Luchith T

Baulko Student Trial

Trial Examination

Higher School Certificate

2021

Physics

2 Unit

General Instructions

- Reading time, 5 minutes
- Working time, 3 hours
- Write your candidate number where indicated
- Board approved calculators may be used
- Write using Black Pen only
- Draw diagrams using pencil
- A Data Sheet, Formulae Sheet and a periodic Table are provided with this paper
- Show all working.

Total Marks: 100

This paper consists of TWO sections

Section I (20 marks)

Multiple Choice
20 marks
Pages 2-10
Allow about 35 minutes for this part

Section II (80 marks)
Written Responses
80 marks
Pages 12-27
Allow about 2 hours, 25 minutes for this part

Section I

20 marks
Only use values on the data sheet.

---

1. A 10g ball rolls off the edge of a 1m tall table at $2ms^{-1}$. How far from the edge of the table does the ball land?

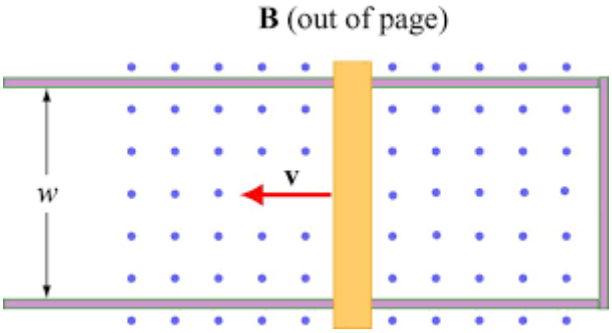
    a) 9.1m

    b) 90cm

    c) 136cm

    d) 64cm

2. A conductor moves through a magnetic field,



    In which direction does the current flow in the external circuit?

    a) There is no induced current

    b) Anti-clockwise

    c) Clockwise

    d) Vertically

3. Two planets, A and B orbit the same star. Planet A has an orbital radius of 2×10^8 m whilst Planet B has an orbital radius of 6×10^9 m. If Planet A's mass is 3×10^{25} kg and has an orbital period of 15 ooshwucks (measurement of time in Planet A). What is the orbital period of Planet B in ooshwucks?

    a) 4.243×10^{-23}

    b) 2465

    c) 493.0

    d) 144.8

Use this stimulus to answer Questions 4 and 5

An electron travelling at 3×10^7 ms^{-1} to the right enters an electric field of strength $10NC^{-1}$ and is deflected. A magnetic field is then set up with direction into the page, acting over the distance of the electric field. This causes the electron to now travel in a straight line

4. What was the magnetic field strength?

   a) 3.33×10^{-7} T

   b) 6.67×10^{-7} T

   c) 3.00×10^{6} T

   d) 6.00×10^{6} T

5. What was the direction of the electric field?

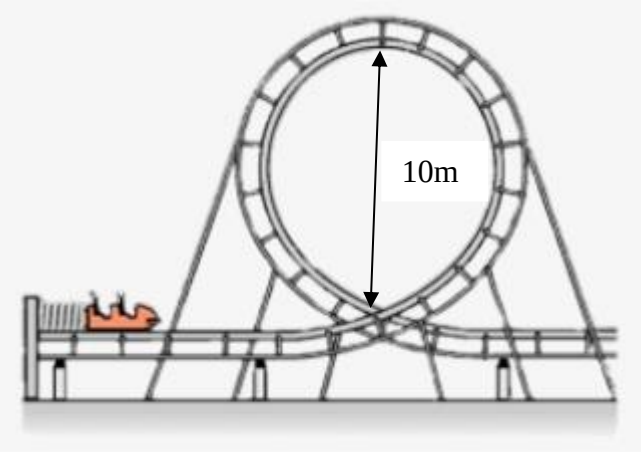
   a) Left

   b) Right

   c) Up

   d) Down

6. A rollercoaster manufacturer wants to design their perfectly circular rollercoaster loop such that the passengers will feel weightless once they reach the top of the rollercoaster.



At what speed (in ms^{-1}) should the rollercoaster enter the loop for this to occur?

   a) $\sqrt{10g}$

   b) $\sqrt{5g}$

   c) $\sqrt{20g}$

   d) $\sqrt{g}$

7. What is the altitude of a geostationary satellite?

   a) 42,230 km

   b) 8.086×10^{13} m

   c) 5083 km

   d) 35,930 km

8. The wires connecting to Mary's household are 240V AC with 3.6A of current running in them. Her iPhone 12 charger (which didn't come in the box) has a non-ideal step-down transformer inside. If her iPhone requires 30V to charge, what is the most likely current output of the charger?

   a) 29A

   b) 28A

   c) 30A

   d) 31A

9. A projectile is fired from the ground at an angle of 45$^{\mathbf{o}}$ to the horizontal and hits the ground 20m away. Find the max height of the projectile.

   a) 1.4m

   b) 1.5m

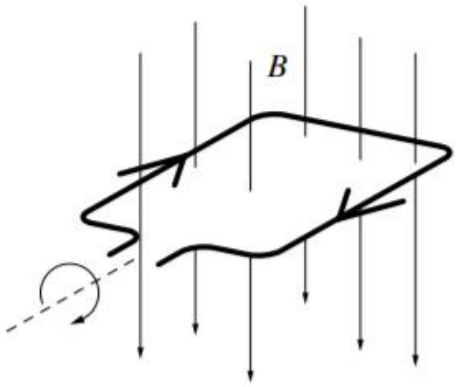
   c) 2m

   d) 5m

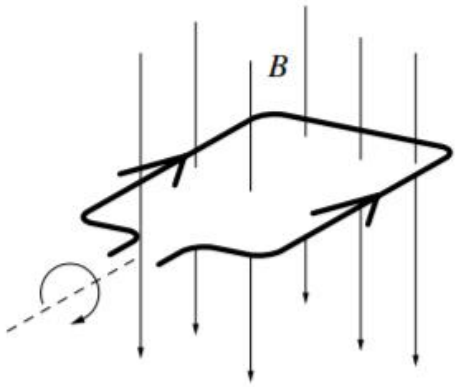
10. A single-turn coil of wire is placed in a uniform magnetic field B at right angles to the plane of the coil as shown in the diagrams. The coil is then rotated in a clockwise direction as shown.

Which of the following shows the direction of current flow in the coil as it begins to rotate?

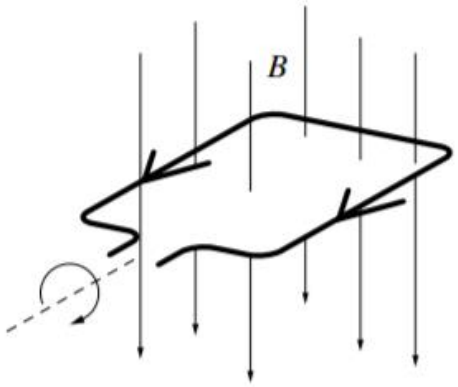
(A)



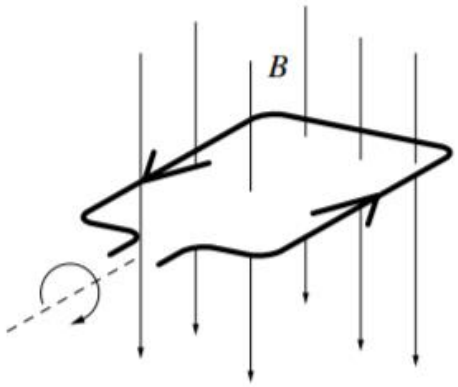
(B)



(C)



(D)



11. A stationary observer on Earth looks at a ship flying past at 0.9c with a clock on it.

What curious observation does the stationary observer make about the clock on the ship?

a) The clock hands move backwards.

b) The clock moves slower than clocks on Earth.

c) The clock moves faster than clocks on Earth.

d) The clock was periodically appearing and disappearing.

12. Which gauge boson carries the weak nuclear force?

a) Gluons

b) Higgs Boson

c) Photons

d) W and Z particles

13. Which of the following was a limitation of the Bohr model?

a) It couldn't explain Hydrogen's emission spectra.

b) It couldn't explain why electrons do not emit EMR in orbit

c) It couldn't explain the emission spectra of atoms with multiple electrons in their valence shell.

d) It couldn't explain why few alpha particles deflected by angles > 90^{o} in the Geiger-Marsden experiment

14. What is the absolute magnitude of a star?

a) The apparent magnitude of a star measured from a distance of 10 parsecs.

b) The apparent magnitude of a star measured from Earth.

c) The apparent brightness of a star measured from a distance of 1 parsec.

d) The total energy released from a star during one cycle.

15. What did Maxwell define the propagation of electromagnetic waves as?

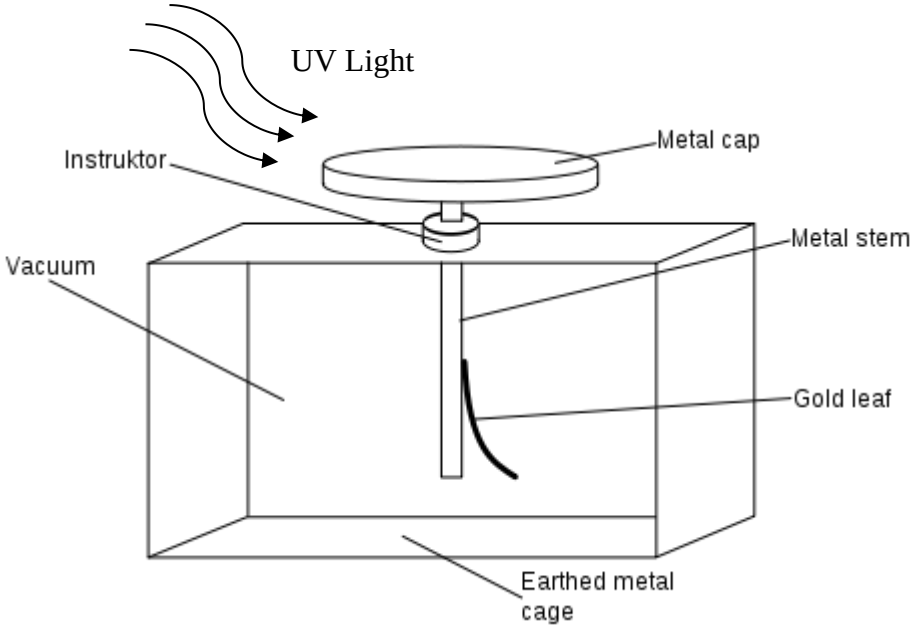
a) Mutually propagating electric and magnetic fields parallel to each other.

b) Adjacent particles having completely elastic collisions to transfer energy.

c) Mutually propagating electric and magnetic fields perpendicular to each other.

d) Many electrons travelling at the speed of light with energy, E = hf.

16. Wilhelm Hallwachs set up a gold leaf electroscope as shown to investigate the photoelectric effect.



What did he observe when the metal cap was positively charged?

a) The gold leaf did not move.

b) The gold leaf extended outwards.

c) The gold leaf collapsed onto the metal stem.

d) The gold leaf vibrated.

17. What is the role of magnetic fields in a synchrotron?

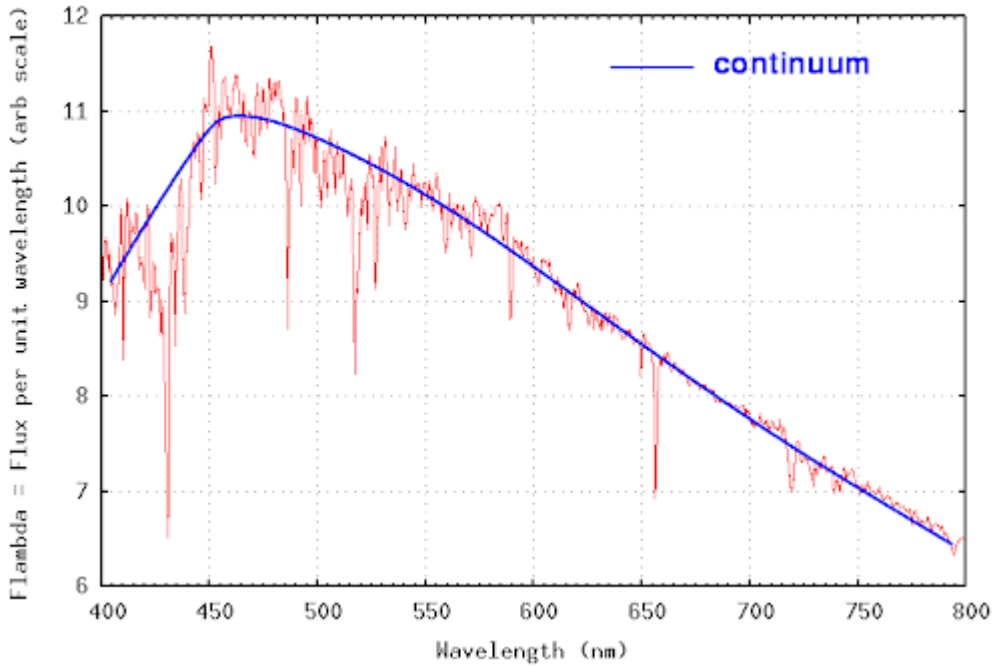
a) To accelerate the charged particle.

b) To ionise the neutral particle.

c) To direct the charged particle.

d) To accelerate the neutral particle.

18. Below is the continuous blackbody spectra of Star XLR8.



Make an educated guess of the colour of Star XLR8.

a) Green

b) Orange

c) Yellow

d) Blue

19. A student shot monochromatic light with a wavelength of exactly 656nm at a sample of hydrogen gas in a dark room. What did they observe behind the hydrogen sample through a spectroscope, and what electron transition occurred?

	Spectroscope	*Electron Transition*
(A)	One black line on a continuous background.	n = 2 to n = 4
(B)	One black line on a continuous background.	n = 2 to n = 3
(C)	One faint bright line on a black background.	n = 3 to n = 2
(D)	One faint bright line on a black background.	n = 4 to n = 2

20. An astronaut from Earth travelled to a planet 10 light years away at a speed of 0.995c. He stays there for 10 years to relax and then returns to Earth at the same speed. What is the age gap now between him and his twin sister to the nearest year?

a) He is older by 18 years

b) He is older by 15 years

c) She is older by 18 years

d) She is older by 15 years

Baulko Student Trial

Trial Examination

2021

Physics

Answer Booklet

Section I
Multiple Choice
20 marks

Select the response which best answers the question and indicate your choice by placing an 'X' over A, B, C or D on the grid below

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**

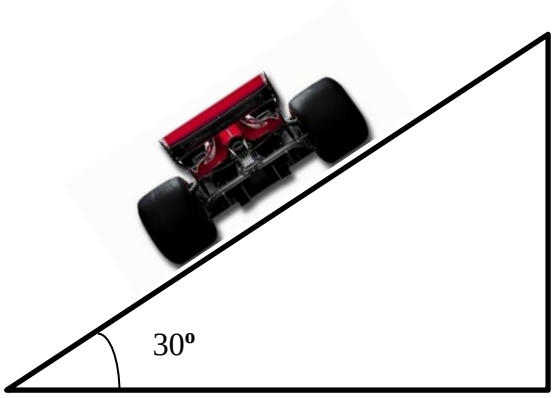
Section II

80 marks
Please write your answers in Part B in the spaces provided.
Individual marks are indicated for each question

Marks

Question 21 (6 marks)

An 800kg F1 car travels on a **rough** banked track in circular motion as shown below. It is travelling at its **max** speed around this corner.

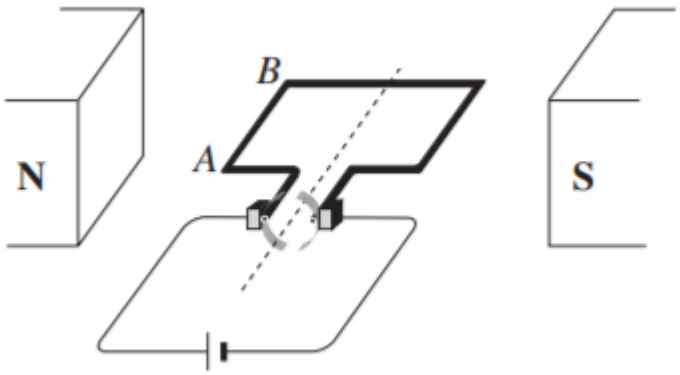


a) Label **ALL** forces acting on the car. And label the net force too with a dotted line. **2**

b) If the radius of the track is 100m and the coefficient of friction of the track is 0.30, find the max speed at which the car can travel around the track. **4**

Question 22 (12 marks)

Below is a DC motor with a 5-turn square coil of side length 4cm, external magnetic field strength of 2 x 10^{-3} T and constant current of 25A.



a) Calculate the torque experienced by the coil and which direction it will rotate. **2**

b) Identify the purpose of a DC motor, and explain how it functions (no need to explain split-ring commutator) **3**

c) Compare a split-ring commutator to a slip ring. **4**

d) A student was about to start the motor, but the teacher suggested they use a variable resistor before starting it, why did the teacher suggest this? **3**

Question 23 (9 marks)

Satvik Gupta is in a hot air balloon at rest on a 10m tall platform. It starts rising vertically at a constant acceleration of $2ms^{-1}$. Satvik stops the burner after 5 seconds, and immediately throws his English text horizontally at $20ms^{-1}$ (in his frame of reference) which impacts the **ground** sometime later.

a) At what height off the ground did Satvik throw his English text? **1**

b) Determine the initial velocity of the English text as viewed from the **ground**. **3**

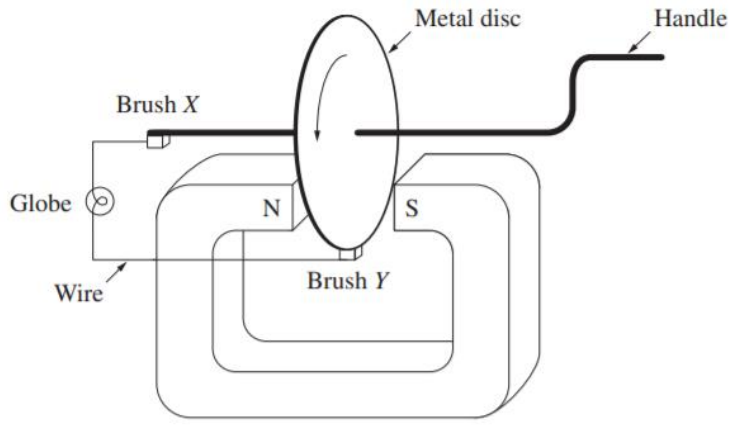
c) Determine the time of flight and range of the English text. **2**

d) Determine the velocity of the English text on impact. **2**

e) If the landing platform is removed so that Satvik lands on the ground, what is the time difference between himself and the English text impacting the ground? **1**

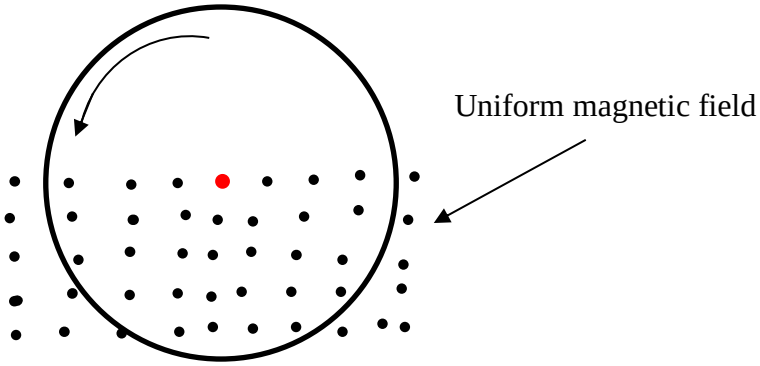
Question 24 (5 marks)

Early electric generators were often very simple. A hand-operated version is depicted below.



Brush X touches the metal axle and Brush Y touches the rim of the disc.

a) Shown below is the metal disc from the view of the handle, label the eddy currents that would form on the metal disc. And then explain why they form. **3**



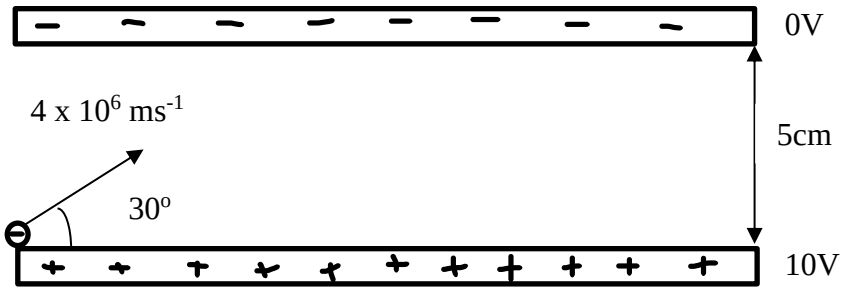
b) Explain which direction current will flow in the external circuit (X to Y or Y to X). **2**

Question 25 (3 marks)

Briefly explain **two** strategies used to increase the efficiency of transformers **3**

Question 26 (5 marks)

An electron is shot into the electric field shown below, with infinitely long plates,

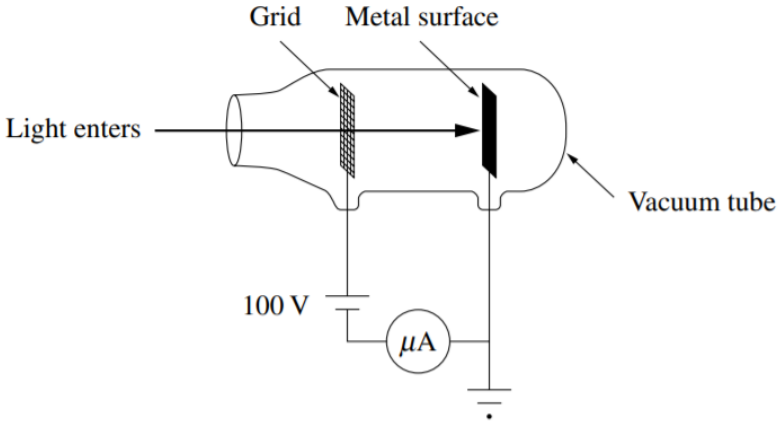


a) Find the acceleration experienced by the electron. **2**

b) Determine the velocity of the electron upon impact and which plate it hits. **3**

Question 27 (6 marks)

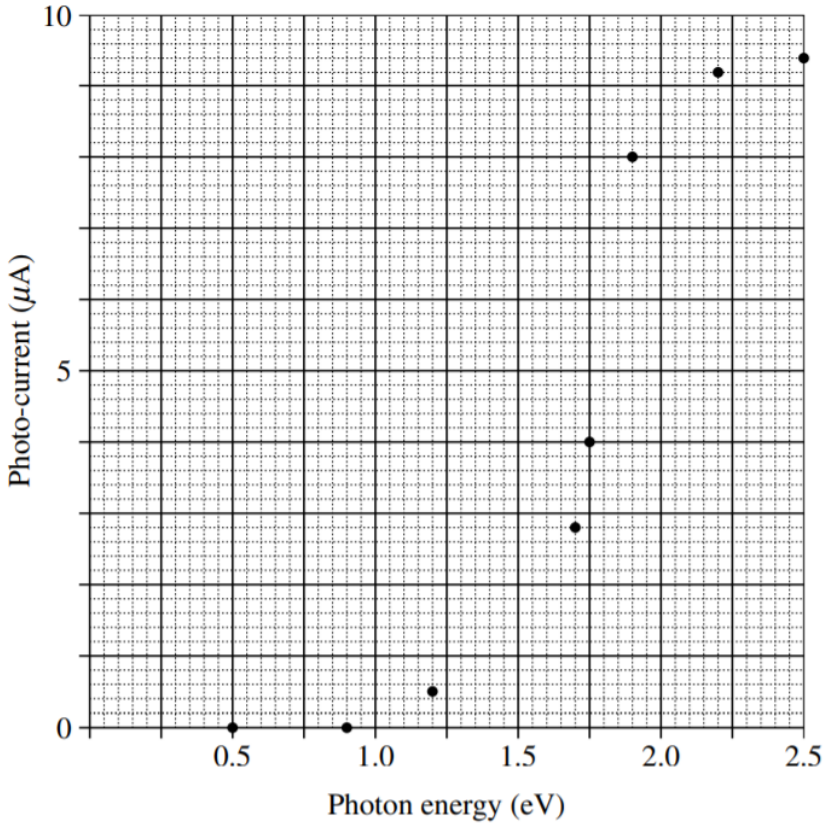
A student conducts an experiment using a photoelectric cell as shown in the diagram.



Light is shone through a grid onto a metal surface. The metal is at earth potential and the grid is at 100 V, so that any electrons emitted from the surface produce a current in the external circuit.

The student shines light sources of different photon energies onto the metal surface and records the current flowing for each. The light sources are adjusted so that their intensities are equal. The results are recorded in the table and shown on the graph.

Photon energy (eV)	*Photo-current* (μA)
0.50	0
0.90	0
1.20	0.5
1.70	2.8
1.75	4.0
1.90	8.0
2.20	9.2
2.50	9.4



a) On the grid provided, draw the straight line of best fit in the region where the photo-current varies greatest with photon energy. **1**

b) From the line drawn on your graph, estimate the minimum energy (work function) for photoelectric emission. **1**

c) The experiment is repeated, but the intensities of the light sources are doubled. Predict the results of this new experiment by drawing a second line on the graph. **2**

d) Justify the line you have drawn in part (c). **2**

Question 28 (5 marks)

Explain how analysing stellar spectra can inform us about the characteristics of stars? **5**

Question 29 (11 marks)

There are three main types of radioactive decay with the following ionising and penetrating powers.

Radioactive Decay	*Ionising Power*	*Penetrating Power*
	High	Low
	Medium	Medium
	Low	High

a) Complete the above table. **2**

b) Explain the different ionising and penetrating powers of the three types of decay. **3**

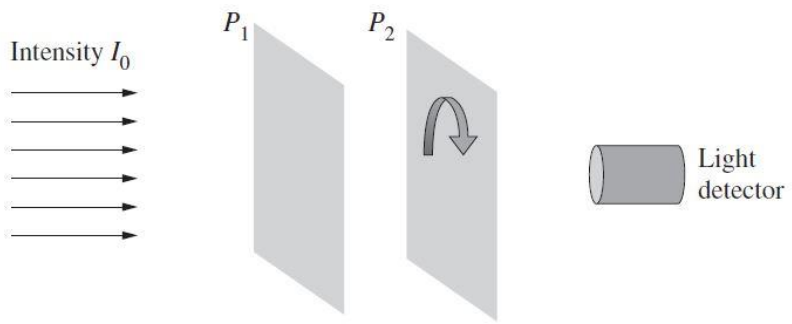
c) Carbon-14 decays into Nitrogen-14, give a **complete** equation to show this decay. **2**

d) Calculate the energy released from this decay in **MeV** if mass of: Carbon-14 = 14.00421u , Nitrogen-14 = 14.00307u and e^- = 0.00055u. **2**

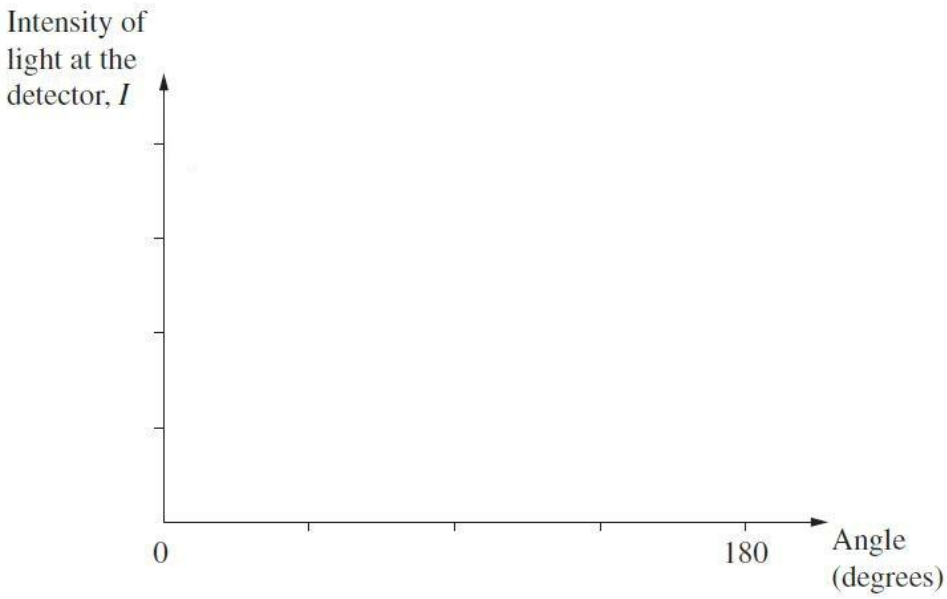
e) A student was casually digging in his backyard and found a skull. Instead of telling the police he remembered from his Year 12 Physics class that he could measure the age of the skull using Carbon-14 dating. From Wikipedia he found the half-life of Carbon-14 to be **5,730 years**. He measured the mass of Carbon-14 in the skull to be **1.45g**. If the skull initially had **92.8g** of Carbon-14 in it, find the age of the skull. **2**

Question 30 (4 marks)

Unpolarised light rays of intensity I_0 pass through two polarising filters P_1 and P_2 to a light detector. The filters are originally aligned so that they produce the maximum amount of light, then filter P_2 is slowly rotated through 180^0 as shown.



a) On the axes provided, sketch a graph showing how the intensity of the light at the detector, *I*, changes as P_2 rotates from zero to 180^0. **2**



b) P_2 is now rotated to a position so that no light reaches the detector. Without moving P_1 or P_2, a third polariser filter ($P_{1.5}$) is inserted between P_1 and P_2 and rotated at an angle from 30**º** from P_1.

Explain using calculations or diagrams, why the light intensity at the detector is no longer zero. **2**

Question 31 (4 marks)

Many attempts have been made to measure the speed of light, some horrendous like Galileo approximating the speed of light to $3400ms^{-1}$, and some better ones today which can measure the speed of light to 9 sig fig.

Contrast a HISTORICAL method to a CONTEMPORARY method of measuring the speed of light. **4**

Question 32 (10 marks)

The early 1900s saw significant development to our understanding of the atom with new models and explanations of how sub-atomic particles behave.

a) De Broglie made a significant prediction about the particle-wave duality. Explain what his prediction was and support that prediction with **ONE** piece of experimental evidence. **4**

b) Calculate the de Broglie wavelength of a 50g tennis ball travelling at $20ms^{-1}$. Then explain why we do not observe everyday objects such as tennis balls to show wave properties. **3**

c) Explain how de Broglie was able to derive Bohr's 3rd postulate "the angular momentum (mvr) of electrons in orbit about a nucleus is quantised as $\frac{nh}{2\pi}$, where n is a whole number." In your answer, use a diagram to illustrate the case for n = 4. **3**

Marking Criteria

Section 1

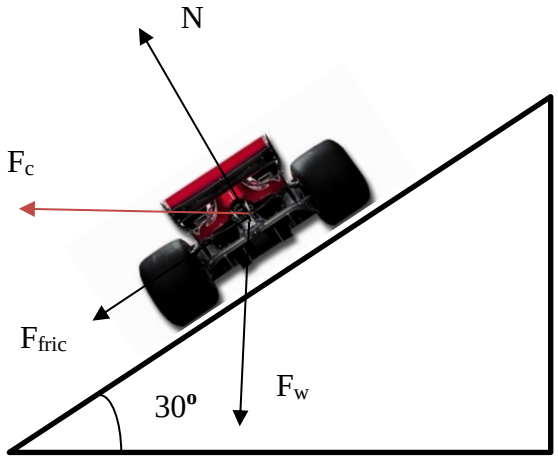
1	2	3	4	5	6	7	8	9	10
B	C	B	A	D	B	D	B	D	A
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
B	D	C	A	C	A	C	D	C	C

Section 2

Question 21 (6 marks)

a)

1	All forces acting on car correctly labelled
1	Centripetal force correctly labelled (don't need to actually say F_c)



b)

1	Sums forces in x and y direction
1	Realises $F_{fric} = \mu N$
1	Derives max speed equation
1	Correct answer

By summing forces in x and y direction, and doing a lot of algebra… you get:

$$v_{max} = \sqrt{\frac{gr(sin\theta+\mu cos\theta)}{cos\theta-\mu sin\theta}}$$

$$v_{max} = \sqrt{\frac{(9.8)(100)(sin30+0.3cos30)}{cos30-0.3sin30}}$$

$v_{max} = 32 ms^{-1}$ (2sfg)

Question 22 (12 marks)

a)

1	Correct torque
1	Correct direction

$\boldsymbol{\tau}$ = nBIAcosθ

$\boldsymbol{\tau}$ = (5)(2 x 10^{-3})(25)(0.04 x 0.04)cos0

$\boldsymbol{\tau}$ = 4 x 10^{-4} nm anti-clockwise

b)

1	Purpose- convert electrical energy to kinetic/mechanical energy
2	Explains how the DC motor functions by the motor effect, referencing both sides of the armature

c)

1	Explains how a split-ring commutator functions
1	Explains how a slip ring functions
1	Contrasts these functions
1	Proposes at least one similarity between them (e.g. they both transfer current from external circuit to the armature)

d)

2	Explains what back EMF is
1	Explains how current will be very high initially due to zero back EMF => high resistance. Reduces current to avoid overloading

Question 23 (9 marks)

a)

1	Uses $s_y = u_yt + ½a_yt^2$ and gets correct answer
1	Correct answer

$s_y = u_yt + ½a_yt^2$

$s_y = 0 + 0.5(2)(5)^2$

$s_y = 25m$

height = 25 + 10 = 35m

b)

1	Uses $v_y = u_y + a_yt$
1	Correct magnitude
1	Correct direction

$v_y = u_y + a_yt$

$v_y = 0 + (2)(5)$

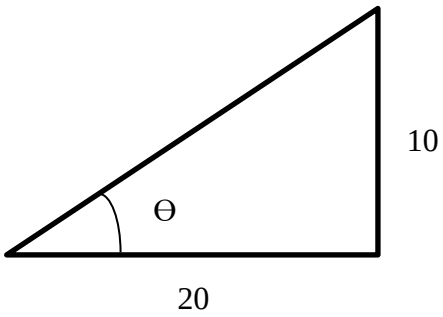
$v_y = 10ms^{-1}$

$|v| = \sqrt{10^2 + 20^2}$

$|v| = 22.36 ms^{-1}$

$\Theta = \tan^{-1}(\frac{10}{20})$

$\Theta = 26.6^{o}$



Therefore v = $22 ms^{-1}$ at 27^{o} above the horizontal

c)

1	Correct time of flight (use $s_y = u_y t + \frac{1}{2} a_y t^2$)
1	Correct range

Time of flight = 3.9s
Range = 78m

d)

1	Correct magnitude
1	Correct direction

v = $34 ms^{-1}$ at 54^{o} below the horizontal

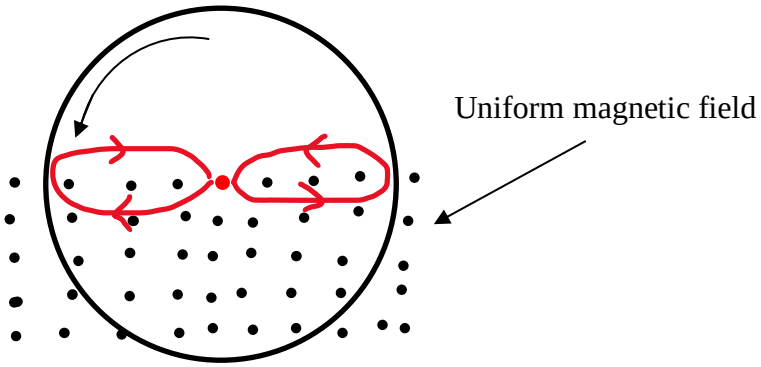
e)

1	Zero time difference

Question 24 (5 marks)

a)

1	Correct labelling of eddy currents
2	Explanation of why eddy currents form (change in flux => Faraday and Lenz)



b)

2	Explains the eddy currents converge at the centre to provide current down the metal plate towards brush Y. Hence current flows Y to X.

Question 25 (3 marks)

1	Explains one strategy
1	Explains another strategy
1	Both are linked to efficiency

Could include:

- Soft iron core- has high magnetic permeability for high flux linkage
- Laminated iron core- reduces size of eddy currents
- Wrapping primary and secondary coil on top of each other for greater flux linkage
- Cooling fins to reduce resistance and heat loss of transformer

Question 26 (5 marks)

a)

1	Correct magnitude
1	Correct direction

$F_{net} = F_e$

$ma = qE$

$a = \frac{qE}{m}$

$a = \frac{(1.602 \times 10^{-19})(\frac{10}{0.05})}{9.109 \times 10^{-31}}$

$a = 3.5 \times 10^{13}$ ms^{-2} down

b)

1	Finds that it hits the negative plate
1	Correct magnitude
1	Correct direction

(Note you could also use suvat equations to find which plate it hits)

$\Delta E_k = -W$ (work is being done in opposite direction to velocity)

$\frac{1}{2}m\Delta v_y^2 = -qV$

$\Delta v_y = -\sqrt{\frac{2qV}{m}}$

$\Delta v_y = -\sqrt{\frac{2(1.602 \times 10^{-19})(10)}{9.109 \times 10^{-31}}}$

$\Delta v_y = -1.875 \times 10^6$ ms^{-1}

And $u_y = (4 \times 10^6)\sin 30 = 2 \times 10^6$ ms^{-1}

Therefore it has enough upwards velocity to hit the negative plate, and will have:

$v_y = (2 - 1.875) \times 10^6 = 0.125 \times 10^6$ ms^{-1} whilst $v_x = (4 \times 10^6)\cos 30 = 3.464 \times 10^6$ ms^{-1}

$|v| = \sqrt{(0.125 \times 10^6)^2 + (3.464 \times 10^6)^2} = 3.466 \times 10^6 \text{ ms}^{-1}$

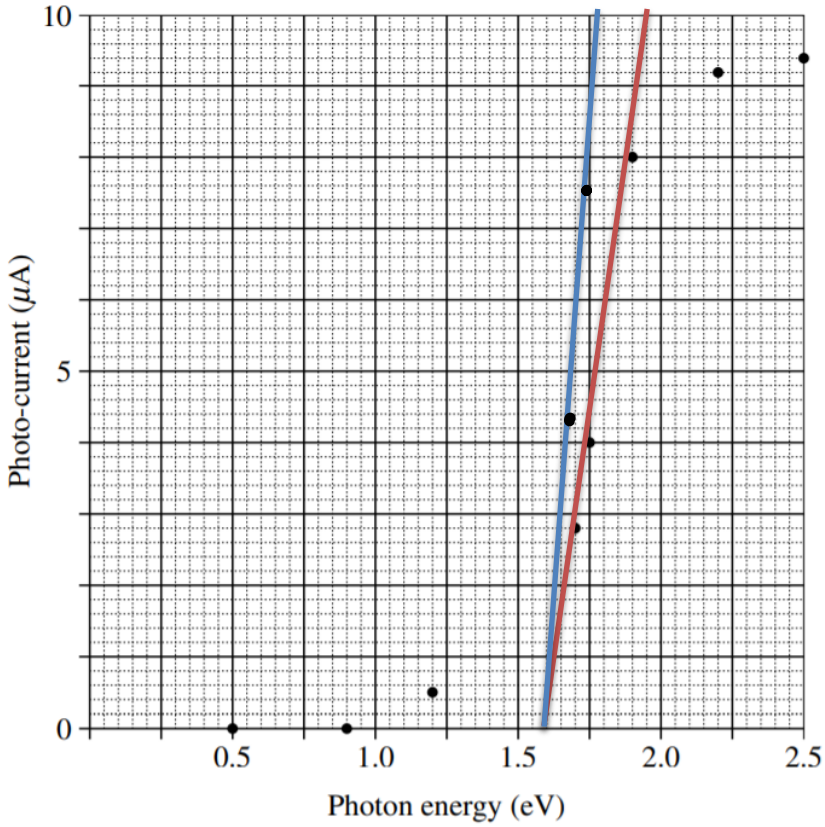
$\Theta = \tan^{-1}(\frac{0.125 \times 10^6}{3.464 \times 10^6}) = 2.07^{\circ}$

Therefore $v = 3.5 \times 10^6 \text{ ms}^{-1}$ at 2.1° above the horizontal

Question 27 (6 marks)

a)

1	Correct line (shown on graph as red)



b)

1	Correct work function (about 1.6eV)

c)

1	Line is to the left of the first line
1	Correct line with double the gradient of the first line (see blue line above)

d)

1	Explains how double light intensity will double the number of photons in the light beam
1	Links this double number of photons to double the number of electrons released and double the photocurrent

Question 28 (5 marks)

3	Explains three different characteristics which can be found

1	Identifies exactly what difference will be seen on the spectra for each characteristic
1	Specifies which spectra they are talking about in each characteristic (emission, absorption, continuous blackbody)

Question 29 (11 marks)

a)

1	Two correct
1	All three correct

Radioactive Decay	*Ionising Power*	*Penetrating Power*
Alpha	High	Low
Beta	Medium	Medium
Gamma	Low	High

b)

1	Relates charge and mass to ionising power (requires high mass and charge)
1	Relates charge and mass to penetrating power (requires low mass and charge)
1	Explain each one sufficiently

c)

1	Has electron as a product
1	Remembers to add anti-neutrino as a product

$$^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e^{-} + {}^{0}_{0}\bar{\nu}_e$$

d)

1	Correct mass defect
1	Correct energy released in **MeV**

$\Delta m = m_{reactants} - m_{products}$

$\Delta m = (14.00421-14.00307-0.00055)\ u$

$\Delta m = 0.00059u$

$E = \Delta mc^2$

$E = 0.00059 \times 931.5 MeVc^{-2} \times c^2$

$E = 0.00059 \times 931.5\ MeV$

$E = 0.55\ MeV$

e)

1	Finds the number of half-lives that have passed (or finds decay constant)
1	Finds correct age of the skull

(Note you could have instead found decay constant, but that takes a bit more time)

$(\frac{1}{2})^n = \frac{1.45}{92.8}$

$(\frac{1}{2})^n = \frac{1}{64}$

n = 6

age = n x $t_{1/2}$

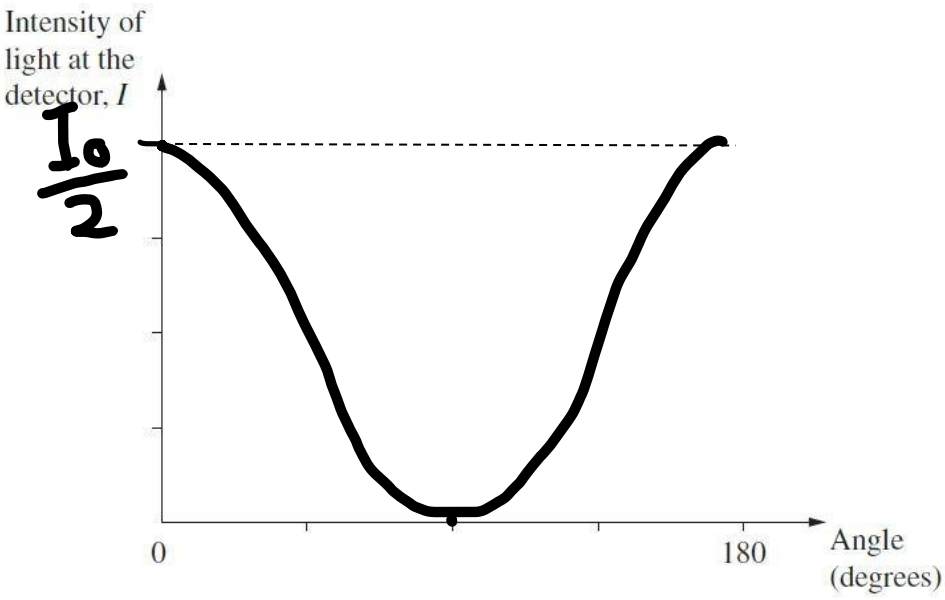
age = 6 x 5730

age = 34,380 years old (:O wow that's old)

Question 30 (4 marks)

a)

1	Has a $\cos^2\Theta$ shape
1	Maximum intensity is $(I_o)/2$



b)

1	Uses calculations or diagrams to explain why light intensity at the detector is no longer zero
1	Logical explanation

E.g. For calculation:

$I_1 = ½ I_o$

$I = I_o\cos^2\Theta$

$I_{1.5} = I_1\cos^2(30)$

$I_{1.5} = 3/8\ I_o$

$I_2 = I_1\cos^2(60)$

$I_2 = 3/32\ I_o$

Therefore light intensity at the detector is no longer zero.

Question 31 (4 marks)

2	Explains one **historical** and one **contemporary** method of measuring the speed of light
1	Uses at least one diagram
1	Contrasts at least one aspect of the two methods (easy one is accuracy)

Some historical examples
- Fizeau
- Foucalt
- Romer
- Bradley
- Michelson

Some contemporary examples
- Geodimeter
- Radio wave interferometer

Question 32 (10 marks)

a)

1	Unification of particles and waves as **matter waves**
1	States formula: $\boldsymbol{\lambda = h/mv}$
1	Explains one experiment which supported de Broglie's hypothesis
1	Uses at least one diagram to explain the experiment

Some experiment examples:
- Davisson-Germer experiment
- G.P Thomson experiment

b)

1	Correctly calculates the de Broglie wavelength of the tennis ball
2	Explains lack of wave properties due to de Broglie wavelength being so small

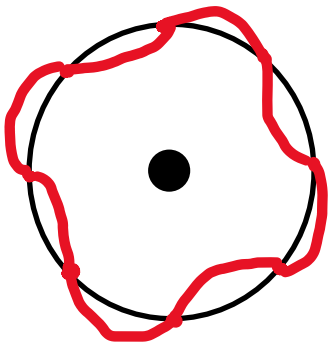
c)

1	Explains that electrons form standing waves in principal energy shells such that: $n\lambda = 2\pi r$
1	Derives $mvr = \frac{nh}{2\pi}$
1	Correct diagram for n = 4

$n\lambda = 2\pi r$

$\frac{nh}{mv} = 2\pi r$ ($\lambda = h/mv$)

$mvr = \frac{nh}{2\pi}$



For diagram:
Sub n = 4
$4\lambda = 2\pi r$, shown with four wavelengths in one orbit =>