Section I

20 marks
Attempt Questions 1–20
Allow about 35 minutes for this section

Use the Section I answer sheet for Questions 1-20.

1. Which one of the following is NOT one of Kepler's Laws?

   A) The planets move in elliptical orbits with the Sun at one focus.
   B) The line connecting a planet to the Sun sweeps out equal areas in equal intervals of time.
   C) For every planet, the ratio of the cube of the average orbital radius, *r*, to the square of the period of revolution, *T*, is the same constant, *k*, as in the equation $r^3 / T^2 = k$.
   D) The weight of an object on the Earth's surface is due to the gravitational attraction of Earth

2. A far-off star has been found to have three planets orbiting it. Information concerning these planets is shown below.

Planet	*Radius in metres*	*Period is seconds*
PK1	?	4.2×10^4
PK2	9.84×10^8	8.4×10^4
PK3	1.56×10^9	1.68×10^5

   Scientists had to determine the nearest planet's orbital radii mathematically.
   What would the calculated radii of PK1 be?

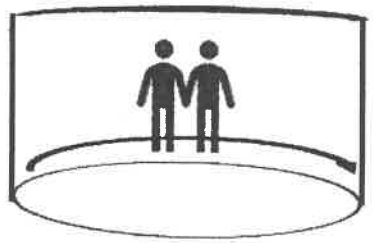
   A) 2.46×10^7 m
   B) 4.92×10^7 m
   C) 4.92×10^8 m
   D) 6.20×10^8 m

3. The reason that some electrical appliances used in the home have transformers is because they

   A) require a source of energy that is DC rather than AC.
   B) require and alternating current at a frequency other than 50 Hz.
   C) consume less energy than a similar device without a transformer.
   D) require a lower voltage than the input voltage from a power point.

Use the following information to answer questions 4 and 5.

In 1979, Mr Blunden went on the ride, The Rotor, at Luna Park and felt very ill afterwards. The Rotor consists of a drum rotating at an increasing rate, until Mr Blunden and his friends remained suspended when the floor dropped away.



4. Which statement best explains why Mr Blunden and his friends were suspended?

   A) The gravitational force balances both the centripetal force and horizontal forces.
   B) The unbalanced centripetal force from the wall pushed Mr Blunden and his friends to the wall causes them to retain their position.
   C) The horizontal frictional force, plus the gravitational force combine to hold them in place.
   D) The centripetal force, due to the drum's rotation, and the reaction force of the wall, are in balance.

5. Before the floor is lowered, the drum needs to rotate at velocity, *v*. This produces a centripetal force, F. After the floor is raised, the velocity is decreased.

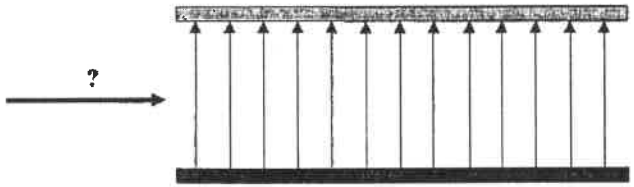
   What will the centripetal force be when the velocity reduces to *v*/2?

   A) F/2
   B) F/4
   C) 2F
   D) 4F

6. Two satellites (Annie and Claudia) are in circular orbits around the Earth. Claudia is R metres from the centre of the Earth and has an orbital velocity of V. Annie is 2R metres from the centre of the Earth. What is Annie's orbital velocity?

A) V/2
B) 2 x V
C) V/1.4
D) 1.4 x V

7. Consider the electric field between two charged parallel plates.



The shape of the resulting motion of an electron in this field and the reason for its motion is:

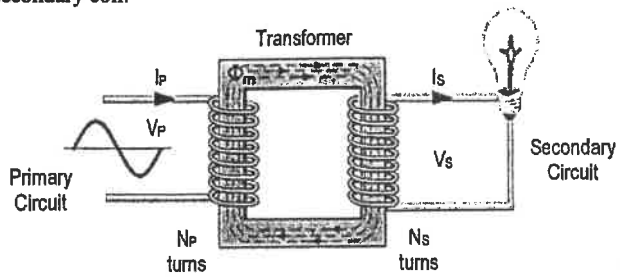
	Path shape	Reason
A)	Parabolic	Both vertical and horizontal forces are constant
B)	Parabolic	Only the vertical force is constant
C)	Circular	Both vertical and horizontal forces are constant
D)	Circular	Only the vertical force is constant

8. Two parallel plates are 2 mm apart and have a potential difference of 100 V between them. An electron is placed halfway between the plates.

What is the magnitude of the force on the electron?

A) 8.0×10^{-18} N
B) 1.6×10^{-17} N
C) 8.0×10^{-15} N
D) 1.6×10^{-14} N

9. Consider the following ideal transformer with 1 000 turns in the primary coil and 1 125 turns in the secondary coil.



If the input voltage is 240 V and current 5A, what is the voltage across the globe and the current through it? Ignore the resistance of the light globe.

A) 213.3 V, 5.6 A
B) 213.3 V, 4.4 A
C) 270 V, 5.6 A
D) 270 V, 4.4 A

10. However, no transformer is ever ideal because of:

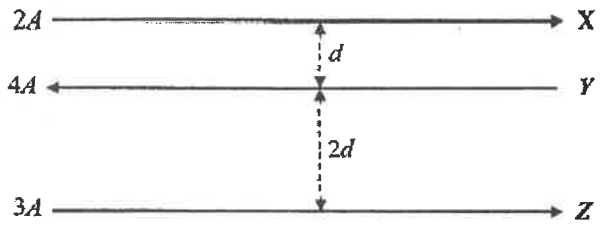
A) Incomplete flux linkage between the primary and secondary coils.
B) Resistive heating in the soft iron core.
C) The production of sound.
D) All of the above.

11. A laser with unknown wavelength is bought from a market stall. It is pointed through a card that has a small pair of slits cut 90μm. A wall is 6 m from the card. When the laser is shone through the slits, bright spots appear on the wall and are measured to be 3 mm apart.

The wavelength of the laser is

A) 427 nm
B) 429 nm
C) 450 nm
D) 459 nm

12. Three current-carrying wires are set up as shown below. The force on wire *Y* due to the other two wires is *F*.



What will happen to the force on Y if the currents in X and Z are both doubled, but the distances remain constant?

A) It will become *F*/2.
B) It will be the same value, but in the opposite direction.
C) It will become 2*F*.
D) It will become 4*F*.

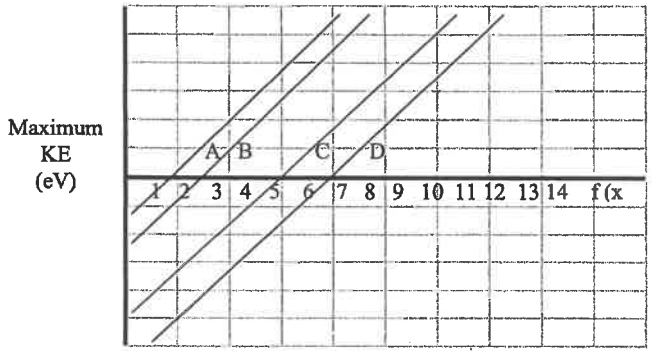
13. Which statement does not relate to evidence that validated Einstein's thought experiments for time dilation and length contraction?

A) Evidence from particle accelerators
B) The results of the Hafele–Keating experiment
C) Early experiments with cathode rays operating in a vacuum
D) Observations of the life of muons that enter the Earth's atmosphere

14. What did James Clerk Maxwell discover through the unification of the theories of electricity and magnetism?

A) Light is a mechanical wave.
B) Light is composed of corpuscular particles.
C) Light is a form of electromagnetic wave.
D) Light travels slower in denser materials.

15. The graph below shows the relationship between the frequency and kinetic energy of electrons emitted by four different metals (A, B, C and D) when they were exposed to light.



What is the wavelength of a photon of light that supplied the threshold frequency for Metal D?

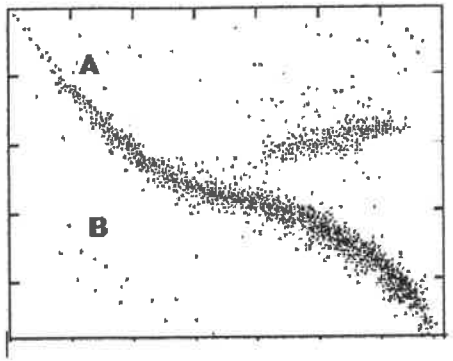
A) 3.75×10^{-7} m
B) 8.00×10^{-14} m
C) 2.66×10^{-7} m
D) 1.8×10^{-14} m

16. The star Rigel emits a continuous electromagnetic spectrum with a peak wavelength of approximately 550 nm.

The surface temperature of Rigel is approximately

A) 5 269 K
B) 5 169 K
C) 5 269 K
D) 6 000 K

17. Below is a Hertzsprung- Russel diagram.



Which group correctly compares the luminosity and surface temperature of stars plotted at positions A and B?

	Stars at A		*Stars at B*	
	Luminosity	*Temperature*	*Luminosity*	*Temperature*
A.	Low	Low	High	High
B.	Low	High	Low	Low
C.	High	Low	Low	Low
D.	High	High	Low	High

18. The signal from a microwave transmitter can be thought of as a beam of photons.

If the photons from the transmitter have a wavelength of 3.5×10^{-2} m, what is the approximate energy of each photon?

A) 5.68×10^{-24} J

B) 1.89×10^{-32} J

C) 2.32×10^{-35} J

D) 7.73×10^{-44} J

19. In which type of star is the CNO cycle the predominant nuclear reaction?

A) Red giant

B) Red giant

C) Low main sequence

D) High main sequence

20. Which of the following contains all the quantities that are required to determine escape velocity?

A) Mass of the rocket and the planet

B) Mass of the rocket and the planet, and the radius

C) Mass of the planet, radius and universal gravitational constant

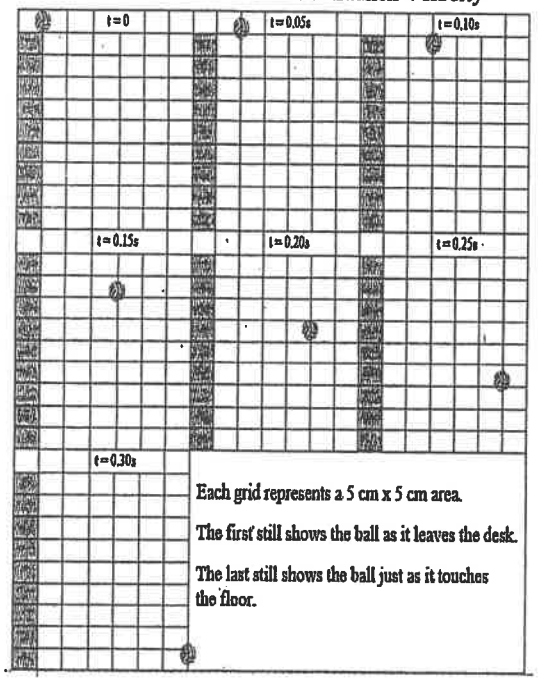
D) Mass of the rocket and the planet and universal gravitational constant

Question 21 (6 marks) LP

Max and Caleb conducted an experiment to analyse the motion of projectiles. They used their phones to film a ball rolling off a desk with various horizontal launch velocities. They used a large, scaled grid for the background.

The picture below shows the consecutive photographic 'stills' they produced for their first launch velocity. The time between each frame is 0.05 seconds.

The Seven Stills of the First Launch Velocity



a) Calculate the ball's first launch velocity. 2

horizontal velocity, $V_x = d_x / t$

$d_x = 6 \times 0.05\ m = 0.3\ m$, $t = 6 \times 0.05\ s = 0.3\ s$

$V_x = 0.3\ m / 0.3\ s = 1.0\ m\,s^{-1}$

b) Calculate the range of the ball if it is launched at 3 ms^{-1} horizontally. 2

* $t = 0.3\ s$, $V_x = 3\ ms^{-1}$

other $R = V_x \times t = 3\ ms^{-1} \times 0.3\ s$

$= 0.9\ m$.

R * $s = ut + \frac{1}{2}at^2$, will accept this method if you have used it correctly.

Question 21 continues over page...

uestion 21 continued...

b) Outline a source of error that could impact on the accuracy of the Max and Caleb's results. 2

① The phone might not be properly calibrated - will give inaccurate time or false picture of the ball's movement.

② "Parallax" will not be accepted without a clear justification.

Question 22 (7 marks) LP

a) Beginning with Newton's law of gravitation, derive an equation for the orbital velocity, v, of a satellite orbiting a planet of mass M at radius r. 2

In orbit, $F_c = F_g$

$mv^2 = GMm/r^2$

$v^2 = GM/r$, $v = \sqrt{GM/r}$

b) Show that the total energy of an orbiting satellite is half of its gravitational potential energy. 2

$U = -GMm/r$, $K = \frac{1}{2}mv^2$

$K = \frac{1}{2}m \cdot GM/r = \frac{1}{2}GMm/r$.

$E_{Total} = U + K = -GMm/r + \frac{1}{2}GMm/r$

$= -\frac{1}{2}GMm/r = U/2$.

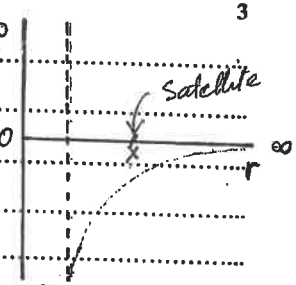
c) Fully explain, with the aid of a diagram, why the gravitational potential energy of an orbiting satellite is negative. 3

• At an infinite distance E_p is zero ($E_g = 0$)

An object brought from infinite distance into a point in the gravitational field is negative; $E_p = -GMm/r$

∴ A satellite at point X in the gravitation will have

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



① • Diagram

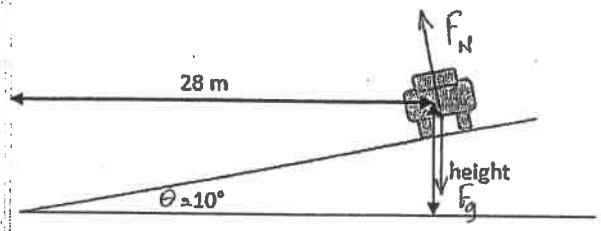
• Explains why E_p is -ve ①

• Relates $-E_p$ to orbiting satellite ①

• diagram ①.

Question 23 (4 marks) LP

Dr Chilwell is driving his car of mass 1,800 kg around a track at 20 ms^{-1} at a radius of 28 metres.



If there is no friction between his tyres and the track, what speed must Dr Chilwell drive so that his car maintains its current height on the track at that speed? 4

$F_c = mv^2/r$

(1) $mv^2/r = F_{net} = F_g \tan\theta$

$F_g = mg$

$mv^2/r = mg\tan\theta$

1 $v^2 = rg\tan\theta$

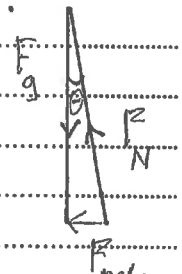
$v = (rg\tan\theta)^{\frac{1}{2}}$

$= (28 \times 9.8 \times 0.176)^{\frac{1}{2}}\ ms^{-1}$

$= 6.96\ ms^{-1}$

1 $= 7\ (ms^{-1})$

(1)



Any one correct / relevant formula (1)

Substitution & working (1)

Correct answer (1)

Correct unit (1)

Question 24 (3 marks)

Tejas and Anurag carried out an experiment measuring the velocity of an 0.1 kg object in uniform circular motion for six different radii, while keeping the centripetal force constant. Their results are shown in the table below. !!

Radius of turn (cm)	*Velocity ($m\,s^{-1}$)*
10	1.48
20	2.10
30	2.60
40	2.97
50	3.32
60	3.63

Their challenge was to use all of the results to determine the constant centripetal force.

Explain how you would calculate the centripetal force. Formulae may be used, but calculations are not required. 3

(1) use $F_c = mv^2/R$ to get $F_c/m = V^2/R$ = Constant
(no mark in its own) or $V^2 = (F_c/m)\,R$

(1) Convert cm → m

(1) LBF or Average

(1) Discuss outlier from either
- LBF - & state outlier is far from line.
or Average - By finding constant V^2/R for each radius and then averaging - as V^2/R is constant, then these numbers should all agree and outlier is one far from the others

Vague statements such as 'ruling out outliers' or 'determine range of errors' without explanation are not accepted.

Question 25 (3 marks)

Muons travel through the atmosphere at a speed of 0.998c. The mean lifetime of a stationary muon is 2.2μs.

Explain why Caleb was surprised that a significant percentage of the muons, which formed at an altitude of 90 km could reach the surface of the earth. 3

[3 MARKS] - Full and Correct application (as Below) with γ and Frame of Ref [FoR]

[2 marks] - Some general attempt including finding γ.

[1 mark] - " " " without " γ

$\gamma = \frac{1}{\sqrt{1-v^2/c^2}} = (1-0.998^2)^{-1/2} = 15.8$ $t_0 = 2.2\mu s$

What Caleb expected.

EFoR: time

- Classical time to reach Earth = $d/v = \frac{9\times10^4}{3\times10^8} = 300\mu s \Rightarrow \frac{300}{2.2} = 136$ lifetimes
- Relativity $t_v = \gamma t_0 = 15.8\times2.2 = 35\mu s \Rightarrow \frac{35}{2.2} = 8.6$ lifetimes (time dilation)

So Caleb can now see that a lot more muons can reach Earth.

or can find how far muon travels in a lifetime.

- classically distance travelled in $2.2\mu s = 2.2\times10^{-6}\times0.998\times3\times10^8 = 660$m.
- Relativity $s = vt = 0.998\times3\times10^8\times35\times10^{-6} = 10,479$m $(= \frac{90,000}{10,479} = 8.6$LT)

Muons FoR:

classically distance to Earth = 90,000 km — distance in $2.2\mu s = 660$m

Relativistically length contraction $L_v = L_0/\gamma = \frac{90,000}{15.8} = 5,696$ m.

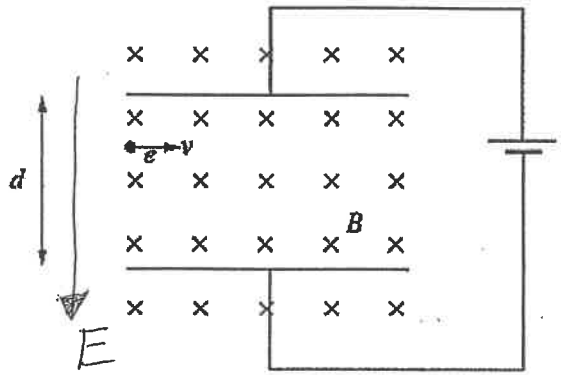
∴ Muon thinks it will take $5,969/660 = 8.6$ LT

or t to reach Earth $L_v/v = \frac{5.676\times10^3}{0.998\times3\times10^8} = 1.90\times10^{-5}$s $= 19\mu s$.

Note. Keep in μs don't use 5×10^{-4}s then go μs etc.

Question 26 (5 marks)

Two parallel charged plates are set up at a distance, *d*, from one another as shown in the diagram below:



The magnetic field strength, $B = 0.02\ T$, the electron's velocity, $v = 3.5\times10^6\ ms^{-1}$, and the distance between the plates, $d = 5mm$.

a) Indicate on the diagram the direction of the electric field that will act on the electron moving between these plates. see diagram. 1

b) Calculate the force on the electron due to the magnetic field. 2

$F = qvB\sin\theta$

$= 1.602\times10^{-19}\times3.5\times10^6\times2\times10^{-2}\times\sin90$

$= 1.121\times10^{-14}$

$= 1.12\times10^{-14}$ (UP) downwards

(1) (1)

Question 26 continued...

c) Calculate the voltage that needs to be supplied to the plates to keep the electron traveling in a straight path, parallel to the plates. 2

$qE = qvB$; $E = vB$; $E = V/d$

$\therefore V = dvB = 3\times10^6\times2\times10^{-2}\times5\times10^{-3} = 350V$

(or use previous ans (b) - BUT use all figures, NOT rounded off.)

(1) - Equation

(1) - correct answer.

Question 27 (3 marks)

Two straight metal rods, *P* and *Q*, have the same length. They are each pivoted at one end and rotate with the same angular velocity so that they sweep out horizontal circular paths as shown in Diagrams X and Y. A constant current, *I*, is flowing along each rod, as shown.

In diagram X, a constant magnetic field is applied *at right angles to the plane of the circular path.* In diagram Y, a uniform magnetic field of the same magnitude is applied *in the plane* of the circular path.

Circle is the path if it is not a wire

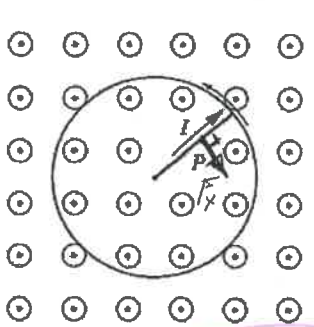


Diagram X

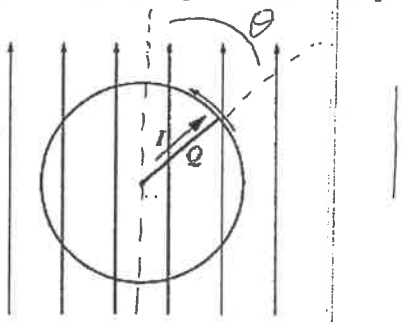


Diagram Y

FORCE IS a MAGNITUDE and a DIRECTION

Compare the forces acting on the wires in Diagram X and Diagram Y and explain why that is the case. 3

① 'E' – Explains Motor Effect $F = BIL\sin\theta$ (common)

① 'D' Direction of force (need both correct)

F_x is 'in the plane' of the motion, see diagram.

F_y is 'out of the plane' of motion, perpendicular to the plane,

→ Out of page θ = ~~range~~ 0 to 180°

→ into page θ = 180 – 360°

($\theta = 90°$ and $-90°$ then $F_y = 0$) (0 when ∥ to each other)

① 'm' Magnitude of Force (need both correct)

→ $|F_x|$ = constant BIL^{16} (as $\sin\theta = 1$)

→ $|F_y| = BIL\sin\theta$, it varys sinusoidally with θ.

Note Lenz's Law is not need/applicable to this question.

∴ Lenz's law isn't a proof ∵ cons. of energy

Question 28 (4 marks)

George placed a strong magnet above a circular copper disc, as shown in the diagram below. The disc is free to rotate, but not free to tilt or fall off the point.

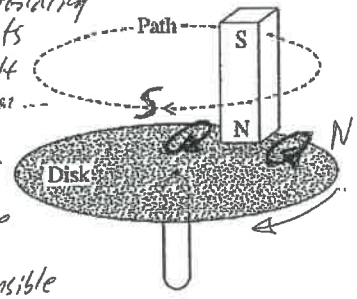
4 marks. correct and clear understanding of order of events w Faraday, $\Delta\Phi/dt$, Lenz, conduction ...

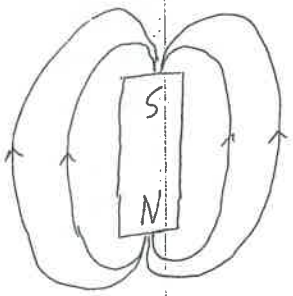
3 marks as 4, but some muddle/unclear

2 marks as 3 but worse

1 mark something nonsensible

* Lose marks for incorrect/contradictory statements.





Explain clearly what happens as the magnet rotates above the thin copper disc and why this occurs. 4

- Cu Disk is a conductor (electrical)
- Moving Magnet's field gives $\Delta\Phi/dt$ increasing in front of magnet
  $\Delta\Phi/dt$ decreasing behind magnet
  ($\Delta\Phi/dt \cong 0$ beneath magnet)
- $\Delta\Phi/dt$ occurs on sections of the disk (just in front & behind)
- $\Delta\Phi/dt$ induces ~~induces~~ a EMF in disk (Faraday's Law)
- EMF induces eddy currents
- Circulating eddy current produces magnet poles (see diagram) R
- By Lenz's Law the current will produce poles to oppose the movement of the disk ∴ N in front & S behind (see diagram)
- But magnet is being Forced to move, ∴ N pushes N and N attracts S, and as disk is free to move, it will rotate in the same direction as the magnet. –/1 mark iff has some justification)

Note • $\Delta\Phi/dt$ → EMF ; Not current ; EMF drives current in conductor

• Vague statements "Lenz's law opposes" is not ~~often~~ sufficient – explain

• "Lenz's Law 'opposes' to ensure conservation of energy" is not good; rather if it 'promoted' then that would violate cons. of energy

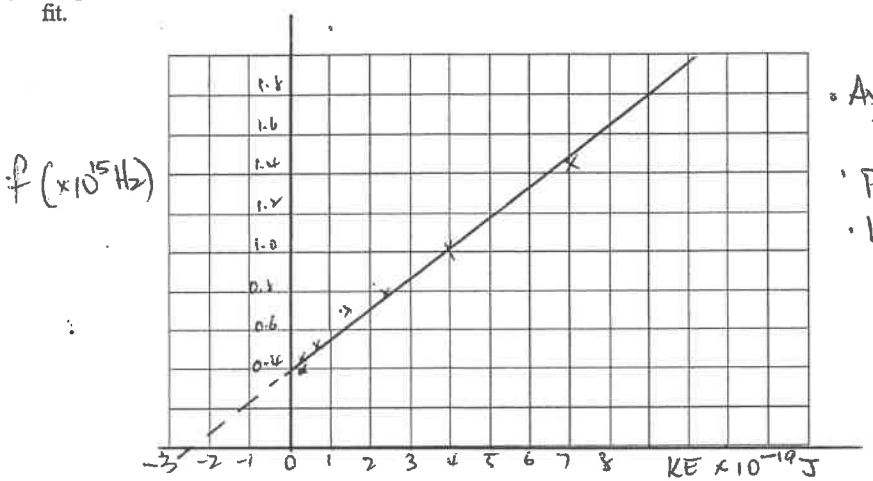
↳ If it didn't oppose it would violate laws of cons. of energy

Question 29 (7 marks)

Balaji conducted a photoelectric effect experiment in class to measure the work function of a photo emitter. His results are shown in the following table.

Wavelength of light (nm)	*Frequency of light (x 10^{15} Hz)*	*Energy carried by each photon (eV)*	*Kinetic energy of emitted electrons (x 10^{-19} J)*
200	1.49	6.21	7.30
300	1.00	4.09	3.97
400	0.76	3.10	2.33
500	0.59	2.50	1.34
600	0.50	2.02	0.66
700	0.43	1.77	0.23

a) Graph the kinetic energy on the *x* axis against the frequency of light on the *y* axis. Include a line of best fit. 3



- Axes with scale Factor
- plot
- L of BF.

b) Use your graph from part a) to determine the work function of the emitter. Express your answer in eV. 2

Work function = 2.75×10^{-19} J EXTRAPOLATE

Convert J to eV.

$\Rightarrow \frac{2.75 \times 10^{-19}}{1.6 \times 10^{-19}} = 1.72$ eV or Similar

GRAPH MUST be USED — by a point on the line / Extrapolation.

c) Use your graph from part a) to determine a value for Planck's constant. Show your working. 2

gradient is $1/h$, $h = 0.15 \times 10^{-34}$ (working) ① gradient ① Answer

$= \frac{1}{0.15 \times 10^{-34}}$

$= 6.67 \times 10^{-34}$ Js.

Question 30 (7 marks)

a) Rutherford's model of the atom was based on results of experiments carried out by Geiger and Marsden.

Outline Geiger and Marsden's experiment and discuss how their results led to Rutherford's model of the atom. 4

EXPT — ① → almost no deflection

RESULTS — ACTUAL / EXPECTED ① → significant deflection

IMPLICATION ① ⇒ NEW MODEL

& : show the link

COHERENCE OF ARGUMENT ① → +ve central mass, central only

b) Draw labelled diagrams of Rutherford's model of the atom following these experiments and a labelled diagram of the model that it replaced. 2

Rutherford's model	Previous model's name: Thomson
Labelled positive nucleus orbiting electrons	positive "glue" embedded electrons distributed throughout

c) Outline Chadwick's contribution to our understanding of the nature of the atom. 1

— discovered neutron ⇒ Contributed to our understanding by explaining - stability of nucleus ①

- mass discrepancy.
- same mass of p+

Question 31 (5 marks)

Throughout history, light has been a mystery that people have tried to explain. During the 1700s, the two prominent scientists, Newton and Huygens, feuded over their different hypotheses of the nature of light.

a) Compare Newton's and Huygens' models of light, stating the major difference between them. 3

	Huygen (wave model)	Newton (corpuscular)
MAJOR DIFFERENCE	= WAVE =	= PARTICLE =
REFLECTION	✓	✓
REFRACTION	✓ SLOW DOWN	✓ SPEED UP
INTERFERENCE	✓	×
DIFFRACTION	✓	×

MAJOR DIFFERENCE CORRECTLY STATED ①
COMPARISON – related to hypotheses (TESTABLE) – ① – ①

b) State whose model was found to be correct and what evidence supported it. 2

In Context of Question: Huygen ① ⇒ FOUCAULT/FIZEAU SPEED OF LIGHT THROUGH DENSER MEDIUMS = SLOW DOWN. ①

OTHER ANSWERS ACCEPTED.

Question 32 (3 marks)

a) Neil replicates Young's double slit experiment where interference fringes are formed on a screen.

With the aid of an equation, describe and explain the effect on the spacing on the screen between the interference fringes if Neil increases the separation between the slits. 2

① Appropriate equation $d \sin\theta = m\lambda$ or a variation

① ↑ slit separation → distance b/w fringes ↓ (since $\sin\theta$ ↓)

b) State one important change that would occur to the pattern on the screen if one of the slits was covered. 1

* any legit Δ = ①

- central max shifts position $\frac{d}{2}$
- anything else legit.
- no envelope in 1 slit pattern
- fewer maxima & minima NB NOT no interference occurs.

Question 33 (4 marks)

a) A massive star is losing mass at a rate of $5.6 \times 10^9 \text{ kgs}^{-1}$

How much energy is being produced per second? 2

① – $E = mc^2$

$= 5.6 \times 10^9 (3 \times 10^8)^2$

$= 5.04 \times 10^{26}$ J ① NB accepted Js^{-1} but not 'Watts'

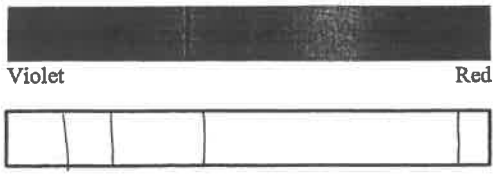
b) The Sun is a typical main sequence star. Briefly outline the life cycle of a star such as the Sun, from the moment that it enters the main sequence. 2

① Main sequence → Red Giant → White Dwarf
(expansion) (contraction)

① Additional relevant info that adds a more detailed description

Question 34 (4 marks)

The diagram below shows the spectrum of light received from the star, Alpha Maleius.



all 4 lines correct.

a) Astrophysicists on Earth deduced that the star is moving towards Earth.

Explain how this spectrum was formed and how the astrophysicists were able to determine that the star was moving towards Earth. 3

① How an absorption spectra is formed.

- certain λ (e.g.) absorbed → e^- ↑, then ↓, then emits particular frequencies of EMR

① ID as absorption spectrum

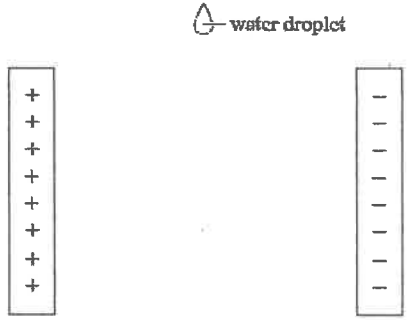
① blue shift = moving towards E.

b) In the box above, draw where the four spectral lines would be if the star is observed from a planet slowly orbiting that star. 1

See above

Question 35 (6 marks)

A dropper bottle was used to release a single drop of water between two vertical charged parallel plates. The drop of water fell straight down at an initial velocity of 0.30 ms^{-1}. The average drop of water has a mass of 2.2×10^{-2} kg and a charge of -1.9 μC. The field between the plates is 7 000 Vm^{-1}. The apparatus is shown below. Ignore acceleration due to gravity and air resistance.



a) Calculate the acceleration of the water droplet between the plates. 3

$F = qE$ $F = ma$

$= -1.9 \times 10^{-6} \times 7000$ $0.0133 = 2.2 \times 10^{-2}(a)$

$\therefore F = 0.0133$ N ← $\therefore a = 0.6\ ms^{-2}$ ←

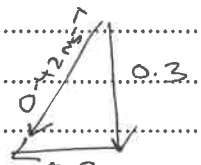
① working ① = correct answer ① direction

b) Calculate the velocity of the water droplet 0.5s after it enters the field. 3

$v = u + at$

$= 0 + 0.6(0.5)$ ① working

$= 0.3\ ms^{-1}$ ← ① mag. of answer



$\tan\theta = \frac{opp}{adj}$ ① UNAMBIGUOUS direction

$= \frac{0.3}{0.3}$

$= 45°$

$a^2 + b^2 = c^2$

$0.3^2 + 0.3^2 = c^2$

$\therefore c = 0.42\ ms^{-1}$

$\Rightarrow 0.42\ ms^{-1}$ 45°

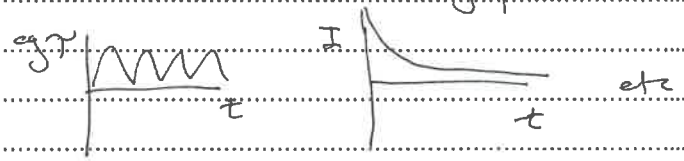
Question 36 (9 marks)

Explain fully the structure and operation of a DC motor. In your answer, include ONE labelled diagram of the motor and TWO relevant graphs. **9**

DIAGRAM (D)
- All components present ①
- All " labelled ①

magnets
coil / armature
S.R.C.
brushes

GRAPHS (G)
1 = one legit graph or an attempt
2 = 2 RELEVANT graphs ± error(s)
3 = 2 " + correct graphs



OPERATION (O)
- ① motor effect applied to the motor → turns / torque + split ring commutator function
- ① Back EMF produced / inductis
- ① → Motor runs at a constant speed. (if not Δ load) limiting max speed.

RELATES TEXT TO DIAGRAM / GRAPHS (R)
- Yes ①
- No ⓪

END OF PAPER

& think & address Q.
9 marks = 15 min
→ a bit of time planing (structure, what you're going to write)

When you turn on the motor, current starts at max ∴ NO back EMF

Graph
- I vs t
- I vs t
- F vs t

} do the easy ones / obvious ones.
→ markers are trying to mark the paper quickly.

D 1
G 2
O 2
R 1