Teacher: ________________________________

Newington College

Year 12 TRIAL HSC EXAMINATION

Thursday 29th August, 2019

PHYSICS

General Instructions

- Reading Time – 5 minutes
- Working Time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- A data sheet, formulae sheet and Periodic Table is provided with this paper
- NESA-approved calculators may be used
- Write your Student Number, at the top of the multiple-choice answer sheet and on the top of each page in this booklet.

Total marks – 100

Part A
20 marks
- Multiple Choice
  Attempt Questions 1–20
- Allow about 35 minutes for this part

Part B
80 marks
- Attempt **all** Questions 21–32
- Allow about 2 hours and 15 minutes for this part

Part A – 20 marks
Attempt Questions 1-20
Allow about 35 minutes for this part

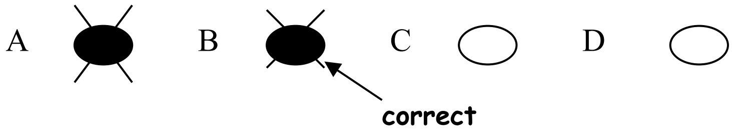
Use the multiple-choice answer sheet to record your answers.

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

Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

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 the correct answer by writing the word **correct** and drawing an arrow as follows.



Part A – 20 marks
Attempt Questions 1-20
Allow about 35 minutes for this part

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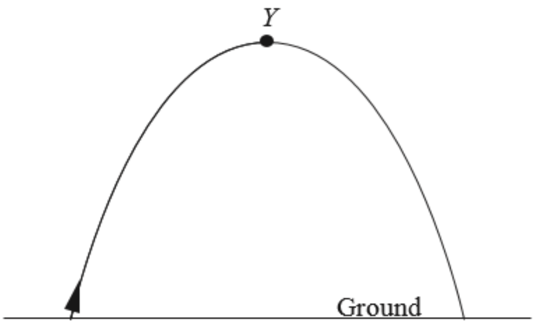
1. Consider an object undergoing projectile motion under an acceleration of gravity as shown in the figure below.



Choose the most correct statement.

(A) The instantaneous velocity at point Y will be zero.

(B) The vertical component of the velocity is a constant.

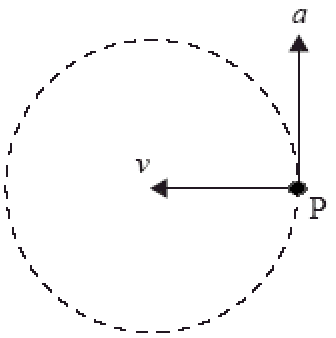
(C) The instantaneous vertical velocity will be the same at launch as at landing at impact.

(D) The initial horizontal velocity on launch will be the same as the final horizontal velocity.

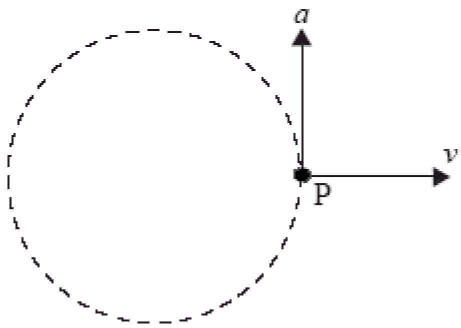
2. A particle ***P*** is moving anti-clockwise with constant speed in a horizontal circle.

Which diagram correctly shows the direction of the velocity *v* and acceleration *a* of the particle ***P*** in the position shown?

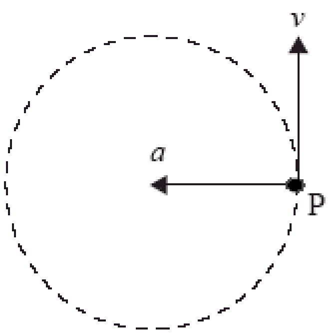
A.



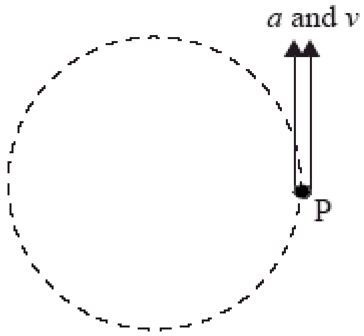
B.



C.



D.



3. If the angular velocity of a second hand of a clock is 0.105 rad s^{-1} and length of hand is 1.8 cm, then speed of tip of the second hand is:

(A) 0.189 cm s^{-1}

(B) 1 cm s^{-1}

(C) 0.189 m s^{-1}

(D) 2 m s^{-1}

4. Titan is a moon of planet Saturn**.** It has a gravitational field strength of 1.35 N kg^{-1} on its surface that is 2575 km from Titan's centre.
What is the mass of Titan closest to?

(A) 6.0×10^{23} kg

(B) 1.35×10^{23} kg

(C) 40×10^{9} kg

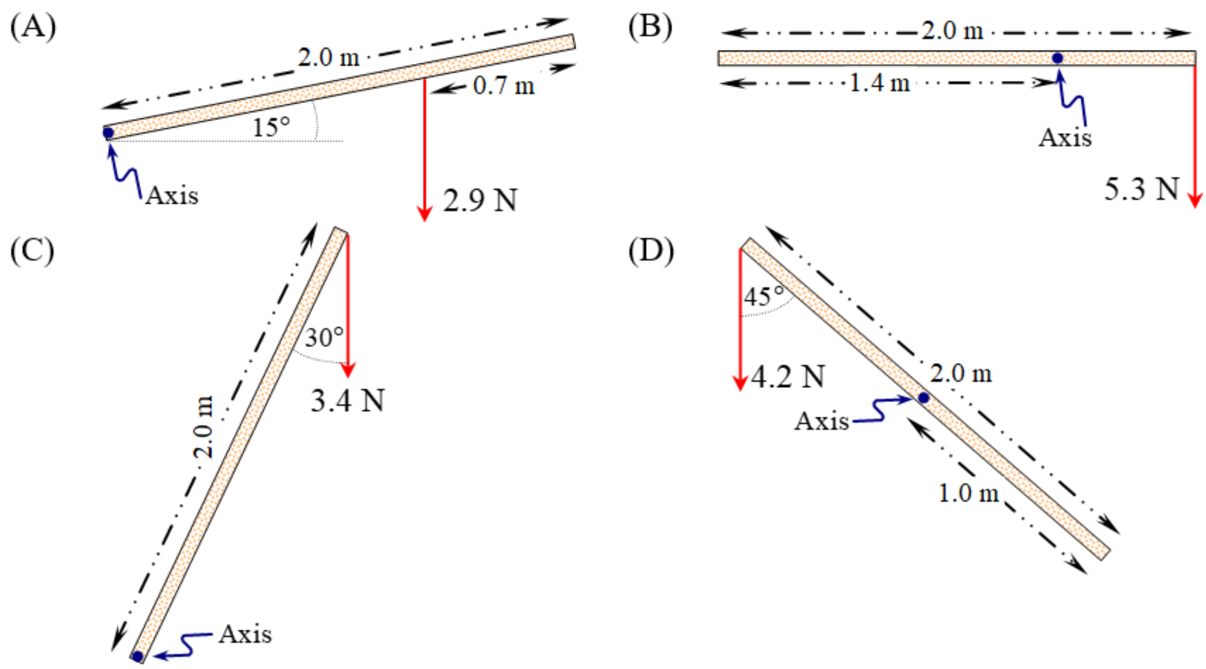
(D) 9×10^{24} kg

5. Which of the following alternatives correctly compares all the identified factors in terms of a satellite in a geostationary orbit around the Earth, relative to the same satellite in a stable circular low-Earth orbit?

Relative to the satellite in a low-Earth orbit, the satellite in a geostationary orbit has:

(A)	Higher speed; longer orbital period; greater orbital radius; more centripetal force
(B)	Lower speed; longer orbital period; greater orbital radius; less centripetal force
(C)	Higher speed; shorter orbital period; greater orbital radius; less centripetal force
(D)	Lower speed; shorter orbital period; lower orbital radius; more centripetal force

6. Consider the following diagrams showing forces being applied to four identical beams, but the magnitudes and directions of the forces are different, and the axis of rotation also varies. Which alternative would apply the maximum torque onto the beam?



7. Millikan's oil drop experiment was important because:

(A) it used a simple apparatus to equate gravity and electrostatic charge.

(B) it established the charge to mass ratio of the electron.

(C) it quantified the charge on an electron.

(D) it enabled the calculation of the mass of a proton when combined with previous data from JJ Thomson.

8. When a beta particle (β) moves at right angles through a uniform magnetic field it experiences a force *F*. An alpha particle (α) moves at right angles through a magnetic field of twice the magnetic flux density with velocity one tenth the velocity of the β particle. What is the magnitude of the force on the α particle?

(A) 0.2 *F*

(B) 0.4 *F*

(C) 0.8 *F*

(D) 4.0 *F*

9. A positive charged particle *q* is accelerated in a uniform electric field E starting from rest. If v_0 is the velocity of the particle at the end of distance d, what is the velocity of the particle at distance 2d in the same electric field?

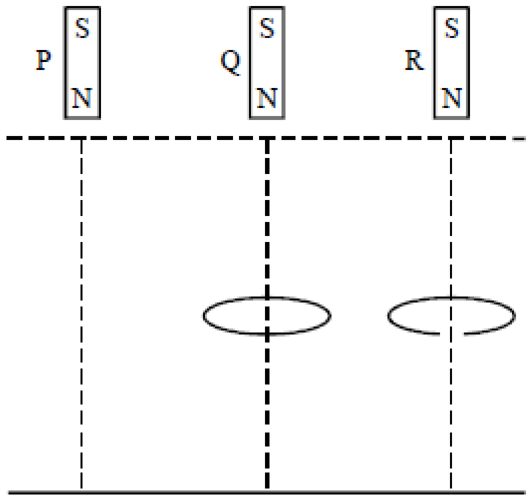
(A) $2\ v_0$

(B) $4\ v_0$

(C) $8\ v_0$

(D) $\sqrt{2}\ v_0$

10. This question refers to the diagram below.



Three identical magnets P, Q and R are released simultaneously from rest and fall to the ground from the same height. P falls directly to the ground, Q falls through the centre of a thick conducting ring and R falls through a ring which is identical except for a gap cut into it. Which one of the statements below correctly describes the sequence in which the magnets reach the ground?

(A) Q arrives after P and R.

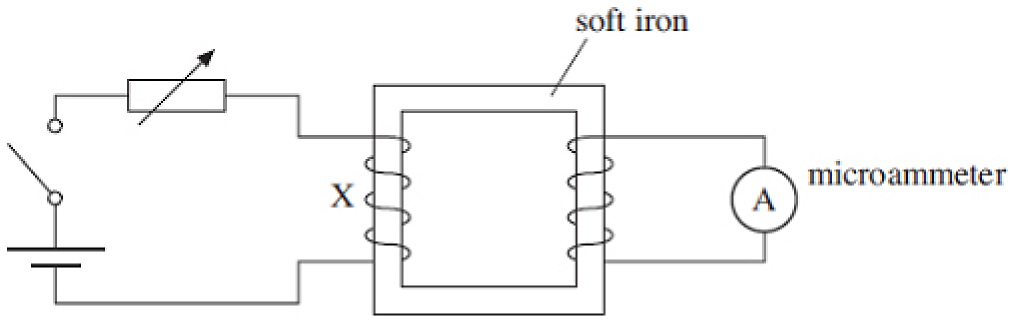
(B) P and Q arrive together followed by R.

(C) P arrives first, followed by Q which is followed by R.

(D) All three magnets arrive simultaneously.

11. Using the circuit shown, and with the switch closed, a small current was passed through the coil X. The current was slowly increased through coil X using the variable resistor.

The current through X then reached a maximum value and was then switched off.



The maximum reading on the microammeter occurred when

(A) a steady current was passing through X

(B) the current was being increased.

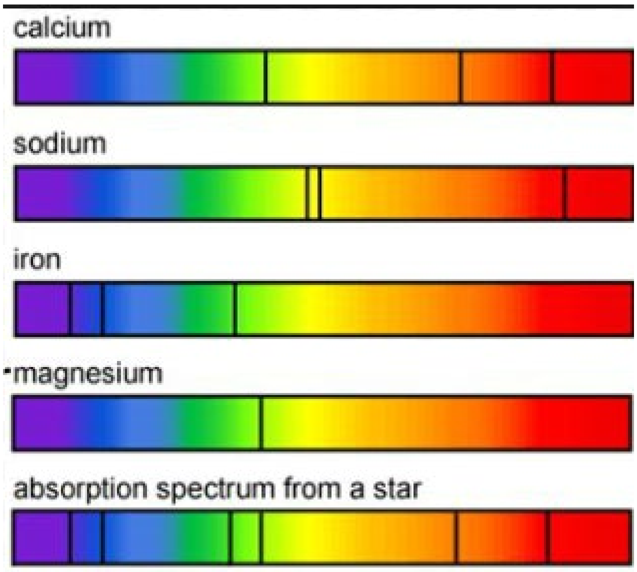
(C) the current was being switched off.

(D) the current in X was zero.

12. Which row links both the photoelectric effect and electron diffraction to the properties of waves and particles?

	Photoelectric effect	Electron diffraction
A	Particle property	Particle property
B	Wave property	Wave property
C	Particle property	Wave property
D	Wave property	Particle property

13. The absorption spectral lines for a number of elements are shown in the figure below along with the absorption spectrum from a particular star.



The elements the star contains are:

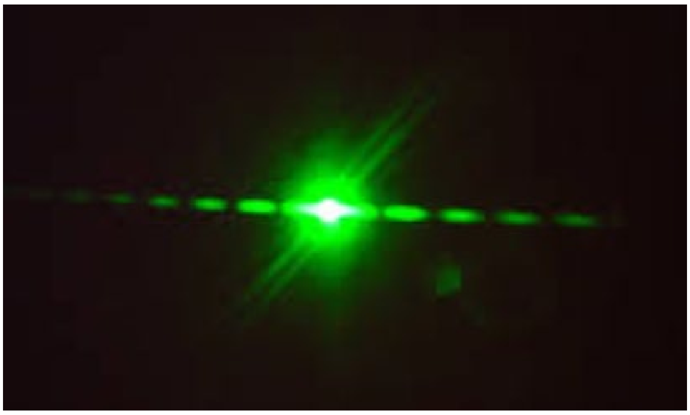
(A) calcium, sodium and iron.

(B) calcium, iron and magnesium.

(C) calcium, sodium and magnesium.

(D) calcium, sodium, iron and magnesium.

14. A student passed a single beam of laser light through a single narrow slit and obtained an image on a screen in a darkened room. The image is shown below.



Which phenomena is responsible for the above pattern?

(A) refraction

(B) reflection

(C) polarisation

(D) diffraction

15. Consider the statements below.

I *A quantum of red light is more energetic than a quantum of microwave radiation*

II *The frequency of microwave radiation is higher than the frequency of red light*

III *The wavelength of red light is greater than microwave radiation*

IV *A quantum of red light is less energetic than a quantum of microwave radiation.*

Which of the statement(s) is/are correct?

(A) I only

(B) I and II only

(C) I and III only

(D) II and IV only

16. Plane-polarized light is incident normally on a polarizer which is able to rotate in the plane perpendicular to the light as shown below.

Diagram 1

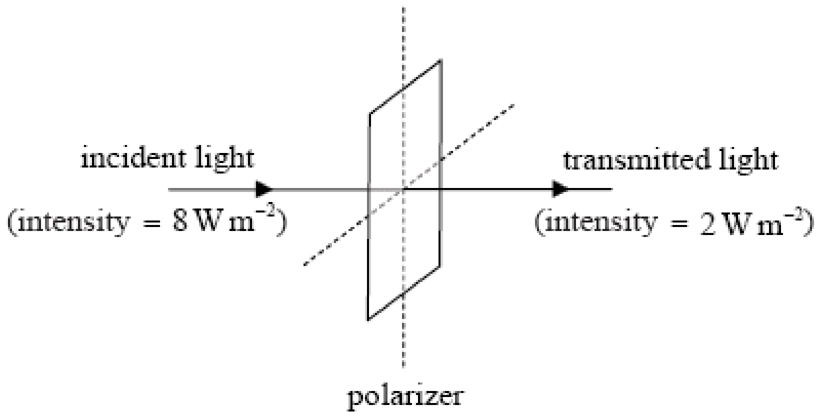
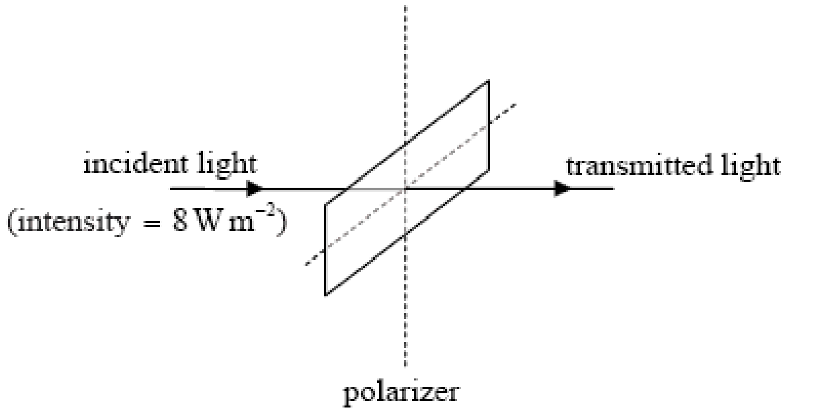


Diagram 2



In diagram 1, the intensity of the incident light is 8 W m^{-2} and the transmitted intensity of light is 2 W m^{-2}. Diagram 2 shows the polarizer rotated 90° from the orientation in diagram 1. What is the new transmitted intensity?

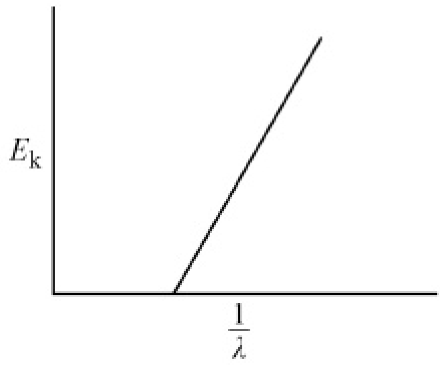
(A) 0 W m^{-2}

(B) 2 W m^{-2}

(C) 6 W m^{-2}

(D) 8 W m^{-2}

17. The graph shows how the maximum kinetic energy E_k of photoelectrons emitted from a metal surface varies with the reciprocal of the wavelength λ of the incident radiation.



What is the gradient of this graph?

(A) c

(B) h

(C) $h\,c$

(D) $h\,c^{-1}$

18. The power output of a nuclear reactor is provided by nuclear fuel which decreases in mass at a rate of 4.0×10^{-6} kg hour^{-1}.

What is the maximum possible power output of the reactor?

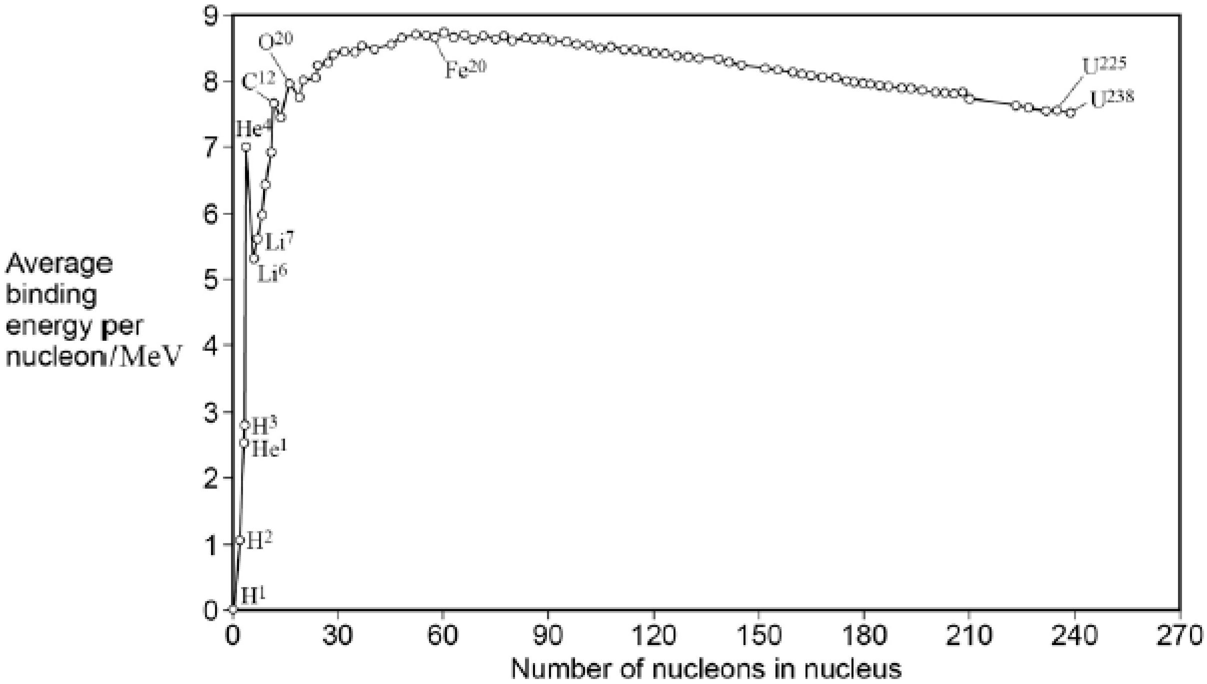
(A) 28 kW

(B) 50 MW

(C) 100 MW

(D) 200 MW

19. The graph shows how the binding energy per nucleon varies with the nucleon number for stable nuclei.



The metric prefix pico, p, can be expressed as 10^{-12}

What is the approximate total binding energy for a nucleus of Tungsten-184? ($^{184}_{74}W$)

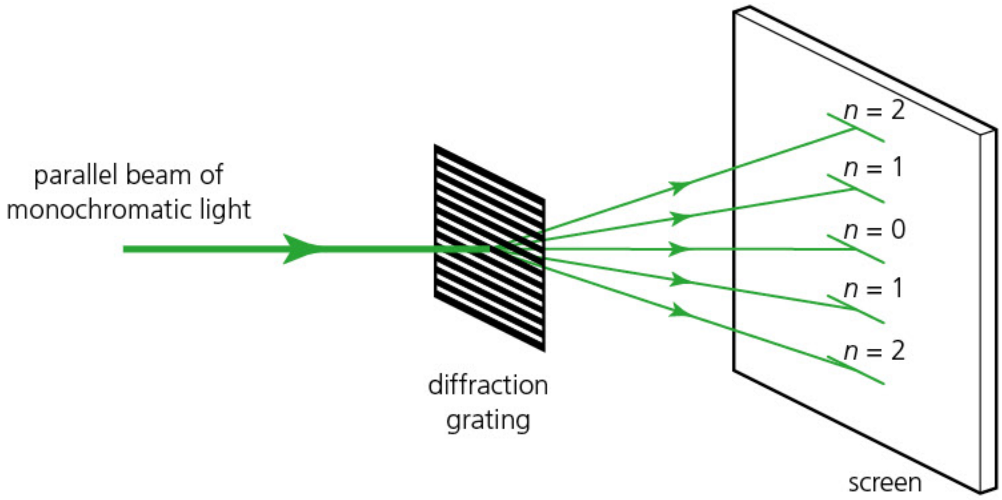
(A) 1.3 pJ

(B) 95 pJ

(C) 100 pJ

(D) 230 pJ

20. In a diffraction-grating experiment the maxima are produced on a screen, as shown below where *n* marks the location of a given maxima where constructive interference has occurred.



What would cause the separation of the maxima of the diffraction pattern to **decrease**?

(A) using light with a longer wavelength

(B) using a grating with a greater slit separation

(C) Not using monochromatic light

(D) increasing the distance between the screen and grating

END OF PART A

Part B – 80 marks
Attempt Questions 21-32
Allow about 2 hours and 15 minutes for this part.

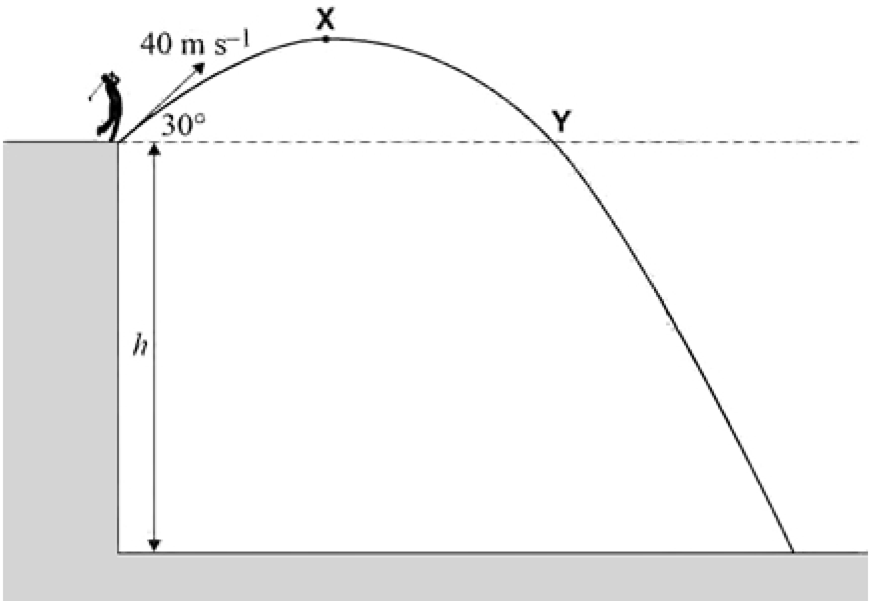
Answer the questions in the spaces provided.
Show all relevant working in questions involving calculations, paying attention to significant figures and units.

Marks

Question 21 (8 marks)

Figure 1 shows a golfer hitting a ball from the top of a cliff. The ball follows the path shown. The ball is hit with an initial velocity of 40 m s^{-1} at an angle of 30° above the horizontal, as shown. Assume that there is no air resistance.

Figure 1



(a) Calculate the initial vertical component of velocity of the ball. **1**

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Question 21 continues on the next page ------------->

Question 21 continued: **Marks**

(b) Draw on the diagram (on the previous page) an arrow to show the direction of the net force acting on the ball when it is at point **X**, the highest point of the flight. Label this arrow **F**. **1**

(c) At point **Y** the ball is level with its initial position.

Find the time taken to reach **Y**. **2**

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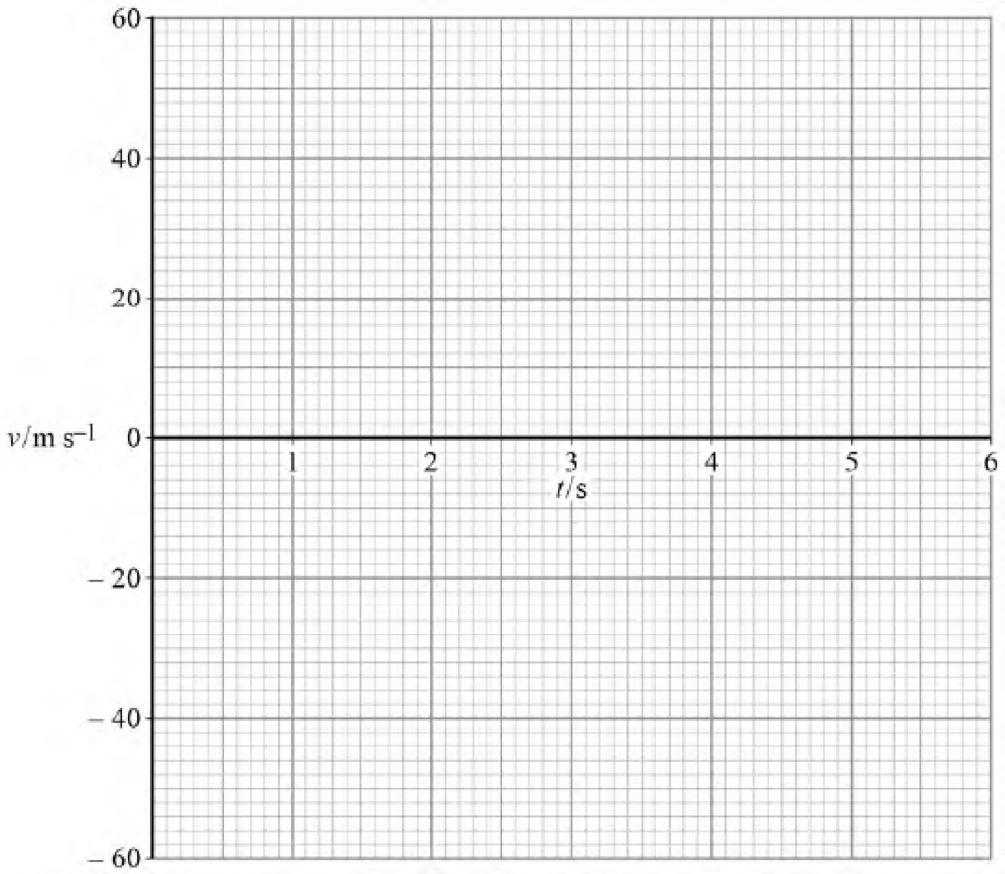
Question 21 continues on the next page ------------------>

Question 21 continued: **Marks**

(d) The total time of flight of the ball is 6.0 s.

Show on **the graph below** how v, the vertical component of the velocity, changes throughout the whole 6.0 s. **2**



(e) Calculate the height h of the cliff. **2**

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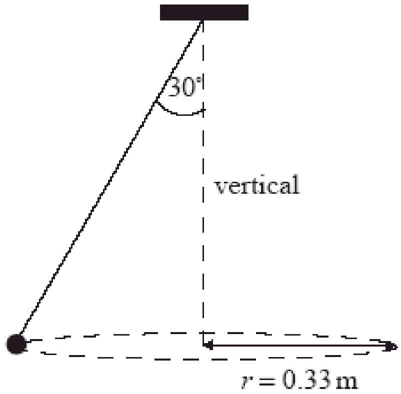
Question 22. (7 marks) **Marks**

A ball of mass 0.25 kg is attached to a string and is made to rotate with constant speed v along a horizontal circle of radius r = 0.33 m. The string is attached to the ceiling and makes an angle of 30° with the vertical.



(a) (i) On the diagram above, draw and label arrows to represent the two forces acting on the ball in the position shown. **2**

(ii) State and explain whether the ball is in equilibrium. **1**

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(b) Determine the tension in the string. **2**

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(c) Calculate the speed of rotation of the ball. **2**

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Question 23 (7 marks) **Marks**

The International Space Station orbits 4.00 x 10^2 km above Earth's surface in a circular orbit.
It has a mass of 4.2 x 10^5 kg.

(a) Calculate the orbital speed of the International Space Station. **2**

(b) Determine the gravitational potential energy of the International Space Station. **2**

(c) Determine the total mechanical energy of the International Space Station. **2**

Question 23 continues on the next page ------------------>

Question 23 continued **Marks**

(d) State the work done by the satellite in one revolution of the Earth. Justify your answer. **1**

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Question 24 (8 marks) **Marks**

A transformer at a power plant has a primary coil with 1000 turns.

The voltage input into the primary is 23kV and is stepped up to 330 kV.

Assume the transformer has 100% efficiency.

(a) Determine the number of turns of the secondary coil. **2**

(b) If the power input of the primary coil is 230MW, calculate the current in the secondary coil. **2**

(c) Explain why it is desirable for the power station to step up the voltage for electricity transmission over long distances. **2**

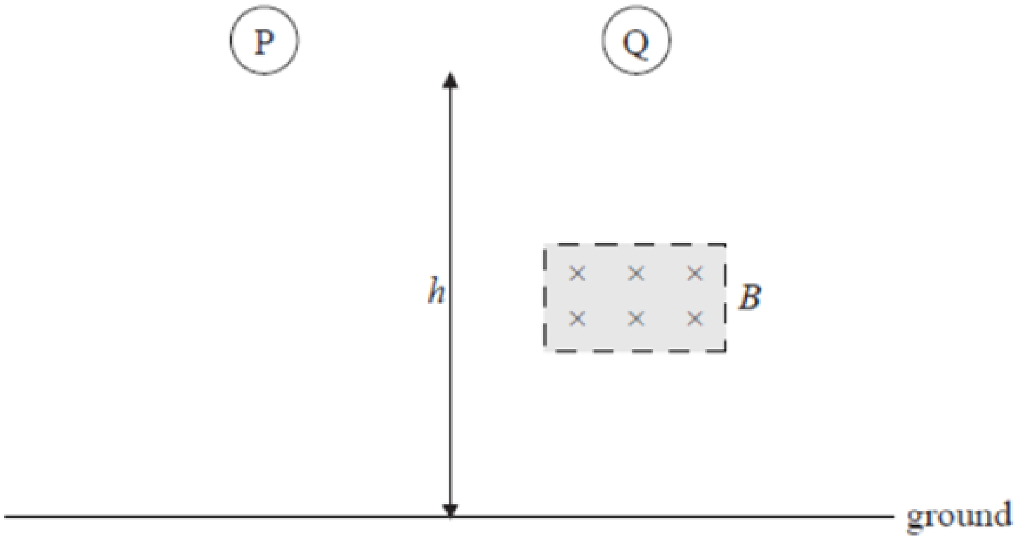
(d) This question assumed that the transformer was 100% efficient. However, there are energy losses when the input power is transformed. Explain the cause of most of this energy loss, and how transformer design attempts to overcome this loss. **2**

Question 25 (7 marks) **Marks**

(a) Two identical aluminium balls are dropped simultaneously from the same height.

Ball P falls through a region with no magnetic field.

Ball Q falls through a region of uniform horizontal magnetic flux density *B*.



Explain why ball Q takes longer to reach the ground than ball P. **4**

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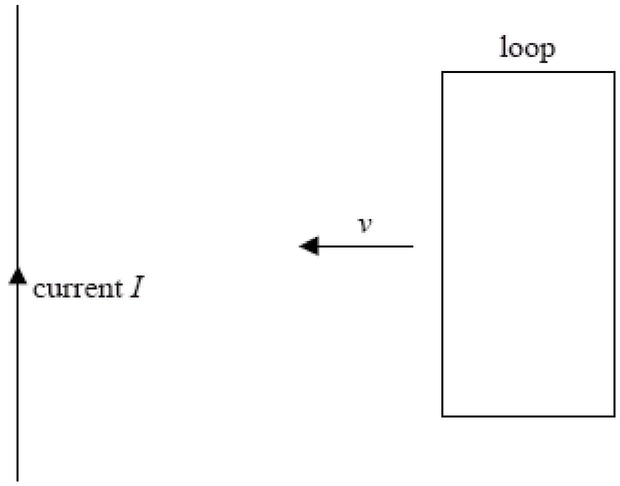
Question 25 continues on the next page ----------------->

Question 25 continued: **Marks**

(b) A square loop of conducting wire is placed near a straight wire carrying a constant current *I*. The wire is in the same plane as the loop.

The loop has an area of 25 cm^2



The loop is made to move with constant speed *v* towards the wire.

(i) On the diagram above draw the direction of the induced current in the loop. **1**

(ii) The loop is now kept stationary. If at this instant the magnetic field strength through the loop has an average value of 0.12 T, calculate the magnetic flux through the loop. **2**

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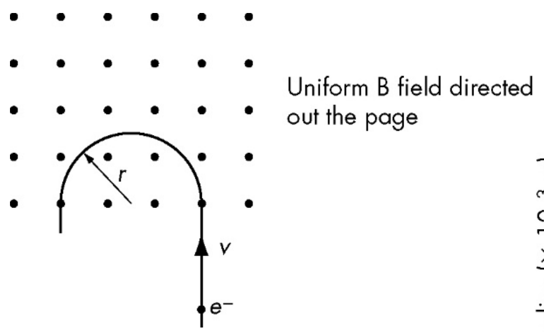
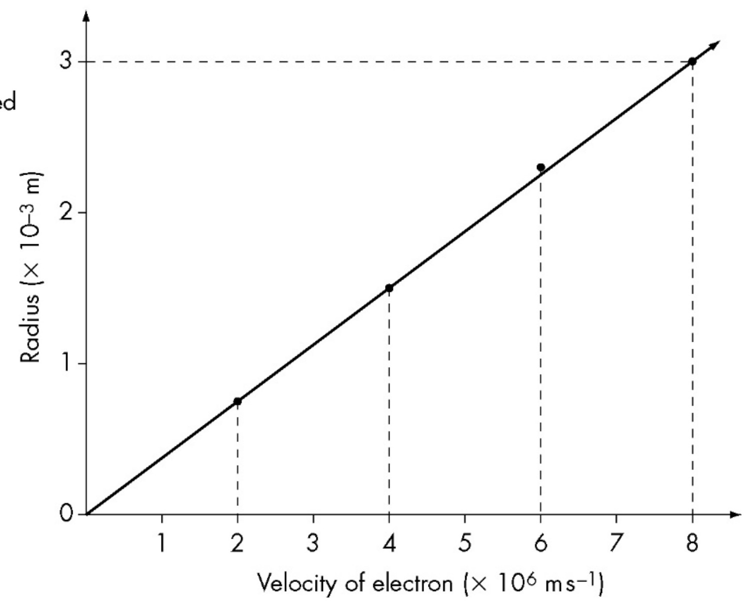
Question 26 (4 marks) **Marks**

(a) A student uses a cathode gun to accelerate electrons to different velocities and then measures the radius of curvature of the path the electrons take in a magnetic field. The electrons enter the magnetic field at right angles to the field. A diagram of the experiment and a graph of the results obtained by the student are shown below.





(a) Determine the gradient of the graph. **2**

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(b) **Use the gradient of the graph** to help calculate the magnetic field strength. **2**

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Question 27 (4 marks) **Marks**

The CERN physics program uses powerful accelerators such as the Large Hadron Collider (LHC) and detectors to study fundamental particles. The laboratory uses huge amounts of electricity in its operations, with much of that electrical energy being consumed when the LHC is in operation accelerating protons.
Each proton in the Large Hadron Collider has around 7×10^{12} eV of kinetic energy and is smashed into another proton travelling in the opposite direction with the same energy.

(a) Determine the total momentum of two colliding protons with energies of 7×10^{12} eV in the LHC. Justify your answer. **2**

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(b) The Large Hadron Collider seeks among other things, to give clarity to aspects of the Standard Model of matter. Part of that model includes quarks and the composite particles known as hadrons. Describe the relationship between quarks and the hadron known as the proton, in the Standard Model. **2**

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Question 28 (9 marks) **Marks**

(a) Explain why nuclei in a star have to be at a high temperature for fusion to take place. **2**

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(b) (i) In massive stars, nuclei of hydrogen $^{1}_{1}\text{H}$ are processed into nuclei of helium $^{4}_{2}\text{He}$ through a series of interactions involving carbon, nitrogen and oxygen called the CNO cycle.

Complete the nuclear equations below that represent the last two reactions in the series. **2**

$$^{\cdots\cdots}_{8}\text{O} \rightarrow {}^{15}_{7}\text{N} + \ldots\ldots\ldots + \nu_e$$

$$^{15}_{7}\text{N} + {}^{1}_{1}\text{H} \rightarrow {}^{\cdots\cdots}_{6}\text{C} + {}^{4}_{2}\text{He}$$

Question 28 continues on the next page ----------------------->

Question 28 continued **Marks**

(b) (ii) The whole series of reactions is summarised by the following equation.

$$4\,{}^{1}_{1}\text{H} \rightarrow {}^{4}_{2}\text{He} + 2\text{e}^{+} + 2\nu_{e}$$

Calculate the energy, in MeV, that is released in this reaction. **3**

Data:

Mass of an electron (or positron) = 0.00055 u

Mass of a proton = 1.00728 u

nuclear mass of ${}^{4}_{2}\text{He}$ = 4.00150 u

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(c) Compare the temperature of the core of red giant stars with main sequence stars. **1**

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(d) Describe, in either words or with nuclear equations the triple - alpha process in red giant stars. **1**

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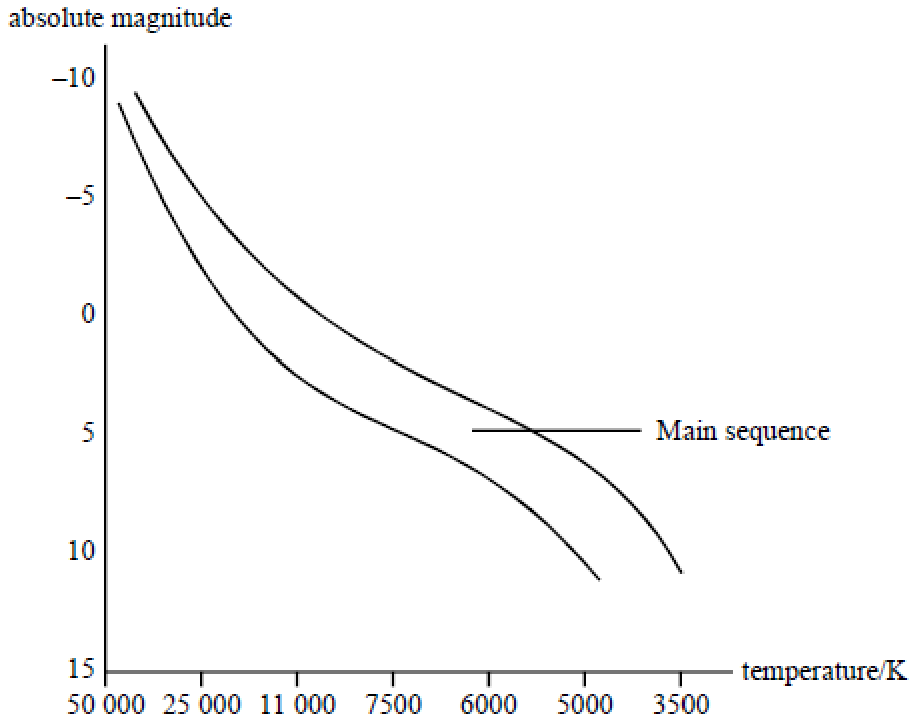
Question 29 (4 marks) **Marks**

A Hertzsprung-Russell diagram for Main Sequence stars is shown below.



(a) Label on the diagram the regions occupied by White Dwarfs and Red Giants. **2**

(b) Explain why Red Giant stars must be very much larger than White dwarfs. **2**

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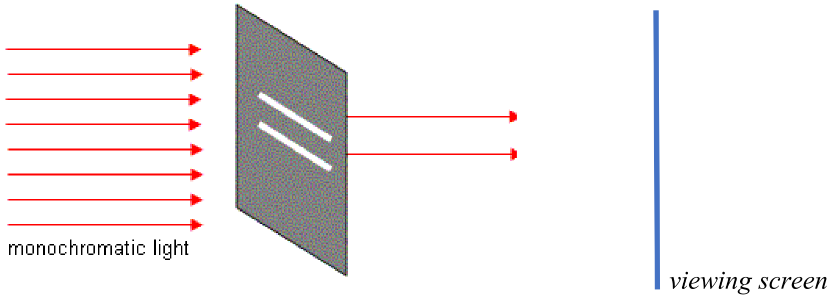
Question 30 (6 marks) **Marks**

(a) As part of an investigation of light, a yellow light of wavelength 5.7×10^{-7} m from a sodium lamp is used as a monochromatic source. This is then aimed at a double slit engraved into a black slide and the interference pattern it produces is observed on a screen at a distance 20 cm from the slits.



(a) In terms of path difference, explain what causes a bright fringe to be formed on the screen. **1**

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(b) A student measures a distance of 3.89 mm between the centres of each of five consecutive interference fringes. Calculate the slit separation distance on the slide **2**

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(c) In your study of interference and diffraction using double slits there were some significant safety issues to address. Outline the important issues and how they were addressed. **2**

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(d) Describe how the method described in the above experiment attempted to improve reliability. **1**

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Question 31 (8 marks) **Marks**

The photoelectric effect was studied by scientists towards the end of the 19th century. However, there were many observations of the photoelectric effect that could not be accounted for using existing models of light. The early 20th century work of Einstein in explaining the photoelectric effect involved a new way of conceptualizing light.

Explain what is meant by the photoelectric effect, and analyse how problems with accounting for the observed phenomena led Einstein to put forward a new model for light. **8**

Question 32 (8 marks) **Marks**

"Scientific progress typically builds on the successes and limitations of previous ideas". **8**

Discuss this statement with reference to the work of Rutherford, Bohr and de Broglie in furthering our understanding of atomic structure.

END OF EXAMINATION

Teacher: CF1

Newington College

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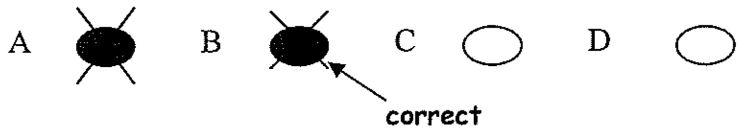

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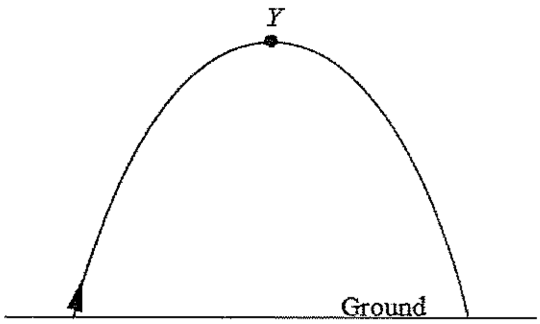
1. Consider an object undergoing projectile motion under an acceleration of gravity as shown in the figure below.



Choose the most correct statement.

(A) The instantaneous velocity at point Y will be zero. X (There is still horiz. velocity)

(B) The vertical component of the velocity is a constant. X (It is under gravity's influence)

X (C) The instantaneous vertical velocity will be the same at launch as at landing at impact.

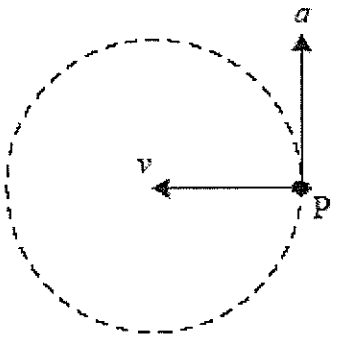
(D) The initial horizontal velocity on launch will be the same as the final horizontal velocity. ✓ remains constant

X NO. As velocity is a vector, and the direction has changed, from up to down.

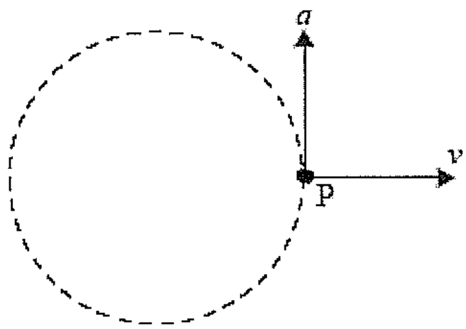
2. A particle ***P*** is moving anti-clockwise with constant speed in a horizontal circle.

Which diagram correctly shows the direction of the velocity v and acceleration a of the particle ***P*** in the position shown?

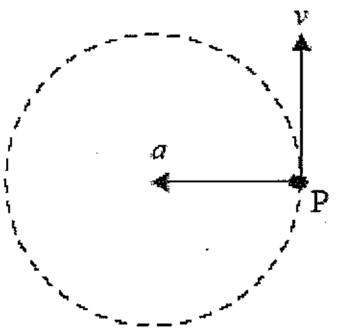
A.



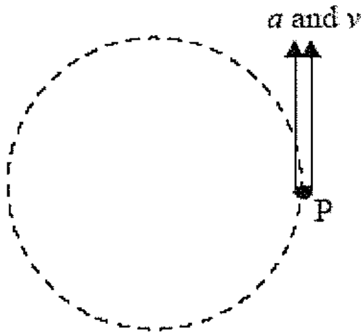
B.



(C) ✓



D.



Centripetal acceleration is towards the centre, and velocity vector is always at right angles to this.

3. If the angular velocity of a second hand of a clock is 0.105 rad s^{-1} and length of hand is 1.8 cm, then speed of tip of the second hand is:

(A) 0.189 cm s^{-1} ✓

(B) 1 cm s^{-1}

(C) 0.189 m s^{-1}

(D) 2 m s^{-1}

$V = \omega r$

$= 0.105 \times 1.8$

$= 0.189\ cms^{-1} = A$

4. Titan is a moon of planet Saturn. It has a gravitational field strength of 1.35 N kg^{-1} on its surface that is 2575 from Titan's centre.
What is the mass of Titan closest to? $r = 2575$ km

(A) 6.0×10^{23} kg
✓ (B) 1.35×10^{23} kg
(C) 40×10^{9} kg
(D) 9×10^{24} kg

$$g = \frac{GM}{r^2}$$

$$M = \frac{gr^2}{G} = \frac{1.35 \times (2575 \times 10^3)^2}{6.67 \times 10^{-11}}$$

$$M = 1.3 \times 10^{23} = B$$

5. Which of the following alternatives correctly compares all the identified factors in terms of a satellite in a geostationary orbit around the Earth, relative to the same satellite in a stable circular low-Earth orbit?

Relative to the satellite in a low-Earth orbit, the satellite in a geostationary orbit has: (much higher radius.)

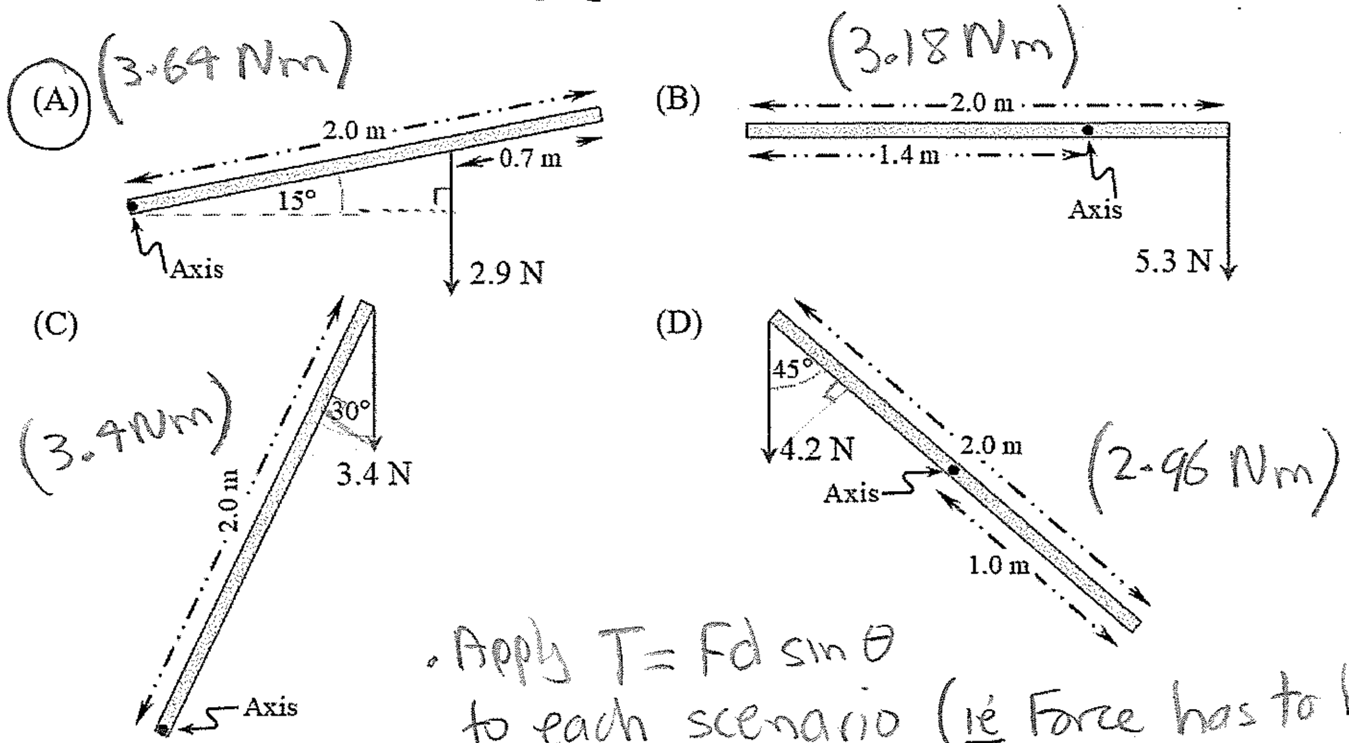
(A)	Higher speed; longer orbital period; greater orbital radius; more centripetal force
✓ (B)	Lower speed; longer orbital period; greater orbital radius; less centripetal force
(C)	Higher speed; shorter orbital period; greater orbital radius; less centripetal force
(D)	Lower speed; shorter orbital period; lower orbital radius; more centripetal force

$v \propto \frac{1}{r}$ (∴ 'v' is lower)

$T^2 \propto R^3$ (As higher radius, ∴ longer period)

$F_c \propto v^2$, and as 'v' is lower, ∴ F_c is also lower for the geostationary satellite

6. Consider the following diagrams showing forces being applied to four identical beams, but the magnitudes and directions of the forces are different, and the axis of rotation also varies. Which alternative would apply the maximum torque onto the beam?



• Apply T = Fd sin θ to each scenario (ie Force has to be at 90° to the beam).

7. Millikan's oil drop experiment was important because:

(A) it used a simple apparatus to equate gravity and electrostatic charge.

(B) it established the charge to mass ratio of the electron.

(C) it quantified the charge on an electron. ✓

(D) it enabled the calculation of the mass of a proton when combined with previous data from JJ Thomson.

• Millikan discovered that charge occurred in multiples of 1.6 ×10^{-19} C.

8. When a beta particle (β) moves at right angles through a uniform magnetic field it experiences a force *F*. An alpha particle (α) moves at right angles through a magnetic field of twice the magnetic flux density with velocity one tenth the velocity of the β particle. What is the magnitude of the force on the α particle?

(A) 0.2 *F*

(B) 0.4 *F*

(C) 0.8 *F*

(D) 4.0 *F*

$F = Bqv$

$F = 2 \times 2 \times 0.1$

$= 0.4$

"α" has twice the charge of a "β" particle

9. A positive charged particle *q* is accelerated in a uniform electric field E starting from rest. If v_0 is the velocity of the particle at the end of distance d, what is the velocity of the particle at distance 2d in the same electric field?

voltage (potential difference)

(A) $2\ v_0$

(B) $4\ v_0$

(C) $8\ v_0$

(D) $\sqrt{2}\ v_0$

$V = Ed$

E

$\therefore$ new $V' = 2V$

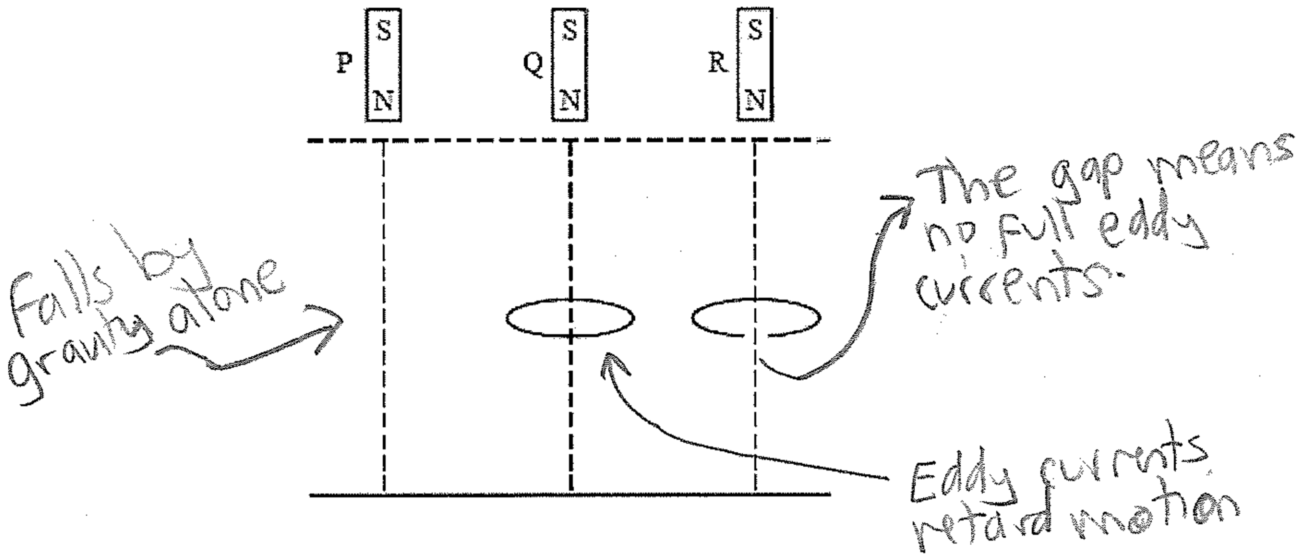
$\frac{1}{2}mv^2 = qV$, and 'm' & 'q' are constant

$\therefore v \propto \sqrt{V}$

As 'V' has doubled from the orginal V_0,

$\therefore$ new $v = \sqrt{2}\ V_0$ = (D)

10. This question refers to the diagram below.



Three identical magnets P, Q and R are released simultaneously from rest and fall to the ground from the same height. P falls directly to the ground, Q falls through the centre of a thick conducting ring and R falls through a ring which is identical except for a gap cut into it. Which one of the statements below correctly describes the sequence in which the magnets reach the ground?

(A) Q arrives after P and R.

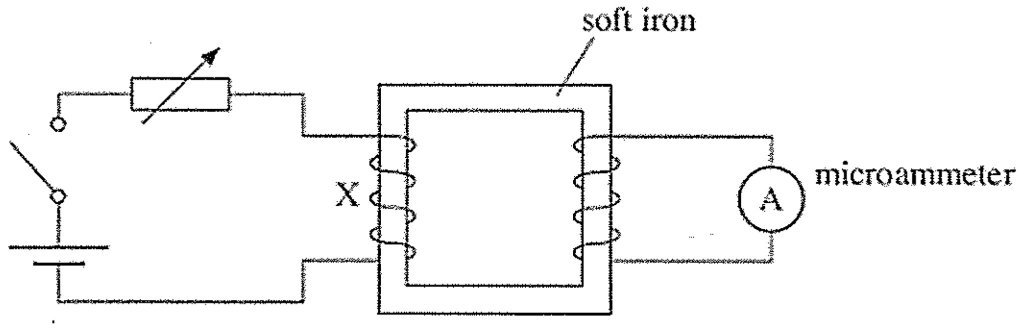
(B) P and Q arrive together followed by R.

(C) P arrives first, followed by Q which is followed by R.

(D) All three magnets arrive simultaneously.

11. Using the circuit shown, and with the switch closed, a small current was passed through the coil X. The current was slowly increased through coil X using the variable resistor.

The current through X then reached a maximum value and was then switched off.



The maximum reading on the microammeter occurred when

(A) a steady current was passing through X No. There's no flux change

(B) the current was being increased.

✓(C) the current was being switched off.

(D) the current in X was zero. No flux at all!, ∴ no induction

(B) is close to being correct, as there IS a changing magnetic field while the current is being increased, but the biggest change in flux occurs when the current in "X" suddenly drops to zero when the current is switched off.

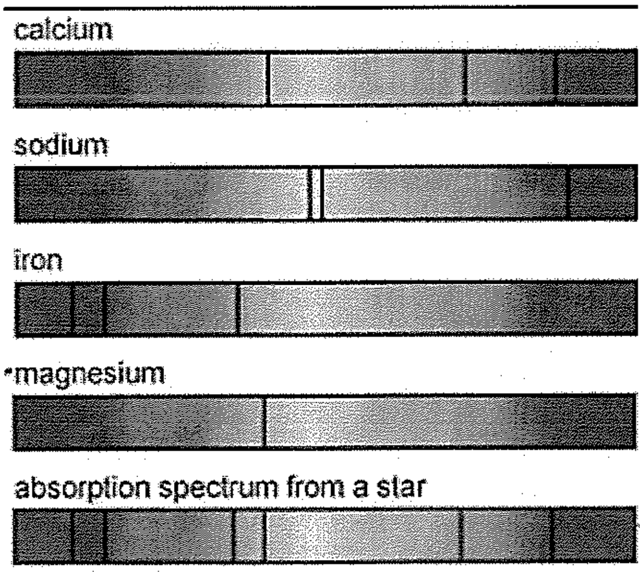
12. Which row links both the photoelectric effect and electron diffraction to the properties of waves and particles?

	Photoelectric effect	Electron diffraction
A	Particle property	Particle property
B	Wave property	Wave property
(C)	Particle property	Wave property
D	Wave property	Particle property

A property of waves

Photoelectric effect cannot be understood via the wave model of light.

13. The absorption spectral lines for a number of elements are shown in the figure below along with the absorption spectrum from a particular star.



no sodium lines

The elements the star contains are:

(A) calcium, sodium and iron.

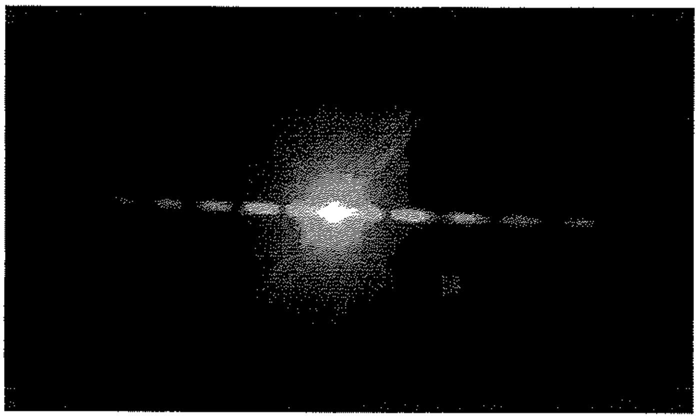
((B)) calcium, iron and magnesium.

(C) calcium, sodium and magnesium.

(D) calcium, sodium, iron and magnesium.

Simply match the spectral lines to the bottom image.

14. A student passed a single beam of laser light through a single narrow slit and obtained an image on a screen in a darkened room. The image is shown below.



Which phenomena is responsible for the above pattern?

(A) refraction

(B) reflection

(C) polarisation

(D) diffraction

(D) Light waves will diffract & spread out in a pattern of maxima & minima.

15. Consider the statements below.

I *A quantum of red light is more energetic than a quantum of microwave radiation* ✓

II *The frequency of microwave radiation is higher than the frequency of red light* ✗

III *The wavelength of red light is greater than microwave radiation* ✗

IV *A quantum of red light is less energetic than a quantum of microwave radiation.* ✗

Which of the statement(s) is/are correct?

(A) I only

(B) I and II only

(C) I and III only

(D) II and IV only

$E \propto f$

$E \propto \frac{1}{\lambda}$

(A) microwave has longer λ than red.

16. Plane-polarized light is incident normally on a polarizer which is able to rotate in the plane perpendicular to the light as shown below.

Diagram 1

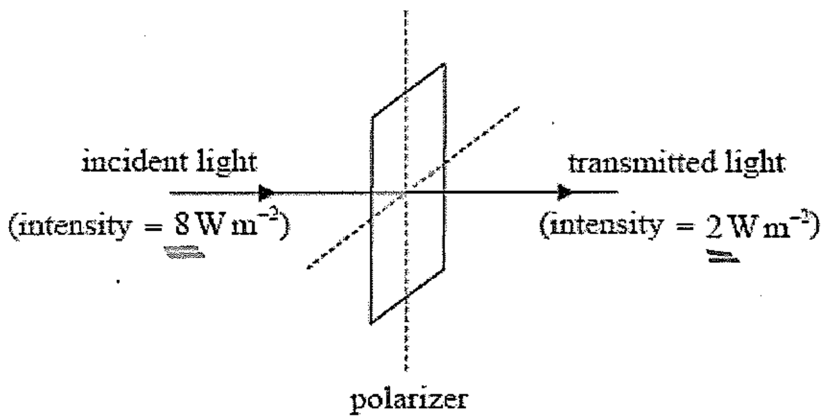
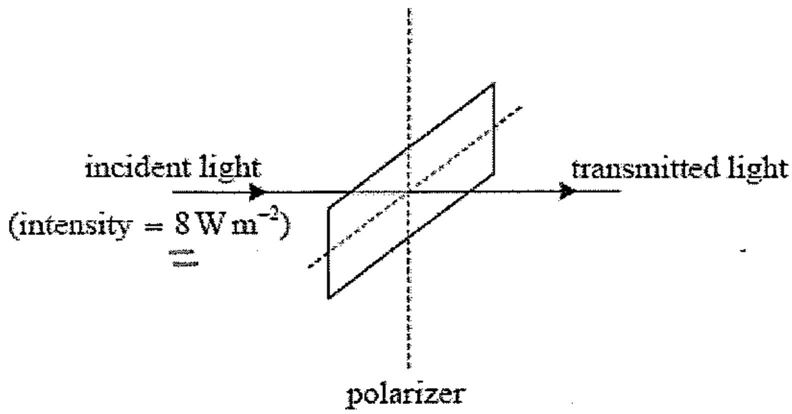


Diagram 2



In diagram 1, the intensity of the incident light is 8 W m^{-2} and the transmitted intensity of light is 2 W m^{-2}. Diagram 2 shows the polarizer rotated 90° from the orientation in diagram 1. What is the new transmitted intensity?

Malus's Law

$I = I_0 \cos^2\theta$

(A) 0 W m^{-2}

(B) 2 W m^{-2}

(C) 6 W m^{-2}

(D) 8 W m^{-2}

C

Diagram ①:

$2 = 8\cos^2\theta$

$\frac{2}{8} = \cos^2\theta$, ∴ $\cos\theta = 0.5$

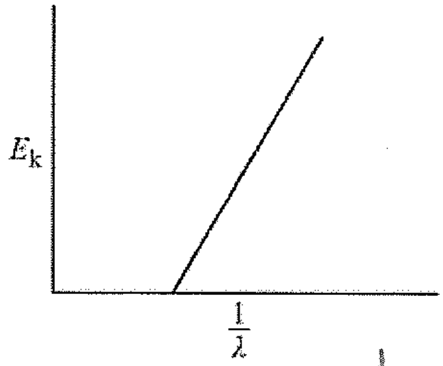
$\theta = 60°$

We now add 90° to 60° = 150°

$I = 8 \times \cos^2 150$

$= 8 \times 0.75 = 6 = C$

17. The graph shows how the maximum kinetic energy E_k of photoelectrons emitted from a metal surface varies with the reciprocal of the wavelength λ of the incident radiation.



$E = hf$ & $c = f\lambda$

grad $= \frac{E}{1/\lambda} = E\lambda$

Now, $E = hf$, and $c = f\lambda$

$\therefore$ gradient $= hf\lambda$

$= hc = C$

What is the gradient of this graph?

(A) c

(B) h

(C) $h\,c$

(D) $h\,c^{-1}$

(C)

18. The power output of a nuclear reactor is provided by nuclear fuel which decreases in mass at a rate of 4.0×10^{-6} kg hour^{-1}.

What is the maximum possible power output of the reactor?

(A) 28 kW

(B) 50 MW

(C) 100 MW

(D) 200 MW

$E = mc^2$

$=$

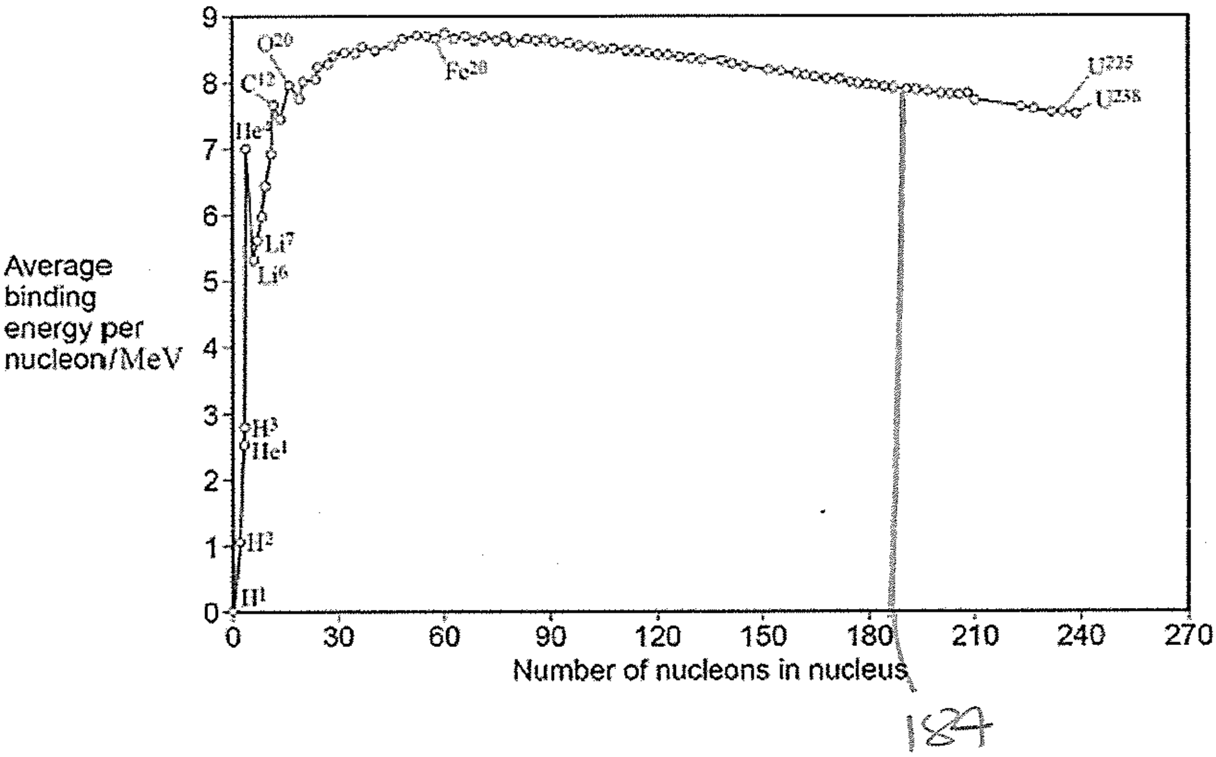
In each second, mass loss $= \frac{4 \times 10^{-6}}{3600} = 1.1 \times 10^{-9}$

$E = 1.1 \times 10^{-9} \times 9 \times 10^{16}$

$= 1 \times 10^{8}$ Joules per second

$= 100$ MW $=$ (C)

19. The graph shows how the binding energy per nucleon varies with the nucleon number for stable nuclei.



The metric prefix pico, p, can be expressed as 10^{-12}

What is the approximate total binding energy for a nucleus of Tungsten-184? ($^{184}_{74}W$)

(A) 1.3 pJ

(B) 95 pJ

(C) 100 pJ

(D) 230 pJ

D

$\approx$ 7.9 MeV per nucleon

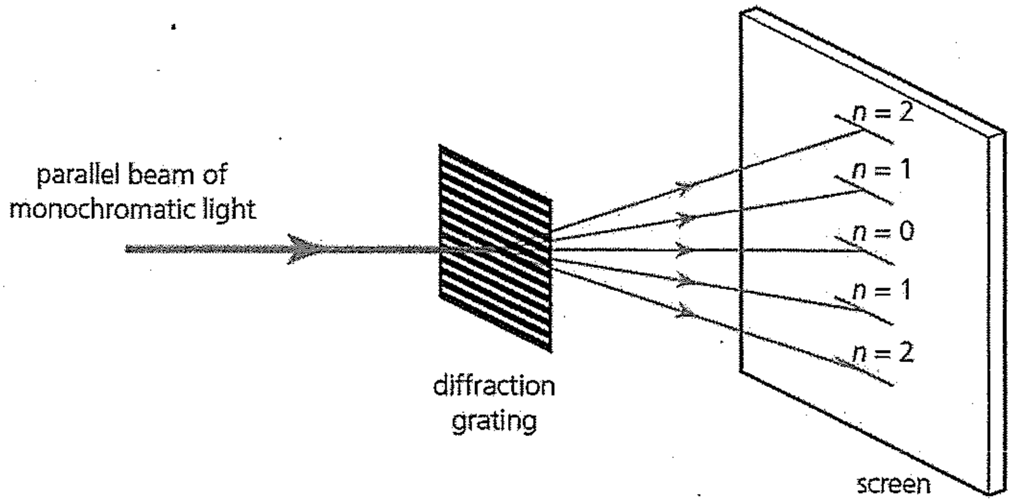
Total $= 184 \times 7.9 \times 1.6 \times 10^{-13}$ J

$= 2.3 \times 10^{-10}$ J

Now, $1\,pJ = 10^{-12}$ J,

$\therefore$ 230 pJ = D

20. In a diffraction-grating experiment the maxima are produced on a screen, as shown below where n marks the location of a given maxima where constructive interference has occurred.



What would cause the separation of the maxima of the diffraction pattern to **decrease**?

(A) using light with a longer wavelength

(B) using a grating with a greater slit separation

(C) Not using monochromatic light

(D) increasing the distance between the screen and grating

$n\lambda = d \sin\theta$

$\sin\theta \propto \frac{1}{d}$

∴ larger value for d gives a lower value for θ, ∴ the maxima are closer together = (B)

END OF PART A

NEWINGTON COLLEGE

HSC PHYSICS

TRIAL EXAMINATION 2019

CFI MARKING CRITERIA

PART A

MULTIPLE CHOICE

1	D
2	C
3	A
4	B
5	B
6	A
7	C
8	B
9	D
10	A
11	C
12	C
13	B
14	D
15	A
16	C
17	C
18	C
19	D
20	B

PART B

21.

(a) Vertical velocity = 40 sin 30 = 20 (m s^{-1}) ✔ **1**

(b) Line vertically **downward from point X** ✔ **1**

(c) Method leading to a numerical answer

e.g. v = u + at / 0 = 20 − (9.81 × t) gives t = 2.0(4) ✔

total time of flight = 4.08 / 4.1 (s) ✔

Any alternative acceptable method allowed, which pays due heed to correct vector directions (it is possible to find a correct value for time by cancelling out the various errors candidates make with vectors!)

2

(d) Single straight line (of negative gradient), starting at 20 ms^{-1} ✔

Crossing the x axis at 2.0s ✔

*(Any single straight line over the 6.0s will score this mark **OR** ecf from part **(a)***

Any line which crosses at 2.0s (and only here) will score this mark)

2

(e) Area under graph (between 4s and 6s) ✔

$= (20 \times 2) + \frac{1}{2}(20 \times 2)$

= 60 m ✔

OR: Alternative method to use equation of motion selecting:

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

$s = (20 \times 2) + \frac{1}{2}(9.81 \times 2^2)$ ✔

s = 59.6 m ✔

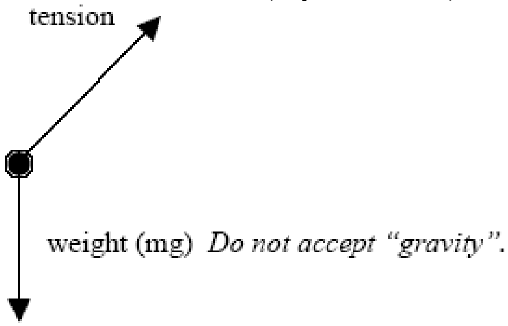
NOTE: Must demonstrate a correct understanding of the underlying physics, and the method is easy to follow. Mistakes with vector directions will not allow marks to be awarded.

(values with 56 − 62 acceptable from graph)

2

22.

(a) (i) 1 each for correct arrow <u>and</u> (any reasonable) labelling; 2



NOTE: the inwards centripetal force, F_c , is the *resultant* of the two forces in the diagram, and is not a force on its own as such.

The weight vector, *ng*, acts form the centre of the mass itself.

(ii) no;
there is a net (centripetal) force on the ball / the ball moves in a circle / the ball has acceleration/it is always changing direction;
*Award **[0]** for correct answer with no or wrong argument.* 1

(b) $T\cos 30° = mg$; **(1)**

$T = m\,g / \cos 30^0$

$T = 0.25 \times 9.8 / 0.866 = 2.8\ N$ ***(1)*** *(Wrong units not penalised)*

(c)

Award 1 mark for correct approach, but a minor maths error made along the way.

Award two marks for correct method, substitution, working *and* correct final answer.

(Ignore any wrong units and to many sig figs in this question).

$$T\left(=\frac{mg}{\cos 30°}\right) = 2.83\text{ N};$$

$$\frac{mv^2}{r} = T\sin 30°;$$

$$v = \left(\sqrt{\frac{Tr\sin 30°}{m}} = \sqrt{\frac{2.832\times 0.33\times \sin 30°}{0.25}}\right) = 1.4\text{ m s}^{-1};$$

or

$T\cos 30° = mg$;

$$T\sin 30° = \frac{mv^2}{r};$$

$$v = \left(\sqrt{gr\tan 30°} = \sqrt{9.81\times 0.33\times \tan 30°}\right) = 1.4\text{ m s}^{-1};$$

23 (a)

Criteria	Marks
● A correct response showing calculations	2
● A correct determination of the radius of satellite orbit *in metres* with an incorrect substitution OR an incorrect determination of the radius of satellite orbit and a correct substitution and subsequent working. ● NO marks awarded if the wrong mass is used in the calculation.	1

Sample answer

Since the ISS orbits 4.00 x 10^2 km above Earth's surface, the radius at which it orbits is the radius of the Earth + 4.00 x 10^2 km. Hence its orbital velocity is:

$$v_{orbit} = \sqrt{\frac{GM_E}{r}} = \sqrt{\frac{6.67\times10^{11}\times6.0\times10^{24}}{6.371\times10^6+4\times10^5}} = 7.69\times10^3\,ms^{-1}$$

(b)

Criteria	Marks
● A correct response showing full calculations	2
● Correct formula chosen, correct substitution of data, but one mathematical error ● OR: correct magnitude of answer, but answer not correctly being shown as negative ● Wrong units not penalised	1

U = - G M m / r

U = - 6.67 x 10^{-11} x 6 x 10^{24} x 4.2 x 10^5 / (6.371 x 10^6 + 4 x 10^5) ***1***

U = - 1.6808 x 10^{20} / 6.77 x 10^6

U = - 2.48 x 10^{13}

U = - 2.5 x 10^{13} J (2 sf) *(note the negative sign)* ***1***

The negative sign is a fundamental aspect of GPE

Zero marks awarded for use of ***GPE = mgh***

Q 23 continues on the next page --------------------->

23. (c)

Criteria	Marks
● A correct response showing full calculations	2
● Correct formula chosen, correct substitution of data, but one mathematical error ● OR: correct magnitude of answer, but answer not correctly being shown as negative ● Wrong units not penalised	1

Sample answer:

TOTAL mechanical energy = *U* + KE

Total energy = - G M m / 2 r (this can either be derived or recalled by candidates)

$= -1.6808 \times 10^{20} / 2\,(6.371 \times 10^{6} + 4 \times 10^{5})$ **1**

$= -1.245 \times 10^{13}$

$= -1.25 \times 10^{13}$ J **1**

OR candidates can use KE = ½ m v^2 to find KE, and then correctly add this to the negative GPE value found earlier.

Note the negative sign in the total energy…this is a fundamental aspect of total mechanical energy, and how the answer is closer to zero compared to the value calculated in part (b)

(d) Work done is ZERO; (no marks just for saying this)

The force and displacement/velocity vectors are always perpendicular **1**

OR

$W = F d \cos\theta$ is quoted appropriately, and force is perpendicular to displacement vector.

OR

There is no change to the energy (in either its GPE or KE) of the satellite, hence no work done on it.

No mark awarded for saying that displacement is zero, as this wrongly implies that work *would* be done if, say, the satellite was only half way or one quarter way through its revolution.

24.

(a) use of transformer equation and correct substitution to give:

$23 \times 10^3 / 330 \times 10^3 = 1000 / n_s$ (1 mark)

Correct value of $n_s = 1.4 \times 10^4$ turns (1 mark)

(b) power in secondary = power in primary = 230 MW (1 mark)

P = I V

<u>I = 697 A</u> (1 mark)

(c)

Marks	Criteria
2	Response indicates desirability for low current. Relevant physics formulae referenced and explained
1	One correct and relevant statement about the desirability for low current with respect to reducing energy or power loss

Sample response:

Power losses are minimised when electricity is transmitted at high voltages *and* therefore low currents.

Power loss is proportional to current **squared**, ($P_{loss} = I^2 R$), and so it is a **big gain** in efficiency if current minimised (due to the transformer increasing the transmission line voltage).

(d)

Marks	Criteria
2	Full explanation of ***cause and effect*** for **both** the cause of energy losses and ***why*** the laminations of the iron core help reduce this.
1	Full explanation of *either* the energy losses OR how they are reduced. However, both issues have not been fully addressed.

Sample Response:

Eddy currents are produced (induced) in the iron core (by the changing magnetic field). These produce unwanted heat (thermal energy), thus lowering efficiency.

The iron core can be divided into individual thin sheets, which are electrically insulated from each other. This is called lamination. Thus, any eddy currents that form are very much restricted in size (reducing production of unwanted heat).

NOTE: many candidates mentioned 'laminations', but did not go on to **explain** *why this is a good thing. The key verb in this question was 'explain', not merely 'describe'.*

25.

(a) ball Q enters/leaves magnetic field / experiences changing flux, as well as falling due to the influence of gravitational forces. However, ball P is *only* experiencing gravitational force (or acceleration); **1**

Therefore an emf, *and hence a current is* induced in ball Q due to it experiencing *changing* magnetic flux. **1**

this induced current in the (metallic) ball causes a magnetic field; **1**

The *magnetic field is in such a direction that it* opposes the motion of / opposes the flux change/exerts an upward force on ball Q; **1**

To achieve full marks; need to at some point in the answer, make reference to the fact that ball P is falling by gravity alone (and even better, acknowledge that ball Q also has gravitational forces on it, but these are *partly* countered by the forces upwards explained above)

NOTE: simply stating the phrase 'Lenz's Law' = maximum of one mark.

NOTE 2: Explaining Lenz's Law, but not in the context of this particular situation = max of 2 marks

Overall, it is not difficult to achieve an entry level mark with this question. And many candidates achieved 2 or 3 marks quite easily, but the answer really needs to be thorough and display a comprehensive knowledge of all the key physics and use terms precisely to score four marks.

(b) (i) anticlockwise arrow(s) clearly seen on diagram. **1**

(ii) convert cm^2 to $m^2 = \times 10^{-4} = 25 \times 10^{-4}\ m^2$ (or $2.5 \times 10^{-3}\ m^2$) **1**

$\Phi = B A$

$\Phi = 0.12 \times 25 \times ^{-4}$

$\Phi = 3 \times 10^{-4}$ Wb (**must have correct unit** to be awarded second mark) **1**

Note: many candidates were not familiar with the unit of the weber. Or, wanted to, wrongly, write Wb^{-1} (or wrongly write 'Tm^{-2}').

26.

(a) Determine the gradient of the graph.

gradient = rise / run = 0.003 / 8 x 10^{-6} = 3.75 $\times 10^{-10}$ s

(1 mark for correct answer, 1 mark for correct units of gradient). The gradient unit is 'seconds' .

(b) Use the gradient of the graph to help calculate the magnetic field strength.

$mv^2 / r = q v B$

$B = mv / q r$

B = m / q x 1 / gradient (1 mark)

B = 9.1 x 10^{-31} / 1.6 x 10^{-19} x 1 / 3.75 x 10^{-10}

<u>B = 0.015 T (1.5 x 10^{-2} T)</u> (1 mark) Note: NO marks if no attempt to use gradient was made.

Note: a small range of values was accepted, based on what was read from graph. Candidates who annotated the graph made sure they got this mark, even if their numbers were slightly off.

Candidates should always use TWO points on the line of best fit to determine a gradient (don't assume 0,0 is a point and always show full working)

27.

(a)

Criteria	Marks
• A correct determination that the total momentum of the colliding protons is zero with an extensive justification that recognises momentum is a vector quantity and that the protons with the same energy must have the same magnitude momentum	2
• A correct determination that the total momentum of the colliding protons is zero without a clear justification that recognises momentum is a vector quantity and that the protons with the same energy must have the same magnitude momentum	1

Sample answer

The total momentum of the collision of the two protons is zero. The protons have the same speed and mass but are travelling in opposite directions. Since momentum is a vector quantity and the direction is opposite but the magnitude of the momentum of each proton is the same, the total momentum must be zero.

(b)

Criteria	Marks
• A detailed description of how a proton is composed of three quarks, with a description of the nature of those quarks leading to a hadron with a charge of +1 • OR: A detailed description of how a proton is composed of three quarks *and* describes the nature of the forces between them (gluon)	2
• A general description of a proton being composed of quarks	1

Sample answer

A proton is a quark composition hadron composed of three quarks. It is hence a baryon. Two up quarks each with electric charge $+\frac{2}{3}$, for a total of $+\frac{4}{3}$ together combine with one down quark with electric charge $-\frac{1}{3}$. Adding these charges together yields the proton with a charge of +1.

28.

(a) nuclei need to be <u>close together</u> (owtte) for the Strong Nuclear Force to be involved or for fusion to take place **1**

e.g. first mark – within the range of the SNF (which only operates over short distances)

(but the electrostatic / electromagnetic force is repulsive (and tries to prevent this)

(if the temperature is high then) the nuclei have (high) kinetic energy / speed (to overcome the repulsion) **1**

(b) (i) One mark for each correct equation:

Equation 1: 15 *and* e^+ ✓ (or β^+, ${}^{0}_{1}\beta$, ${}^{0}_{1}e$) **(1)**

Equation 2: 12 **(1)**

(2)

Marker comment: for the first equation most students did not pick up on the cue that the electron neutrino is associated with beta positive (positron) decay.

(ii) Δ mass = 4 × 1.00728 − 4.00150 − (2 × 9.11 × 10^{-31} / 1.661 × 10^{-27})
or

Δ mass = {4 × 1.00728 − 4.00150 − 2 × 0.00055}(u) ✓

(4×1.00728=4.02912)

Δ mass = 0.02652(u) ✓

2nd mark - for calculated value
0.02652u

Δ binding energy (= 0.02652 × 931.5)

Δ binding energy <u>**= 24.7 MeV**</u> ✓

NOTE: can solve using $E = m c^2$ (with masses all in kg) and then finally convert to MeV as required.

(c) red giant stars have much higher core temperatures (only their surface temps are cooler than main sequence stars) **1**

(d) As the name suggests, a *triple alpha* reaction combines three helium nuclei (alpha particles) to form a carbon-12 nucleus.
1

Marker comment: for part (c) – many students confusing the core temperature with the surface temperature and for part (d) a number of students treated the triple alpha reaction as a part of the CNO cycle for main sequence stars.

29.

(a)

correct location of Red Giants **and** White Dwarfs **(2)**
(May award a *global* mark if location of both star types is not quite correct)

(b) Red Giants colder than White Dwarfs (or identifying correct difference in luminosity between the two stars) **(1)**

But as Red Giants have higher luminosity (or more negative magnitude) must have larger surface area/larger radius.

To obtain the second mark candidates may reference the Stefan Boltzmann relationship, (luminosity proportional to Area (R^2) and T^4) **(1)**

Note: Candidates should have left space for Supergiants at the top of diagram - Red Giants do not have the maximum absolute magnitude on the HR diagram. This was discussed at length and the decision made to allow a mark if Red Giants were in the Supergiant region (poorly defined difference between those two star types & syllabus does not explicitly reference them beyond 'characteristics of stars').

30.

(a) There is a path difference of an integer (whole number) number of wavelengths to cause constructive interference at the bright spots. **(1)**

(b)

Criteria	Marks
• A correct response showing relevant calculations	2
• A correctly applied relevant calculation, but one error made	1

Sample answer

Both slits provide a source of light. The difference in the path length for an adjacent maximum must be a single whole wavelength to produce constructive interference. If the first maximum from the central maximum is considered, the angle θcan be determined by trigonometry.

$$tan\theta = \frac{3.89 \times 10^{-3}}{2 \times 10^{-1}}$$

$$\theta = 1.1142624°$$

Now

$$dsin\theta = m\lambda$$

$$d = \frac{m\lambda}{sin\ 1.1142624}$$

$$d = \frac{5.7 \times 10^{-7}}{sin\ 1.114262}$$

$$d = 2.93 \times 10^{-5}\ m$$

<u>Students may start with :</u> $x = \lambda L / d$ (or equivalent expression)

(c) The laser light is a significant safety hazard, especially if it is shone in the eye. **1**

The hazard can be reduced by either appropriate signage when the laser is in use,

or

allocating a person to ensure that there is a clear path kept in front of the laser when in use,

or

by using only a low intensity laser that would only cause minimal damage if accidentally shone onto human tissue. **1**

Note: the best responses recognises the plural in the question (issues)

(d) The experiment took five measurements of the fringe separation **1**

31

Marks	**Criteria**
7-8	Defines photoelectric effect. (A labelled diagram is acceptable) Identifies prevailing view of light being a wave. Details why wave model could not explain observed phenomena. Describes Einstein's explanation of photoelectric effect, including relevant equations (with terms defined). Describes how Einstein moved towards the dual wave-particle model *For 8 marks answer must show depth, be clear and be logically sequenced and contain no errors.*
5-6	Substantially correct response, but one significant aspect not covered Eg: no Einstein photoelectric equation and explanation Or: does not adequately cover the issues with the wave model in explaining observations. OR: key ideas covered, but answer is somewhat incoherent and/or significant errors of fact made.
3-4	Response contains several correct and relevant statements. However, there is either significant confusion/ambiguous/factually incorrect information. OR: The requirements of the question have only been partially addressed.
2	Two correct and significant statements
1	One significant and correct statement Eg: defines photoelectric effect, or identifies the move away from a purely wave model of light, or writes Einstein's photoelectric effect equation,

Q 31 Sample answer on next page ------------

Question 31 sample answer:

Sample answer

The photoelectric effect occurs when light of a certain frequency hits a metal surface, causing the emission of electrons.

In the late 19^{th} century the prevailing view of light was that it was a wave, and a transverse electromagnetic one at that.

Early experiments on the photoelectric effect (by scientists such as Lenard) produced some results that were not consistent with light being a wave, with its energy spread continuously over an even wavefront. For example, when the incident light was below a certain *threshold* frequency, then there was NO photoelectric observed, no matter how high the intensity. The wave model made no allowance for why a higher or lower frequency would affect whether the photoelectric effect is observed. Also, *if* the photoelectric effect occurred, then it would occur instantly. However, the wave model assumed that there would be a short time delay (especially in dim light, as it would take time for energy to build up on the metal so that electrons could escape).

Einstein's *photon* explanation made use of Planck's relatively new $\boldsymbol{E = hf}$ quantisation concept, where the energy of lights was concentrated in small packets or quanta (later known as photons).

Einstein explained that below a certain frequency, the incident light would not have sufficient energy to release an electron. This is summarised in this equation:

$E_{max} = hf - \Phi$

Where E_{max} = *maximum kinetic energy of the released electron, 'hf' is the energy of the incident photon of light, and* Φ *is the 'work function' (ie minimum energy of photon required to dislodge the electron form the metal surface).*

Thus the new model of light sees it no longer seem as a purely a wave. It now has 'particle' properties as well. This is known as the dual model of light.

Note: The best responses <u>had</u> to be supported by equations. Generally well answered, but some candidates confused Planck's vs. Einstein's involvement with photoelectric effect and should review.

32.

Marks	**Criteria**
7-8	Covers the key successes *and* limitations of Rutherford **in depth** Covers the key successes *and* limitations of Bohr **in depth** Covers the developments made by de Broglie. Answer makes logical links between the work of each of the scientists *For 8 marks to be awarded, answer must show depth, be logically sequenced and contain no errors of fact*
5-6	Describes strengths and weaknesses of the work of BOTH Rutherford *and* Bohr and the work of de Broglie also covered. However, the response is not coherent, and lacks depth and possibly has ambiguous or significant factually wrong statements. OR The work of de Broglie covered, along with relevant information about Bohr and Rutherford. However, **overall response lacks depth**.
3-4	Describes strengths and weaknesses of the work of BOTH Rutherford *and* Bohr OR The work of de Broglie covered in some depth, along with relevant information about either Bohr or Rutherford
2	Describes work of TWO of the scientists OR Describes strengths and weaknesses of the work of either Rutherford or Bohr
1	Makes a correct statement about the work of one of the scientists

Q 32 Sample response on the next page ----------->

Markers comment: better responses provided an accurate and coherent outline of each model and then made clear links between them via their limitations and successes.

Overall, students demonstrated a sound understanding of this area of study. Any inconsistencies or inaccuracies can readily be tidied up with further study.

Several students wrote very comprehensive responses that went across more than two pages. It is recommended that they continue to hone their writing skills in order to maintain the sophistication in a more concise manner.

Sample response for question 32

Rutherford's alpha scattering experiments led him to propose that the mass of the atom was concentrated in a central small, dense and positively charged *nucleus*. Most of the rest of the atom was empty space, with (negative) electrons orbiting the nucleus in circular orbits. Rutherford's model successfully explained the alpha scattering data, and was thus an improvement of J J Thomson's 'plum pudding' model, which lacked a central nucleus. However, it did not explain the hydrogen emission spectral lines, nor did it explain why the electrons did not spiral into the nucleus , emitting EMR as they did so, thus leading to the collapse of the atom.

Bohr built on Rutherford's ideas, by keeping the concept of a positive nucleus surrounded by orbiting electrons. He said electrons existed in *stationary states* where they were able to orbit the nucleus without emitting EMR. He also explained the hydrogen spectral lines were due to electrons dropping from a higher stationary state to a lower one. However, it lacked a mechanism for explaining *why* the stationary states existed.

De Broglie was able to explain *why* Bohr's stationary states existed. To do his he had to start considering the electron as a wave (and his equation $\lambda = h / mv$ assigned electrons a tiny yet measurable wavelength), and not just as a particle. This led to the wave-particle model for matter. In de Broglie's model the electrons formed standing waves in their orbits, and as standing waves they did not radiate energy; thus remaining stable. Direct experimental evidence for de Broglie's ideas came from Davisson and Germer who observed electron diffraction (diffraction being a defining property of waves).