The string when hanging vertically will just support a load of 44 N without breaking.

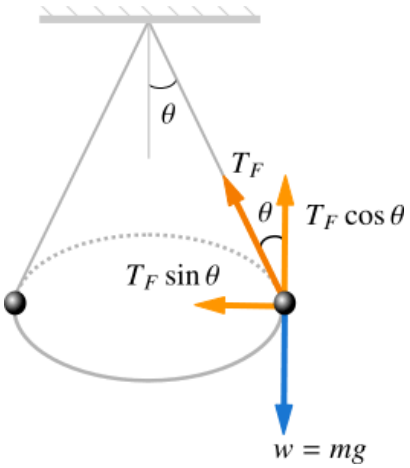
3

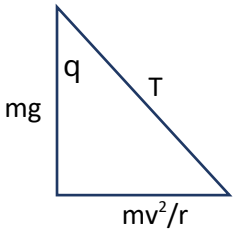
(a) Draw the force diagram, in the space provided for the spinning mass, showing the vectors and their vertical and horizontal components.

Criteria	Marks
• Labelled diagram using data from the question AND/OR correct equations • Diagram showing the tension and the weight with correct relative components. • Diagram showing the components of the tension	3
• Labelled diagram using data from the question AND/OR correct equations • Diagram showing the tension and the weight with correct relative components.	2
• Partial diagram	1

Force diagram showing labels. The components are

vertical; $mg = T\cos\theta$ and *horizontal;* $F_c = mv^2/r = T\sin\theta$





(b) Calculate the angle q and the maximum angular speed in rad.s^{-1} of the mass before the string breaks.

Criteria	Marks
• Recall the fact that that the vertical components of the weight and the tension are balanced and calculate the angle q AND • Identify the centripetal force to the horizontal component of the tension to calculate the angular velocity ω	3
• Attempt TWO calculations Correctly ○ Recall the fact that that the vertical components of the weight and the tension are balanced and calculate the angle q OR ○ Identify the centripetal force to the horizontal component of the tension to calculate the angular velocity ω	2
• Attempt ONE calculation Correctly ○ Recall the fact that that the vertical components of the weight and the tension are balanced and calculate the angle q	1

OR ○ Identify the centripetal force to the horizontal component of the tension to calculate the angular velocity ω	

Sample answer

$\cos \theta = mg/T$

$\cos \theta = 0.87 \times 9.8/44$

$\underline{\theta = 78.8°}$

$\sin \theta = r/0.85$ so $r = 0.83$ m

$T \sin \theta = mv^2/r = m\omega^2 r$ since $v = \omega r$

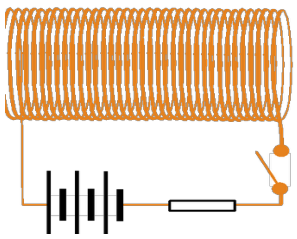
$\omega^2 = \sin\theta/mr$

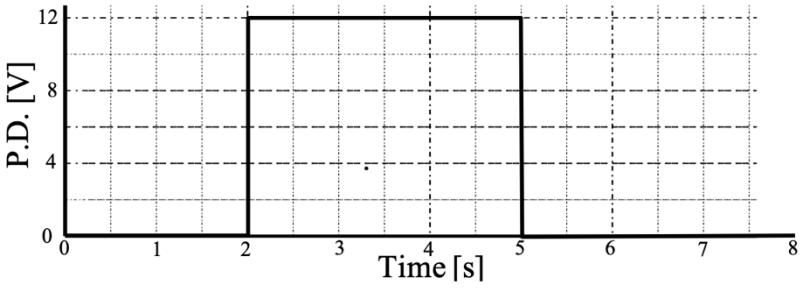
$= \sin 78.8 / (0.87 \times 0.83)$

$\underline{\omega = 7.7 \text{ rad.s}^{-1}}$

Question 29 (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

• Identification of times • Link between voltage, current and magnetic field	2
• Identification of times	1

Sample answer:
The magnetic field in a solenoind is proportional to current ($B=\mu_0 \ni \frac{¿}{L}$)¿. It will have maximum strength from time=2-5 seconds. During this time, the switch is closed and the battery will cause the maximum current to flow (V=IR)

(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

• Identify change in flux • Identify time where flux changes • Link between induced back emf and change in flux	3
• Two of above	2
• One of above	1

Sample answer:

An emf is induced in the solenoid when there is a change in magnetic flux($\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$). The magnetic flux change is greatest at time = 2s (no supply emf at time = 5s).

(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

• Correct formula • Correct substitution of appropriate quantities	2
• Correct formula or correct substitution	1

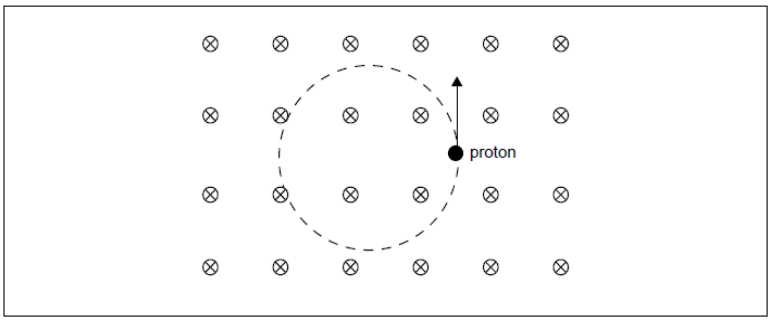
$$\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$$

$$\varepsilon = -220\frac{(0.032-0.004)\times\pi(0.031)^2}{26\times10^{-3}}$$

$$\varepsilon = 0.72\,V$$

Question 30 (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

• Describe force on charge in magnetic field • Link to circular motion	2
• Unclear link between force and circular motion	1

Sample answer:
The force on a charged particle moving in a magnetic field is at right angles to the velocity and field at all times.
At the position shown in the diagram, the force will be towards the centre of the dashed diagram. As the direction of the proton changes, the force always acts towards the centre of the dashed circle providing the required centripetal force for circular motion.

(b) Calculate the radius of the path.

2

• Correct formulas • Correct substituion	2
• One correct formula identified.	1

$$F_B = F_c$$

$$q v_\perp B = \frac{m v^2}{r}$$

R = 5.97×10^{-2} m

Question 30 (continued)

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

2

• Correct formulas or reasoning • Correct substitution of appropriate values	2
• One of above	1

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

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

$$T = 0.19\,\mu s$$

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

1

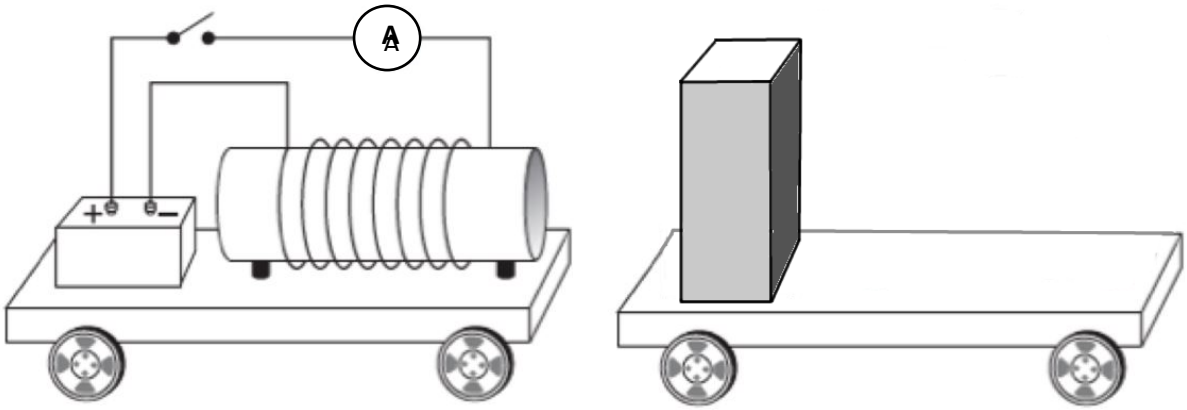
• Identification of work done or appropriate formula with substitution	1

$$W = F_{\parallel} s$$

Since the force is always perpendicular to the displacement vector, work = 0.

Question 31 (7 marks)

A solenoid is mounted on trolley 1 as shown below. The solenoid is connected to an ammeter, an open switch and a battery. The solenoid is sitting near a copper block that is on trolley 2. Both trolleys are free to roll.
The mass of trolley 1 is 4.0 kg and the mass of trolley 2 is 2.0 kg.



trolley 1- with solenoid trolley 2 – with copper block

The switch is closed and this causes trolley 1 to start moving at 1.5 ms^{-1}.

Describe and explain the motion of the two carts. Include a quantitative analysis.

7

• Comprehensive understanding of interaction involving induced currents and conservation of momentum to explain the motion of both carts • Appropriate calculations performed to support motion.	7-6

• Detailed understanding of interaction involving induced currents and conservation of momentum to explain the motion of both carts • Some appropriate calculations performed.	5-4
• Some appropriate understanding demonstrated of induced currents or conservation of momentum. • Some attempt at quantifying an aspect	3-2
• Some valid information provided	1

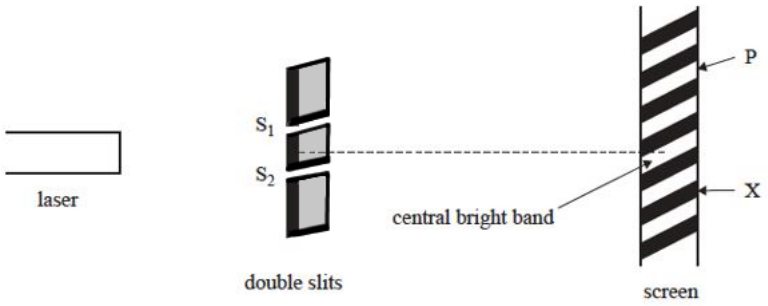
Sample answer:
When the switch is closed, a current flows in the solenoid and this has an associated magnetic field with a south pole on the right of the solenoid. As the field in the block increases from zero, eddy currents are induced in the block and these have an associated field by Lenz's law with a south pole on the left side of the block. The blocks will repel and move apart.
Momentum will be conserved. Since trolley 1 moves to the left with speed 1.5 m/s, trolley 2 has half the mass so initially moves to the right with speed of 3.0 m/s.
Kinetic energy will not be conserved as some energy is lost as heat.

Question 32 (4 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 distance between slit 1 and X is given by S_1X
The distance between slit 2 and X is given by S_2X.

The path length difference between $S_1X - S_2X$ is measured to be 726×10^{-9}m.



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

• Identify superposition or interference of waves from the two slits • Describe aspect of waves that results in zero intensity at point X.	2
• Identifies superposition of the two waves.	1

Sample answer:

A dark band forms at X due to the interference of waves that come from slits 1 and 2. At point X, the waves have a path length difference of 1.5 wavelengths since it is the second dark band from the maximum. The waves undergo destructive interference at X and a dark band occurs.

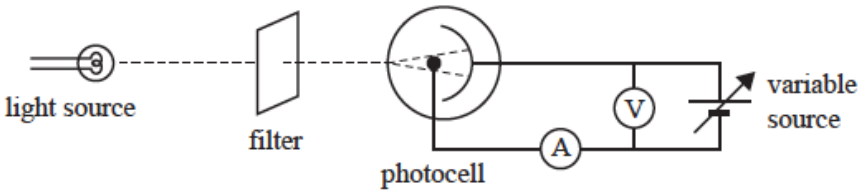
(b) Calculate the wavelength of the laser.
2

• Correct determination of path length • Substitution of correct values. •	2
• One of above	1

$726 \times 10^{-9} m = 1.5 \lambda$

$484 \times 10^{-9} m = \lambda$

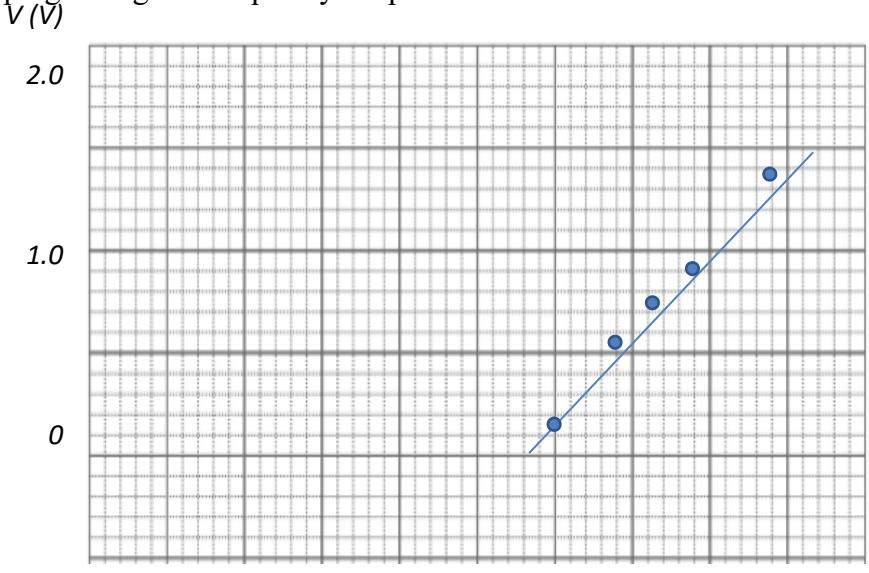
Question 33 (12 marks)
Amy carried out a photoelectric effect experiment. Electrons from a light source travelled through a filter onto a photocell. The filters were changed to shine a particular wavelength onto the photocell. The variable voltage was increased until the photocurrent just went to zero, and then recorded as the stopping voltage. Amy repeated this process for different frequencies.



Frequency (Hz)	Stopping 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) Using the range from zero to $9x10^{14}$ Hz, plot the results on the grid below.
3

Stopping voltage vs frequency for photocell.



Frequency ($x10^{14}$ Hz)

• Title and X-axis label complete • All points plotted correctly • Appropriate scale/range chosen	3
• Some of above points missing	2-1

Question 33 continues on the next page

Question 33 (continued)

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

• Cause of work done by electric field due to applied voltage • Effect of work done on electron by electric field.	2
• Either cause or effect of applied field on energy of electron	1

The stopping voltage is the applied voltage when the work done by the field on the electrons is equal to the maximum energy of the electrons when they leave the surface of the photocell by the photoelectric effect. The stopping voltage is the lowest applied voltage when no photocurrent is recorded.

(c) Use the graph to determine the work function in eV, as well as Plank's constant.
3

• Draw the line of best fit • Determine work function from graph or equation • Determine Planck's constant.	3
• Determine work function • Determine Planck's constant.	2-1

Slope = V/f = E/q /f = h/q= 1.5/(3.7x10^{14}) → h = 6.5 x10^{-34} Js

Work function = y-intercept = hf – Emax. At threshold frequency = 5.7 x10^{14}Hz, Emax = 0

Work function = hf = 5.7 x10^{14} x 6.5 x10^{-34} = 3.7 x10^{-19} J = 2.3 eV

Question 33 (continued)

(d) Amy repeats the same procedure. This time she doubles the intensity of the incident light and produces a new graph which is identical to the first one. Use the appropriate model of light to account for this observation.

4

• Identifies photon model of light • Link between photon model and observed stopping voltage for given frequencies. • Explains result of doubling intensity	4
• Identifies photon model of light • Link between photon model and maximum kinetic energy or relates to frequency • Explains result of doubling intensity	3
• Some combination of above points	2 -1

Sample answer:

The photon model of light accounts for this observation. When the intensity of the light is doubled, twice the number of photons are incident on the surface of the photocell for every particular frequency. Since the same stopping voltage is recorded for each frequency (as shown by identical graphs) the maximum kinetic energy of electrons at each frequency must be the same as for the original procedure. This is correctly modelled by the photon model of light $K_{max} = hf - \phi$ where the maximum kinetic energy is independent of the intensity of light and only depends on the frequency.