ACE

Name: Daniel Borbarshi

Subject: Physics

Class: Vonathy Tues

2020 **HIGHER SCHOOL CERTIFICATE EXAMINATION**

Section I

Multiple Choice Answer Sheet

Instructions

- Write using black pen.
- Answer Questions 1–20 only on this answer sheet.
- Select the alternative A, B, C or D that best answers the question.
- Fill in the response oval completely.
- If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.
- If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer with a labelled arrow.

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**

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2020 HIGHER SCHOOL CERTIFICATE EXAMINATION

Name: Daniel Bocdachi

Class: Jonathy

Physics

Section II Answer Booklet

80 marks

Attempt Questions 21–32

Allow about 2 hours and 25 minutes for this section

Instructions

- Write your Name and Class at the top of this page.
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Please turn over

Question 21 (4 marks)

A laptop charger, which typically delivers 12 V AC to a laptop computer whilst charging it, is intended for use in Australia using a 240 V AC powerpoint.

(a) Identify the type of electrical device the laptop charger is. **2**

Step down transformer with a $V_p : V_s = 20 : 1$

(b) The laptop typically draws 30 W of power when being charged. **2**

How much current is being drawn from the powerpoint whilst being charged?

$P = VI$

$30 = 240 \times I$

$I = 0.125\ A$

Question 22 (6 marks)

Low Earth Orbits are circular orbits around the Earth that are utilised by many satellites.

(a) Identify ONE use of a Low Earth Orbit satellite and relate it to its properties. **2**

GPS/Navigation → as the period of a Low Earth Orbit satellite ≈ 24 hours, this means that the satellite hovers over 1 point on the Earth's surface, meaning it views the same area of Earth constantly, making it easy to standardise GPS

(b) Calculate the change in gravitational potential energy ΔU, experienced by a satellite of mass 550 kg launched from the surface of the Earth into a circular orbit with an altitude of 750 km. **4**

$\Delta U = \left(-\frac{GMm}{r_f}\right) - \left(-\frac{GMm}{r_i}\right)$

$= GMm\left(\frac{1}{r_i} - \frac{1}{r_f}\right)$

$= (6.67\times10^{-11}) \times 6\times10^{24} \times 550\,kg \left(\frac{1}{6.371\times10^{6}} - \frac{1}{6371\times10^{6}+750\times0^{3}}\right)$

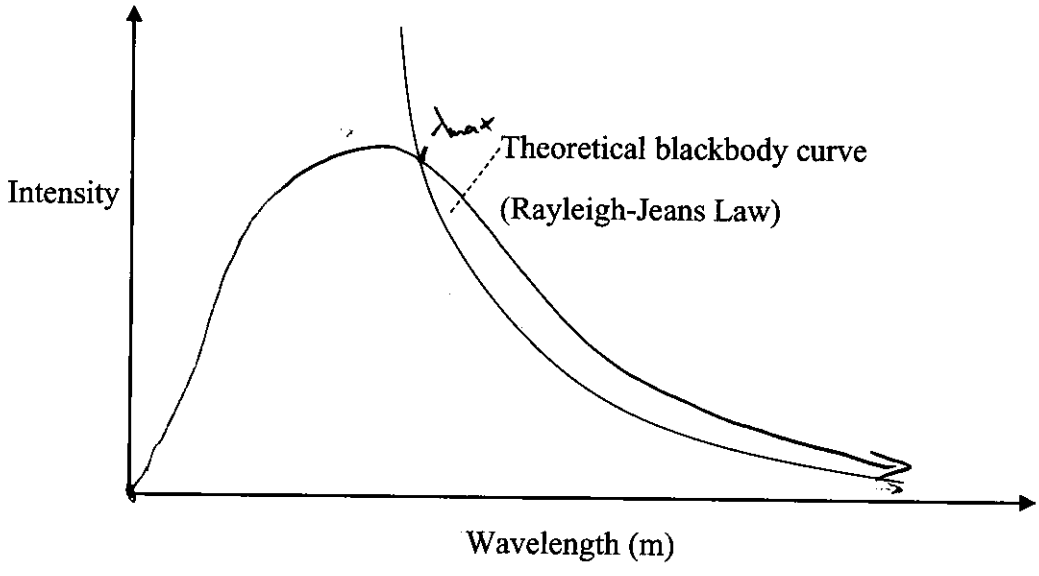
$= 3638751909\ J$

$\approx 3.6\times10^{9}\ J$

$\approx 3.6\ GJ$

Question 23 (6 marks)

Before the development of modern physics, classical physics described the theoretical relationship between intensity and wavelength of radiation emitted from a blackbody via a curve known as the Rayleigh-Jeans law, depicted in the graph shown below.



(a) Draw a typical experimental blackbody curve on the graph shown above. **1**

(b) Discuss, using physics principles, the main limitation associated with the theoretical blackbody curve. **3**

The theoretical black body curve states that as $\lambda \propto \frac{1}{I}$ as $\lambda \to 0$, $I \to \infty$. This means as wavelength approaches zero, the emitted radiation from the black body reaches infinite, breaking the law of conservation of energy as infinite energy is impossible. This means the classical theory was wrong in this case $\lambda_{max} \propto \frac{1}{I}$ is the only case where Rayleigh-Jeans Law holds, peak wavelength

and as

Question 23 continues on page 16

Question 23 (continued)

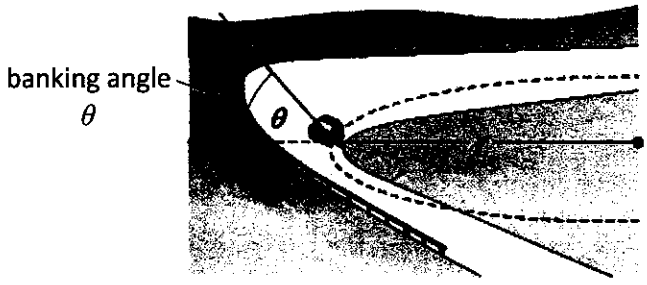
(c) Briefly outline Planck's contributions to developing our understanding of blackbody radiation. **2**

Planck hypothesized that energy emitted from a black-body was emitted in certain quantities, or quanta. He described the radiation, including light were pachets of energy with a set energy. The dip in the curve meant that there were lower probabilities of an wave being emitted with that high energy/intensity, ~~showing~~ explaining the black body curve anomaly.

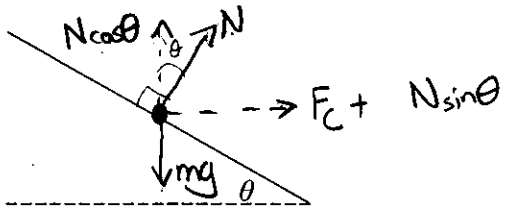
End of Question 23

Question 24 (6 marks)

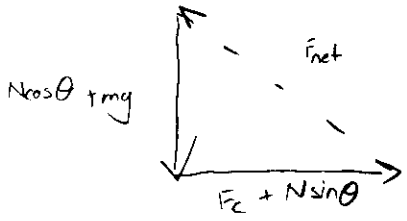
A car is travelling along a road banked at an angle of θ to the horizontal. The radius of curvature is r, as shown in the diagram below.



(a) Draw a free body diagram of all the forces acting on the car as it traverses the banked road, in the space provided below, ignoring the effects of friction. **3**



(b) Hence, or otherwise, show that the maximum speed the car can travel without skidding is given by: $v = \sqrt{rgtan\theta}$ **3**



$N\cos\theta = -mg$

$F_{x_{net}} = 0 = N\cos\theta + mg$ ①

$F_{y_{net}} = 0 = N\sin\theta + F_{C_{in}}$

$N\sin\theta = \frac{+mv^2}{r}$ ②

② ÷ ①

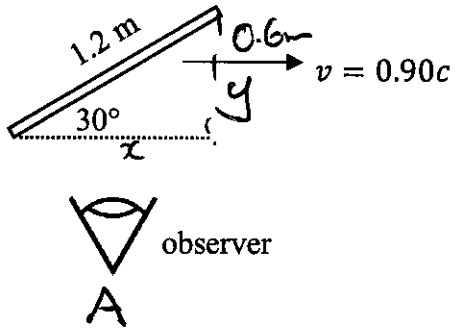
$\frac{N\sin\theta}{N\cos\theta} = \tan\theta = \frac{\frac{+mv^2}{r}}{+mg} = \frac{v^2}{gr}$

$v^2 = grg\tan\theta$

$v = \sqrt{grtan\theta}$

Question 25 (5 marks)

A 1.2 m long rod moves at a speed of 0.90c towards the right past an observer as shown in the diagram below.



The rod is inclined at an angle of 30° to the horizontal.

Explain how the rod would appear to a stationary observer. Include all relevant calculations in your answer. **5**

Length parallel to observer: $\cos 30 = \frac{x}{1.2}$, $x = 1.04\text{m}$

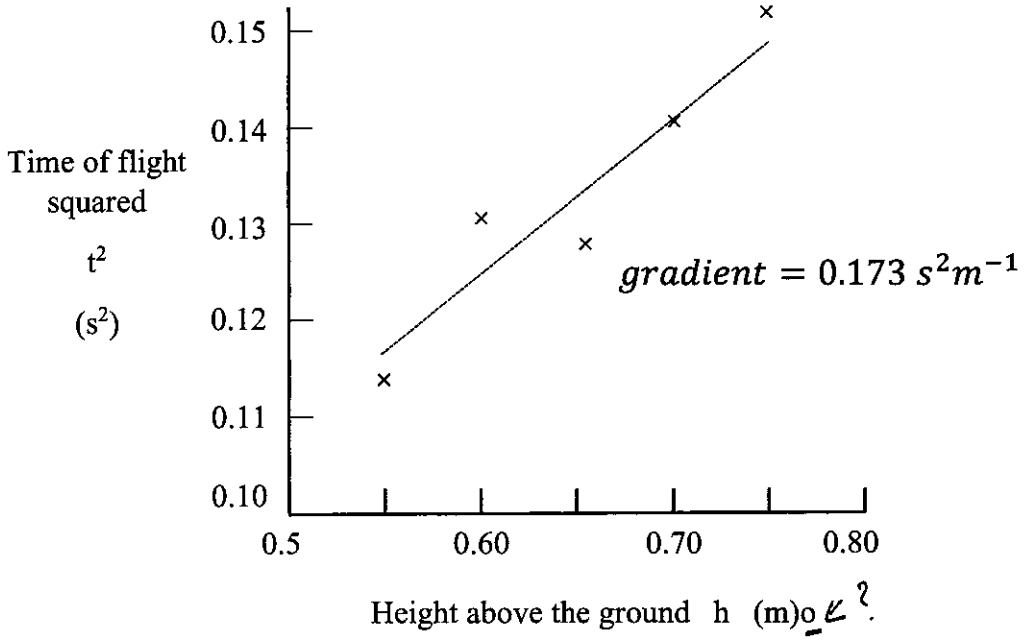
$l = l_0\sqrt{1 - \frac{v^2}{c^2}} = 1.04 \times \sqrt{1 - 0.9^2} = 0.45\text{m}$

As the rod moves perpendicular to the observe at an incline, the only dimension that appears contracted by Einstein's theory of special relativity is the side denoted x from if the rod was stationary relative to A, its rest length would be 1.04m. However, due to the relativistic speed it travels at, its length contracts to 0.45m in x with $y = 1.2\sin 30 = 0.6\text{m}$. This means that the length observed of the rod is shortened in the x direction only, not y, making the new length $\sqrt{0.45^2 + 0.6^2} = 0.75\text{m}$

Question 26 (8 marks)

A student designs a simple experiment to measure the value of the acceleration due to gravity, g, using a golf ball in free-fall motion and the equation $t^2 = \left(\frac{2}{g}\right)h$.

- The golf ball is dropped from a height h above the ground, measured using a metre ruler.
- The time of flight t taken for the ball to drop to the floor is measured using a stopwatch.
- The student repeats this for five different values of h.
- The results are plotted on the graph shown below.



(a) Is the experimental method outlined above a valid one? Justify your answer. **2**

The experiment was invalid as using a stopwatch instead of a stop-motion camera means there is a consistent error of ±0.2s, meaning that as it is not accounted for, it is a variable that is not controlled. & Furthermore 5 values are not enough to make an experiment valid when its results are very scattered.

Question 26 continues on page 20

Question 26 (continued)

(b) Discuss the accuracy and reliability of the experimental results. 4

The experiment was inaccurate as the gradient $0.173 = \frac{2}{g}$, $g \approx 11.56 ms^{-2}$ from this experiment, ~~was~~ an $g \approx 9.8 ms^{-2}$ this means the value of g was off by 17%, meaning that it was highly inaccurate as it did not come close to the expected value. The experiment was not reliable as there was a large scatter from the line of best fit, showing the large inconsistencies in the results. Furthermore, these results were not repeated and therefore not averaged, making the experiment highly unreliable

(c) Explain ONE strategy the student could implement to improve the accuracy of the experimental results. 2

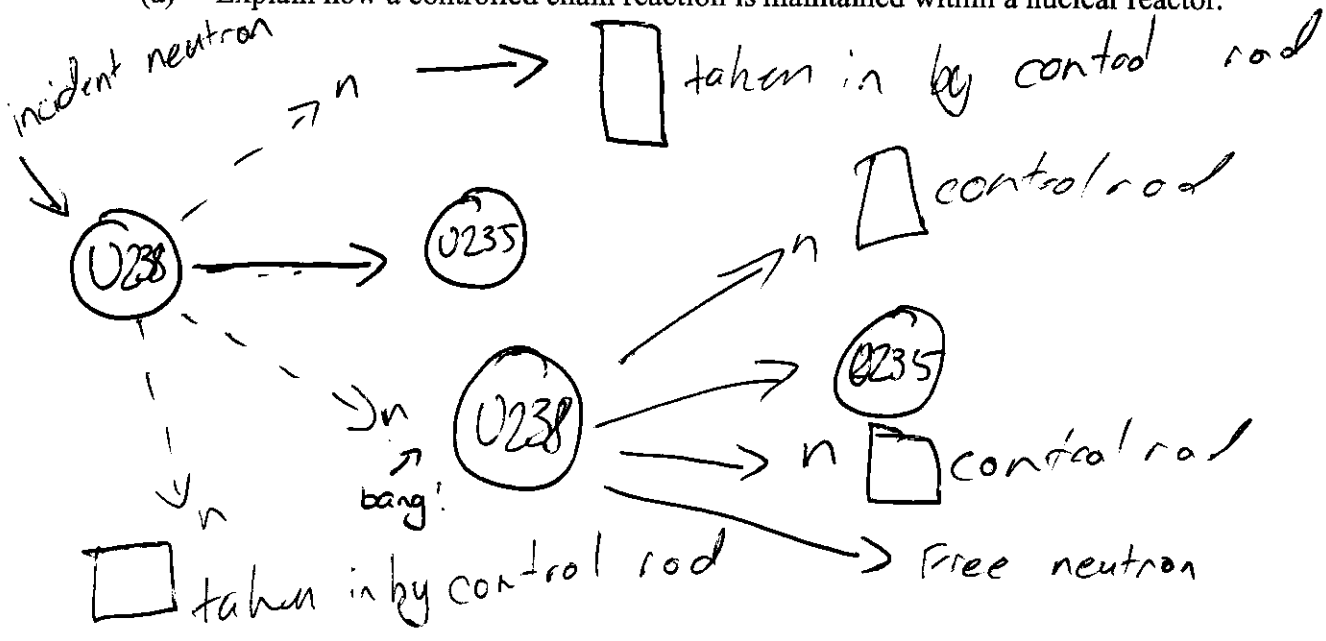
Increasing the height of the drop. This allows for a greater t^2 and therefore the larger data values can minimise the variations from timing errors, human reaction time, etc. This would even out the results and make the experiment much more accurate due to smaller experimental variation

End of Question 26

Question 27 (8 marks)

Nuclear reactors are commonly used in order to produce energy from nuclear fission.

(a) Explain how a controlled chain reaction is maintained within a nuclear reactor. **4**



In a fission reaction, the heavy nuclei splits, such as in Uranium-238 by $^{238}_{92}U \rightarrow ^{235}_{92}U + 3\,^{1}_{0}n$. These neutrons acton as nuclei splitters, as when a neutron collidas with a nucleus (no electrostatic repulsion) the nucleus splits. This is the cause of a chain reaction. If the reaction is not carefully controlled with some controlling mechanism such as boron encased steel rods, this means that the 3 extra neutrons go out and cause more chain reactions, releasing energy at an exponential rate by $E=mc^2$. Control rods such up the excess neutrons so that the reaction occurs linearly, not exponentially. Emergency rods hang above the reaction chamber in case of emergency which can take many excess neutrons out to prevent a nuclear bomb.

Question 27 continues on page 22

Question 27 (continued)

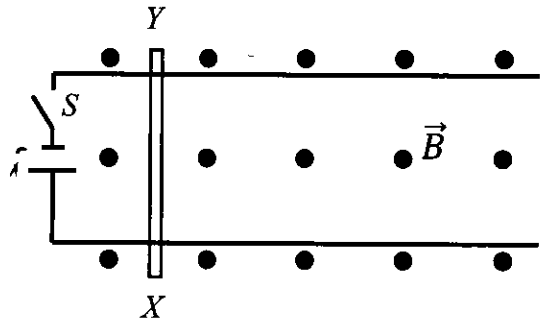
(b) Explain why moderators are used in nuclear reactors. 4

As the Strong Nuclear Force (SNF) has a range of .12 fm and the nucleus is small, it is harder for neutrons ejected at high speeds from fissile material such as anium 238 to be caught by the SNF of another U238 atom. Moderators slow down neutrons as they are ~~after~~ ge in very dense in number meaning neutrons collide, losing <E, but not causing a nuclear fusion reaction, for uch purposes, deuterium (heavy water) is where at least one of the hydrogen in the H_2O has an extra neutron attached, which will not fuse with the neutron, but slow it down. As s $\propto \frac{1}{t}$, the neutron spends more time in the vicinity of the SNF's range, meaning that it is more likely to be captured and cause a fission reaction.

End of Question 27

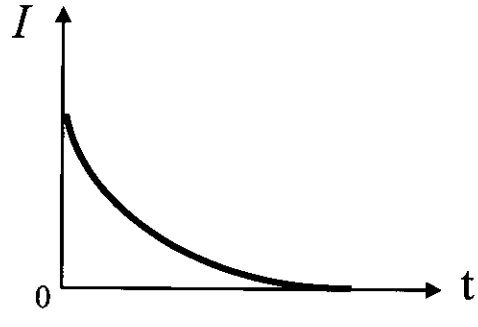
Question 28 (8 marks)

A light cylindrical conducting rod XY of mass m is placed on top of parallel metal rails. The metal rails are attached to a DC power supply via a switch S.



The rods and rails are situated inside a uniform magnetic field $\vec{B}$ directed out of the page.

When the switch S is closed, the rod XY begins to accelerate, resulting in a decreasing current flowing from X to Y in the rod, as shown in the graph below.



(a) Explain why the rod XY begins accelerating to the right after the switch S is closed. 2

The motor effect is that a current carrying conductor in a $\vec{B}$ field will experience a force. Thus using the right hand palm rule, this means current up the page, $\vec{B}$ field out of the page, the force is directed right and so the force acts to the right by $F = IL_{\perp}B$, $\theta = 90$, $\therefore F = IlB$

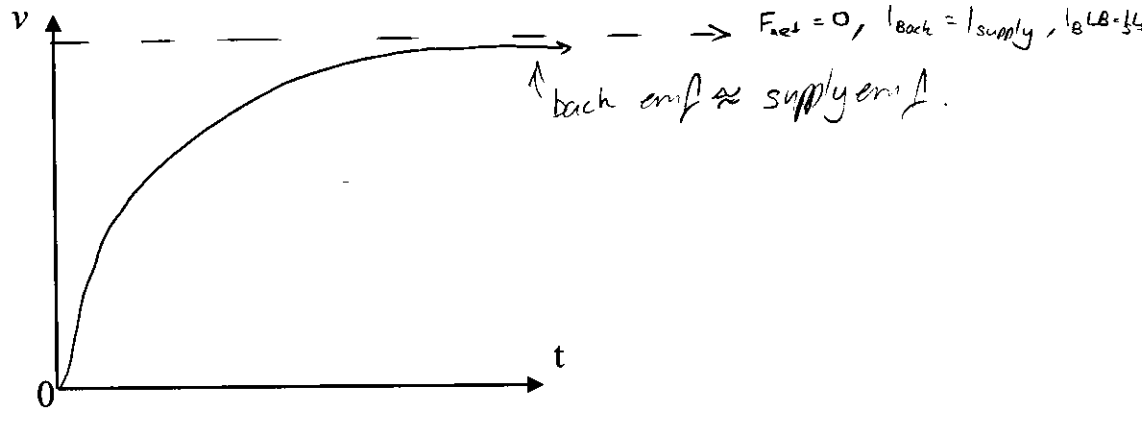
Question 28 continues on page 24

Question 28 (continued)

(b) Explain, using relevant physics principles, why the current through rod XY decreases after the switch is closed. 4

As the rod moves right, the area in the loop increases, increasing ϕ or BA. This means that flux increases threading the coil. By Faraday's Law, an emf is induced, and by Lenz's law, this is induced to oppose the its motion by $\varepsilon_{ind} = -N\frac{\Delta\phi_B}{\Delta t} = -\frac{\Delta\Phi}{\Delta t}$. This induced emf induces a current opposing the initial current that goes anticlockwise, generating a motor effect force opposing the rods motion. This means I_{net} decreases as $I_{net} = I_{supply} - I_{back}$. The back emf will oppose the current so that the velocity becomes constant and so there will be almost no net current in the rod. Also, very minorly, as the distance between rod and supply increase, so does wire length with current meaning resistance slightly increases. Also, resistive heat loss and $P_{loss} = I^2R$

(c) Sketch a speed vs time graph for the motion of rod XY on the axes provided below. 2



End of Question 28

Question 29 (8 marks)

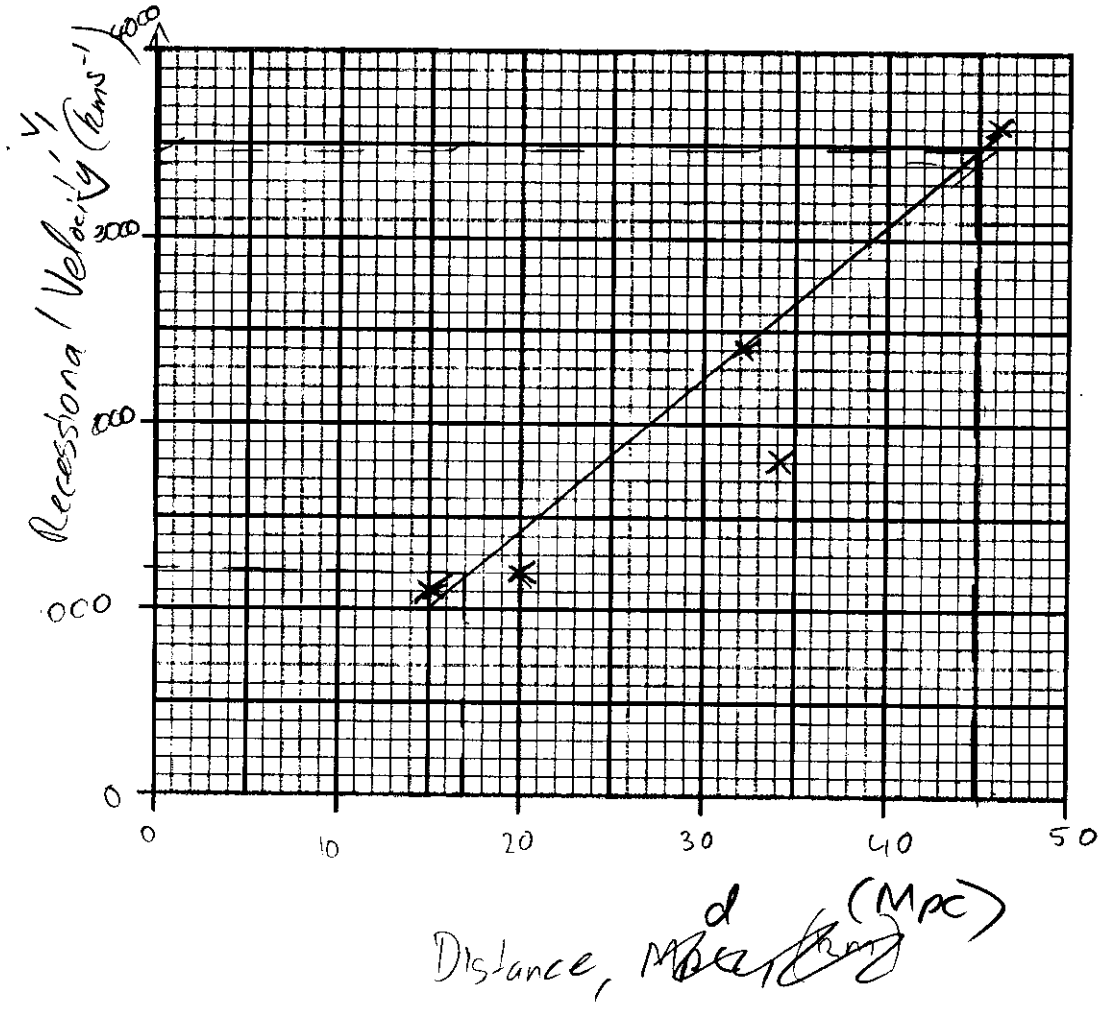
In 1929, Hubble discovered a relationship between the recessional velocity of galaxies and their distance, $v = H_0 d$.

The table opposite shows the recessional velocities for a number of galaxies at various distances, in megaparsecs (Mpc) from Earth.

Distance d (Mpc)	Recessional velocity v (kms^{-1})
15	1100
20	1200
32	2400
34	1800
46	3600

$$1\ Mpc = 3.086 \times 10^{19}\ km$$

(a) Complete a graph of recessional velocity vs distance on the grid provided below, including a line of best fit. **3**



Question 29 continues on page 26

Question 29 (continued)

(b) Use your graph to estimate the age of the universe in billions of years. 2

Points: (17, 1200) and (45, 3500)

$m = \frac{\Delta y}{\Delta x} = \frac{(3500-1200) \times 3.086 \times 10^{19}}{(45-17) \times 3.086 \times 10^{19}} = 2.53 \times 10^{-18}$ ~~2.66×10^{-18}~~ s^{-1} ~~$= 3.944 \times 10$~~

$\therefore$ Age of universe $= (2.53 \times 10^{-18})^{-1} = (2.66 \times 10^{-18})^{-1} = 3.76 \times 10^{17}$ s

~~$= 2.859 \times 10^{11}$~~ years

$= 1.191 \times 10^{10}$ years

$= 11.91$ billion years

≈ 12 billion years

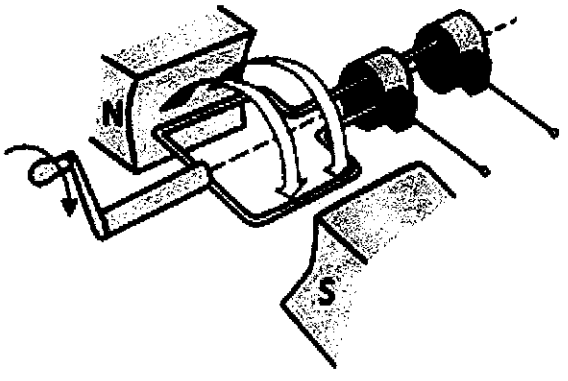
(c) Outline how Hubble's work supported the Big Bang model of the universe. 3

His ~~Their~~ means ~~from~~ meant the universe was not infinite in age, meaning there must have been a beginning. By using recessional velocities, he ~~proved~~ hypothesized that if time was reversed, the universe originated from a single point, and that as recessional velocity increased with distance to Earth the universe was expanding from some place. This is supported by the red shifting of light from stars and planets

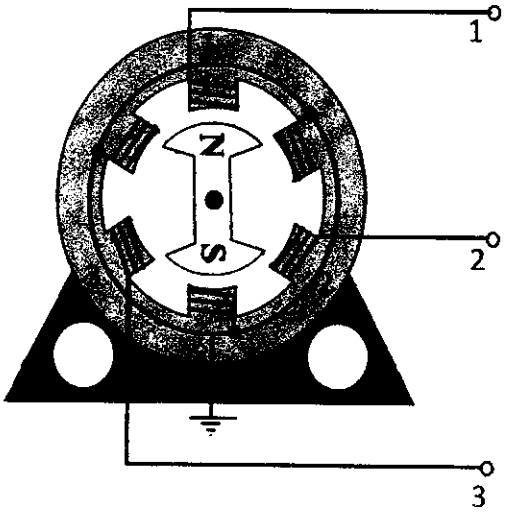
End of Question 29

Question 30 (8 marks)

Two different types of AC generators are shown in the diagram below.



SIMPLE AC GENERATOR



3-PHASE AC POWER GENERATOR

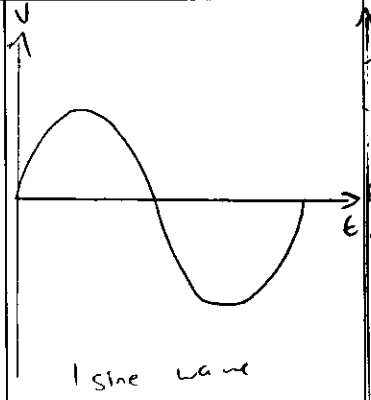
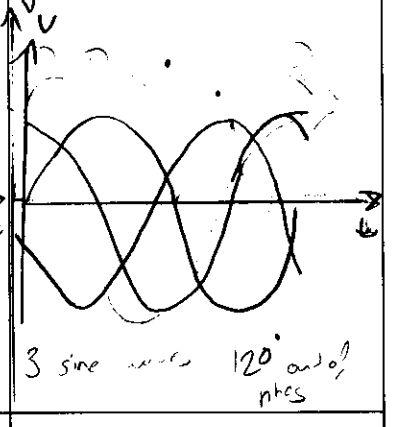
(a) Identify ONE advantage of using a 3-phase AC generator for industrial applications. **1**

Consistent ~~power~~ voltage and current/power output due to 3 inputs being 120° out of phase and adding to each other

Question 30 continues on page 28

Question 30 (continued)

(b) Compare the structure/operation of a 3-phase AC power generator to a simple AC Generator, by completing the table below. 7

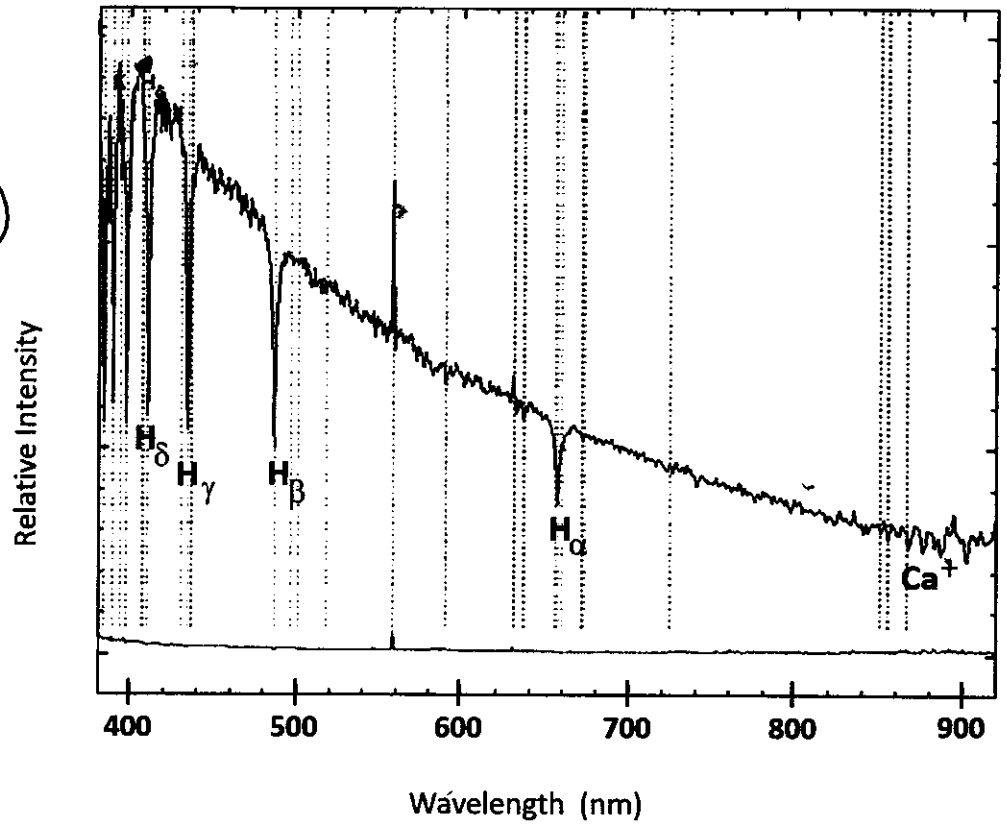
Similarity/Difference	Simple AC Generator	3-phase AC power generator
Method by which output voltage is produced	Motor effect and electromagnetic induction	
Energy conversion	Rotational Kinetic Energy to Electrical Potential	
Stator	1 set of permanent or electromagnets	3 sets of electromagnets
Commutators	1 pair of slip ring	3 pairs of O
Output voltage graph	 1 sine wave	 3 sine waves 120° out of phase
Durability (long/short) + reason	Short Sparking Friction due to contact from brushes and circuit	Long No electrical contact as it is all electromagnetically induced

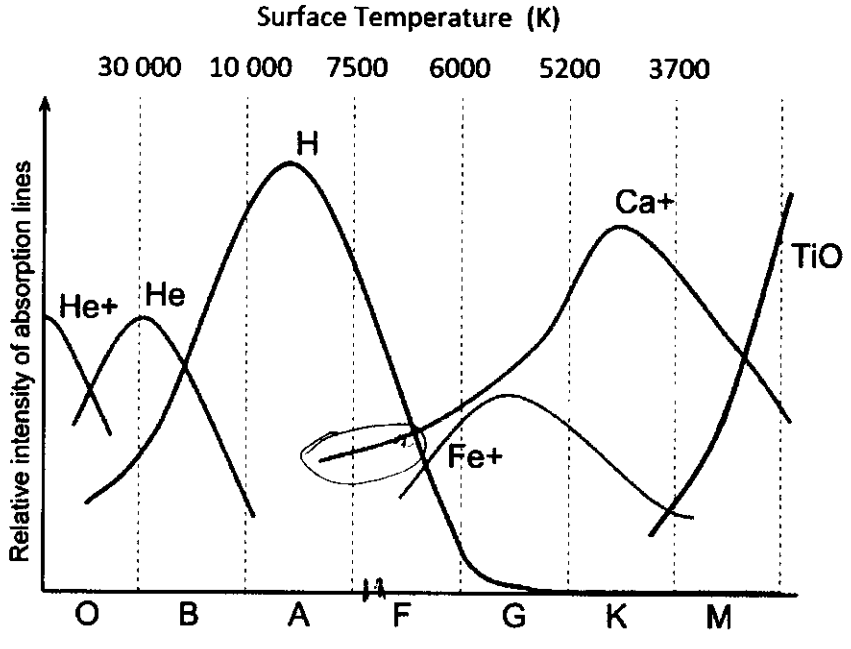
End of Question 30

Question 31 (4 marks)

Consider the graphs shown below.

spectral lines for an unknown star.





Question 31 continues on page 30

Question 31 (continued)

Deduce which spectral class this star belongs to, giving THREE reasons to support your answer. 4

Given by the large spectral lines of H, with no other dominant feature, this means it is a cooler star undergoing only Hydrogen fusion. This restricts it to cooler than A0 class. The presence of ionised calcium lines shows it must be in a range of A7 or lower. However, as the H lines are more intense than the Ca^+ lines, it restricts its class to between A7 and F6 class, where the Hydrogen lines are more intense than the Ca^+ lines.

From Graph 1 $T = \frac{b}{\lambda_{max}}$, where $\lambda_{max} \approx 400 \times 10^{-9}$ m

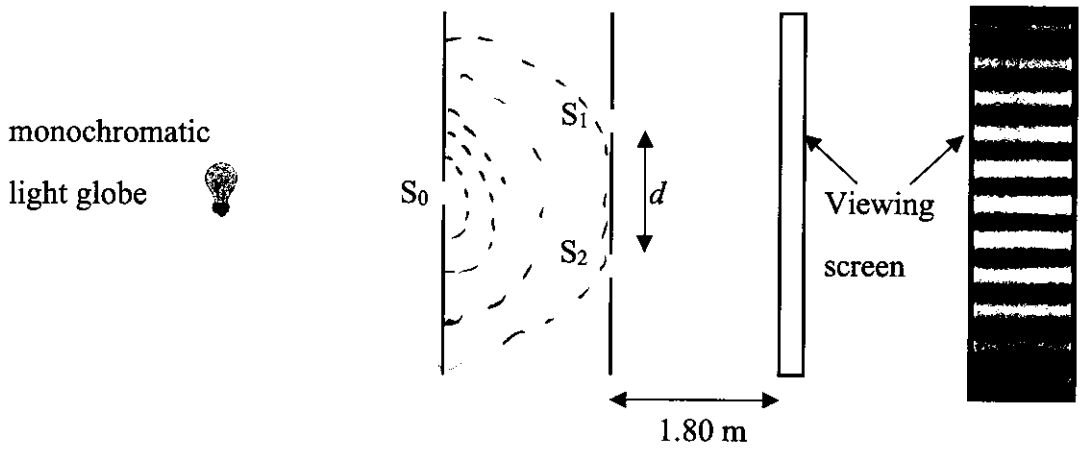
$\therefore T \approx 7245$K = Surface Temperature

From Graph 2 This means it is an F Class star, most likely an F1 Class

End of Question 31

Question 32 (9 marks)

The apparatus shown below is set up to simulate Young's double slit experiment.



Slits S_1 and S_2 are equidistant from S_0

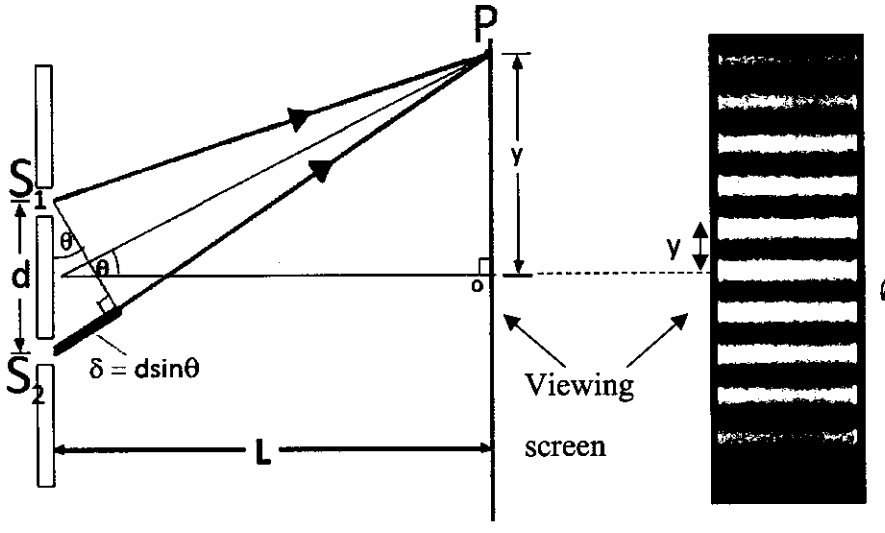
(a) Explain the purpose of the slit S_0 in this experiment. **3**

As S_0 is equidistant, it diffracts the light by Fraunhofer diffraction, so the wavelengths/frequency are guaranteed to be the same when they reach S_1 and S_2. It also focuses the light to be a diffracted point source of light, proving that light was a wave, as diffraction is a wave property. This meant Young, and other people could tell if light was a wave or a particle

Question 32 continues on page 32

Question 32 (continued)

(b) The resultant pattern on the viewing screen is shown below.



Explain how this alternating pattern of bright and dark bands is formed, using relevant physics principles. **6**

S_1 and S_2 act as point sources of light. As light reaches point P, there was either constructive or destructive interference, constructive as when $d\sin\theta$ was an integer multiple, m of each successive area of constructive interference, or maxima. At point O is the central maxima and is the brightest spot, where the most constructive interference occurs. as As seen on the screen, each successive bar of light is dimmer. $d\sin\theta = m\lambda = \frac{y}{L}$ where each region is where constructive interference is a maximum. Further Constructive interference occurs optimally when the two arriving waves from S_1 and S_2 are in phase. If they are out of phase, the destructively interfere with $d\sin\theta = m(\lambda + \frac{1}{2})$, where m is each consecutive destructive maxima. This shows that light is a wave supporting Huygen's wave model of light and debunking Newtons particle, or corpuscle model, as interference is a wave property. However, each of the maxima are blurry, this is due to partial interference (both constructive and destructive interference)

Cont

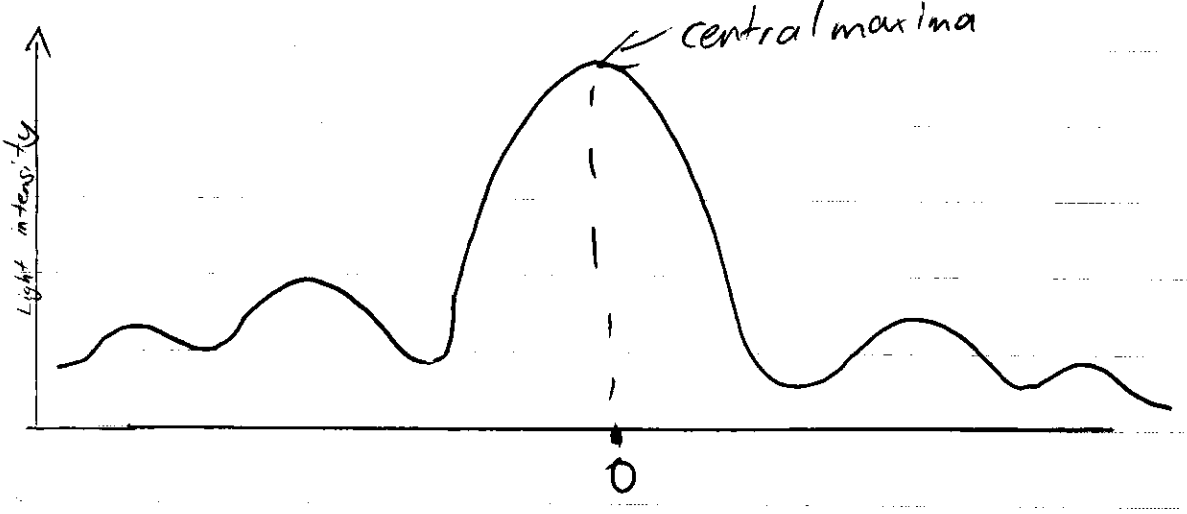
End of paper

Section II extra writing space

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

Q32b)

meaning that the light bands had blurry/ fuzzy edges. These patterns of constructive, destructive and partial interference can be graphed by intensity



Each peak is a maxima, or the middle of a bright band. Each trough is where destructive interference occurs. As distance from 0 increases, so does the ~~probability that the~~ intensity, as the light covers more area by the inverse square law where $I \propto \frac{1}{r^2}$.

Section II extra writing space

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