PHYSICS

Year 12, 2012

Semester Two Examination
SECTION A
Question/Answer Booklet

Teacher:
JAA \ MV

Name:

EXAMINERS USE ONLY	
Section A	
Section B	
Section C	
Total	

TIME ALLOWED FOR THIS PAPER

Reading time before commencing work: Ten minutes

Working time for paper: Three hours

MATERIAL REQUIRED/RECOMMENDED FOR THIS PAPER

TO BE PROVIDED BY THE SUPERVISOR

This Question/Answer Booklet comprising 12 pages

Data and Constants Sheet are provided on the back pages of the various answer booklets.

TO BE PROVIDED BY THE CANDIDATE

Standard Items: Pens, pencils, eraser or correction fluid, ruler

Special Items: Drawing instruments, templates and calculators satisfying the conditions set by the Curriculum Council.

IMPORTANT NOTE TO CANDIDATES

No other items may be taken into the examination room.

It is your responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you hand it to the supervisor BEFORE reading any further.

STRUCTURE OF PAPER

Section	No. of questions	No. of questions to be attempted	No. of marks out of 180	Proportion of examination
A: Short Answers	14	ALL	54	30.0%
B: Problem Solving	7	ALL	90	50.0%
C: Comprehension and Interpretation	2	ALL	36	20.0%

ASSESSMENT WEIGHTING

Course Unit	Specific Questions	No. of marks out of 180	Proportion of examination
Unit 3A			
Forces and Motion in a Gravitational Field	A11,A12,A13,B1,	30	16.8%
Electricity and Magnetism	A8, A9,A10 B2, B3	35	19.4%
Unit 3B			
Motion and Forces in Electric and Magnetic Fields	A4,A5,A6, A7, C2	25	13.8%
Particles, Waves and Quanta	A1,A2,A3,B4,B5, B6,C1,C2	90	50.0%

INSTRUCTIONS TO CANDIDATES

This examination consists of **THREE (3)** sections.

Write your answers in the spaces provided for each question.

The value of each question (out of 180) is shown following each question.

The enclosed *Physics: Formulae and Constants Sheet* may be used as required.

Calculators satisfying the conditions set by the Curriculum Council may be used to evaluate numerical answers.

Answers to questions involving calculations should be evaluated and given in decimal form.

Quote the final answers to no more than four significant figures.

Despite an incorrect final result, credit may be obtained for method and working, provided these are clearly and legibly set out.

Questions involving working should be answered with a complete, logical, clear sequence of reasoning showing how the final answer was arrived at; correct answers which do not show working will **not** be awarded full marks.

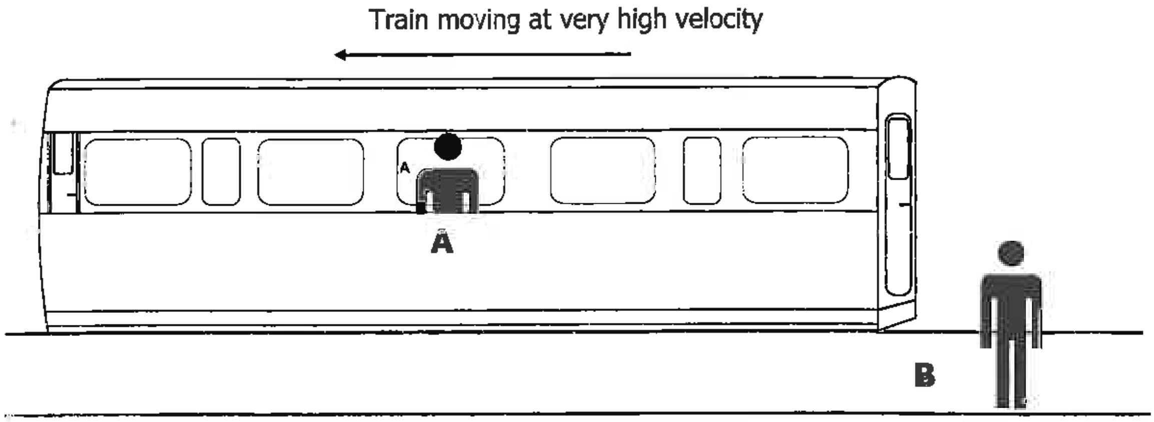
Questions containing the instruction **estimate** may give insufficient numerical data for their solution. Students should provide appropriate figures to enable an approximate solution to be obtained.

SECTION A : Short Answers

Marks Allotted: 54 marks out of 180 (30%). Attempt ALL **14** questions in this section. Answers are to be written in the spaces provided.

QA1. [4 Marks]

An observer at position A at the midpoint of a train carriage (a moving frame of reference), sends light signals to the front and back of the carriage at the same time. These light beams open doors at each end of the carriage. Another observer at position B is stationary on the platform, watching the train moving away from him at high velocity.



Observations of carriage doors opening are found to differ for the two observers.

1a) Describe and compare the observations made by each observer when the light signals are sent from position A.

OBSERVER A: BOTH DOORS OPEN SIMULTANEOUSLY.

OBSERVER B: THE DOOR CLOSEST TO HIM OPENS BEFORE THE DOOR FURTHER WAY. (I.E NOT SIMULTANEOUSLY.)

(2 marks)

1b) Which observer is correct? Carefully explain your reasoning.

BOTH OBSERVERS ARE CORRECT.

ONE SET OF SIMULTANEOUS EVENTS ARE NOT NECESSARILY SIMULTANEOUS FOR ANOTHER OBSERVER MOVING AT A DIFFERENT SPEED (DIFFERENT INERTIAL FRAME OF REFERENCE)

(2 marks)

QA2. [6 Marks]

The following information regarding some sub-atomic particles may be useful in answering the following questions:

Quark	Charge
Up (u)	$+\frac{2}{3}e$
Down (d)	$-\frac{1}{3}e$
Charmed (c)	$+\frac{2}{3}e$
Strange (s)	$-\frac{1}{3}e$
Top (t)	$+\frac{2}{3}e$
Bottom (b)	$-\frac{1}{3}e$

Hadron	Quarks
Proton	*uud*
Neutron	*udd*
Kaon-minus	$s\bar{u}$
Pi-plus (π^+)	$u\bar{d}$
Sigma-plus	*uus*
Lambda-zero	*uds*
Charmed Omega	*ssc*

1a) Determine the charge (in coulombs) of the Charmed Omega:

SSC = $-\frac{1}{3} - \frac{1}{3} + \frac{2}{3} = 0$ ∴ 0 COULOMB

(1 mark)

1b) Identify (list) the types and number of quarks and leptons in a tritium ($_1H^3$) atom:

1 × ^3_1H = 1 PROTON + 2 NEUTRON + 1 ELECTRON

AND 1 PROTON = u + u + d WHILE 2 NEUTRON = 2 × (u + d + d)

∴ 1 LEPTON (AN ELECTRON)

9 QUARKS COMPRISING: 4 UP QUARKS + 5 DOWN QUARKS

(3 marks)

1c) Briefly explain why quarks of like charge are not repelled from each other in a hadron.

ANY REASONABLE STATEMENT REFERRING TO EITHER (RESIDUAL) STRONG NUCLEAR FORCE / COLOUR CHARGE / GLUON EXCHANGE LEADING TO ATTRACTIVE FORCE STRONGER THAN ELECTROMAGNETIC REPULSION BETWEEN INDIVIDUAL QUARKS!

(2 marks)

QA3. [3 Marks]

Briefly describe the "Big Bang" theory and the evidence that supports it.

OUR UNIVERSE WAS INITIALLY A "SINGULARITY" – INFINITELY SMALL, INFINITELY HOT, INFINITELY DENSE SOMETHING THAT RAPIDLY EXPANDED (NOT EXPLODED) AND COOLED – AND CONTINUES TO EXPAND.

EVIDENCE:

- HUBBLE'S LAW – GALAXIES MOVING AWAY, SPEEDS $\propto$ DISTANCE
- COSMIC MICROWAVE BACKGROUND RADIATION – REMNANT HEAT
- ABUNDANCE OF LIGHT ELEMENTS
- RED-SHIFT

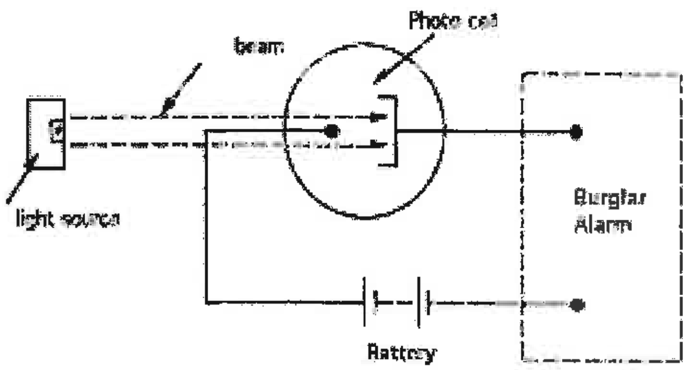
(3 marks)

QA4. [3 Marks]

An electronic burglar alarm consists of a light source that shines onto a photocell.

When ultraviolet light shines upon the photocell photoelectrons may be emitted from the photocathode surface completing the circuit.

When the light beam is interrupted the alarm sounds.



The light source is replaced with one emitting visible red light. What likely effect will this have on the operation of the alarm? Carefully explain your answer.

THE RED LIGHT HAS A FREQUENCY BELOW THE THRESHOLD FREQUENCY (WHICH IS U.V.) SO IT HAS INSUFFICIENT ENERGY ($E = hf$) TO EJECT THE PHOTO-ELECTRONS NEEDED TO MAINTAIN THE CIRCUIT.

THE CIRCUIT IS NO LONGER COMPLETE (BROKEN/OPEN) AND THE ALARM WILL CONTINUE TO SOUND.

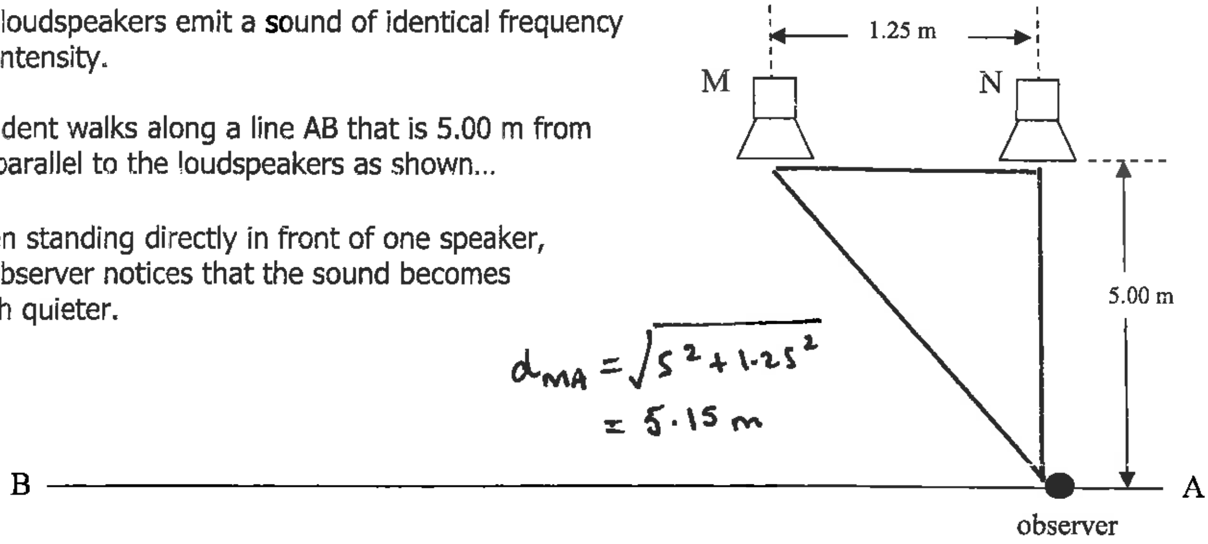
(3 marks)

QA5. [3 Marks]

Two loudspeakers emit a sound of identical frequency and intensity.

A student walks along a line AB that is 5.00 m from and parallel to the loudspeakers as shown...

When standing directly in front of one speaker, an observer notices that the sound becomes much quieter.



$d_{MA} = \sqrt{5^2 + 1.25^2}$
$= 5.15\text{ m}$

Determine the lowest possible frequency of the emitted sound.

OBSERVER AT A NODAL POSITION (QUIETER ≡ DESTRUCTIVE INT.)

∴ PATH DIFFERENCE = $\lambda/2$ (180° OUT OF PHASE)

∴ $d_{MA} - d_{NA} = \lambda/2$

∴ $\lambda = 2(5.15 - 5.00) = 0.30\text{ m}$

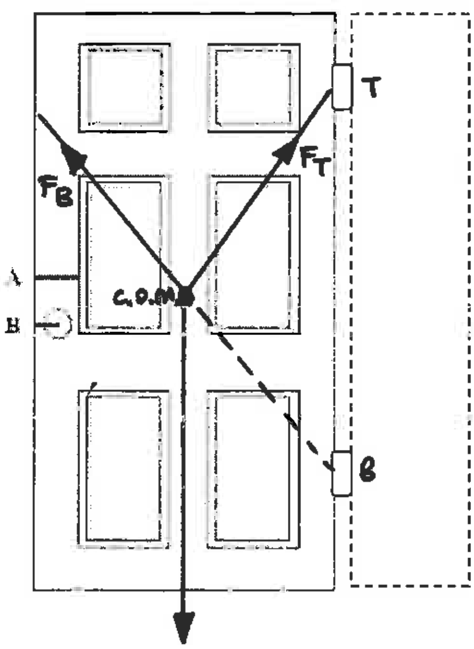
∴ $f = v/\lambda = 346/0.30 = 1153\text{ Hz}$

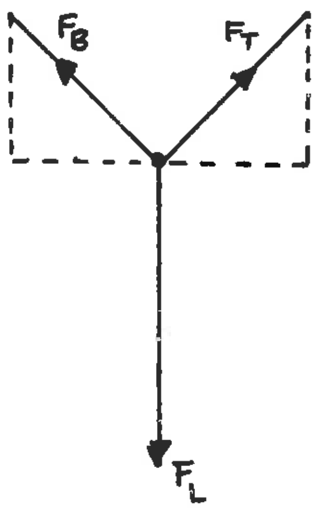
(3 marks)

QA6. [3 Marks]

Draw a labelled free-body diagram to carefully illustrate the forces acting on a stationary door that is evenly set ("hung" and "fixed") on two hinges to a wall.

✓ ALL FORCES THROUGH C.O.M.





$\Sigma F = 0$

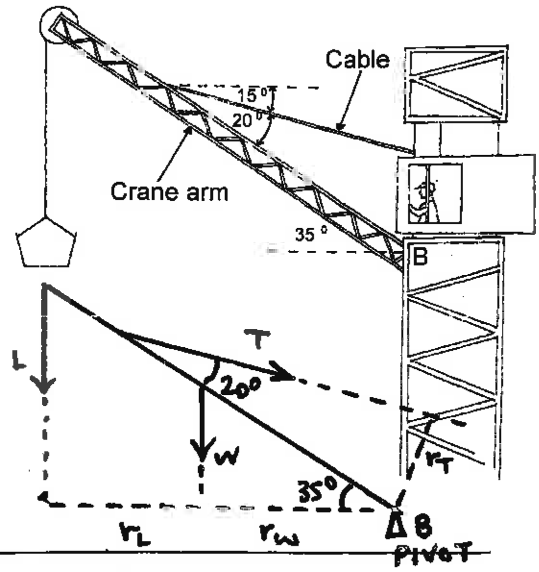
$F_{BH} = -F_{TH}$

$F_{BV} + F_{TV} = -F_L$

(3 marks)

QA7. [4 Marks]

A crane lifts 7×10^2 kg loads of concrete on a building site. The 8.00 m crane arm is uniform and has a mass of 3×10^2 kg. The cable used to raise and lower the load is attached to the crane arm 6.00 m along the arm. Calculate the tension in the cable.



TAKING MOMENTS ABOUT B :

$\Sigma CWM = \Sigma ACM$

$\therefore T \times r_T = (L \times r_L) + (W \times r_W)$

$r_T = 6 \times \sin 20° = 2.05$

$r_W = 4 \times \cos 35° = 3.28$

$r_L = 8 \times \cos 35° = 6.55$

$\therefore T = \frac{(L \times r_L) + (W \times r_W)}{r_T}$

$\therefore T = \frac{(7 \times 10^2 \times 9.8 \times 8 \times \cos 35°) + (3 \times 10^2 \times 9.8 \times 4 \times \cos 35°)}{6 \times \sin 20°}$

$\therefore T = 2.66 \times 10^4$ N

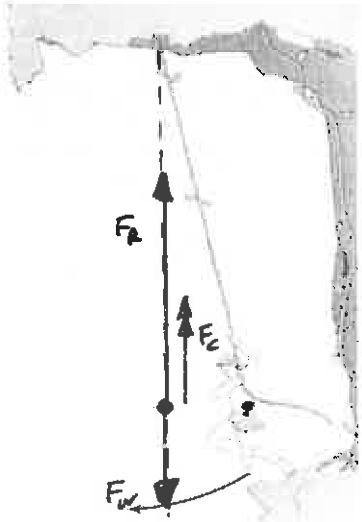
(4 marks)

QA8. [4 Marks]

Tarzan plans to cross a crocodile infested river by swinging in an arc from a hanging vine.

Tarzan has a mass of 75.0 kg and the vine is 3.64 m in length.

If the breaking (maximum) tension of the vine is 2410 N, what is the maximum speed possible at the lowest point of the swing?



SINCE $\vec{F_c} = F_{NET} = \vec{F_W} + \vec{F_R}$

THEN $\frac{mv^2}{r} = (m.g) + F_R$

$\therefore v^2 = \frac{((m.g) + F_R).r}{m}$

$\therefore v^2 = \frac{((75 \times -9.8) + 2410) \times 3.64}{75}$

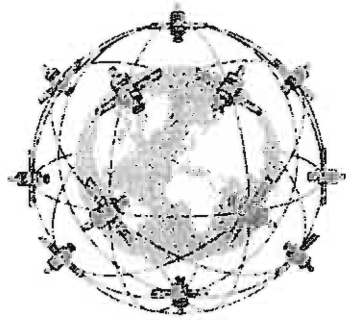
$\therefore v_{MAX} = 9.02 \text{ ms}^{-1}$

(4 marks)

QA9. [6 Marks]

In 10 years Global Positioning System [GPS] has gone from the USA military to being navigator tools to being a normal feature in many luxury cars today. They work by transmitting a beam of electro-magnetic radiation from an aerial on your car roof to one of 24 satellites surrounding the Earth. The reflected beam is received also by an aerial on your roof and your location on the ground can be determined to 50 m. In military application the resolution is less than 10 cm.

a) If the height of any one of these satellites is 17 800 km, what is the period of its orbit?



RADIUS OF ORBIT $= 6.37 \times 10^6 + 1.78 \times 10^7$

$= 2.42 \times 10^7$ m

USING $F_G = F_C$ AND $v = \frac{2\pi r}{T}$

THEN $\frac{GmM}{r^2} = \frac{mv^2}{r} = \frac{4\pi^2 r}{T^2}$

THUS $T^2 = \frac{4\pi^2 r^3}{G.M}$

$= \frac{4\pi^2 (2.42 \times 10^7)^3}{6.67 \times 10^{-11} \times 5.98 \times 10^{24}}$

$\therefore T = 3.73 \times 10^4$ s

i.e $T = 10.4$ h

(3 marks)

9b) Determine the strength of Earth's gravitational field at this orbiting height. Note: your answer must be express in appropriate units.

SINCE $F_W = F_G$

$m.g = \frac{G.mM}{r^2}$

$\therefore g = \frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24}}{(2.42 \times 10^7)^2}$

$\therefore g = 0.682$ N kg^{-1}

(NOTE: THE UNITS)

(3 marks)

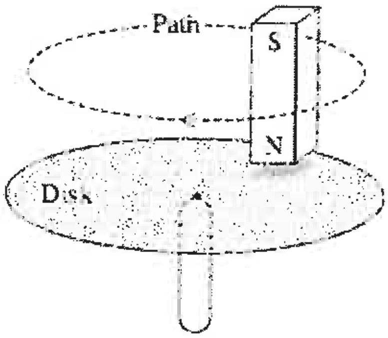
QA10. [3 Marks]

A non-magnetic metal disk is balanced on a support as shown in the diagram below.

The disk is initially stationary.

A magnet is moved in a circular path just above the surface of the disk, without touching it.

Carefully describe and explain what is observed.

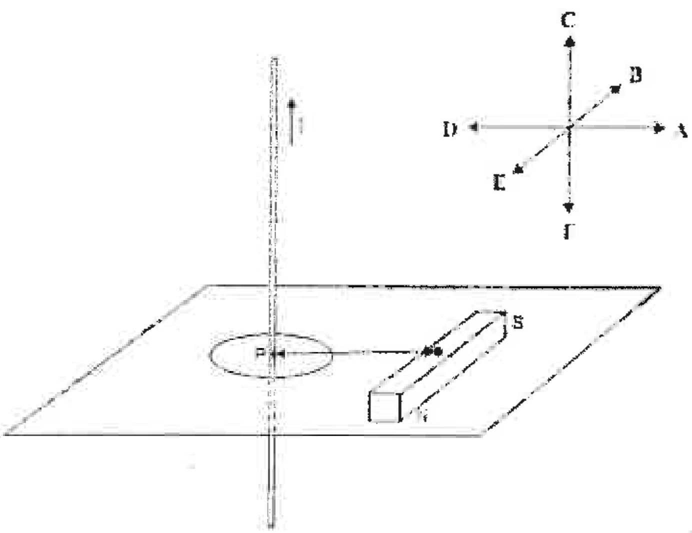


- THE DISK ROTATES IN THE SAME DIRECTION AS THE MAGNET.
- IN ACCORDANCE WITH LENZ'S LAW: THE CHANGING MAGNETIC FIELD DUE TO THE MOTION OF MAGNET INDUCES AN EMF / EDDY CURRENT IN THE DISK. THE DIRECTION OF THE INDUCED CURRENT WILL ITSELF OPPOSE THE CHANGE. THE INTERACTING FIELDS DERIVES A FORCE / TORQUE IN THE MOTION OF THE DISK.

(3 marks)

QA11. [4 Marks]

A vertical wire carrying a current is placed opposite the centre of a permanent bar magnet as shown.



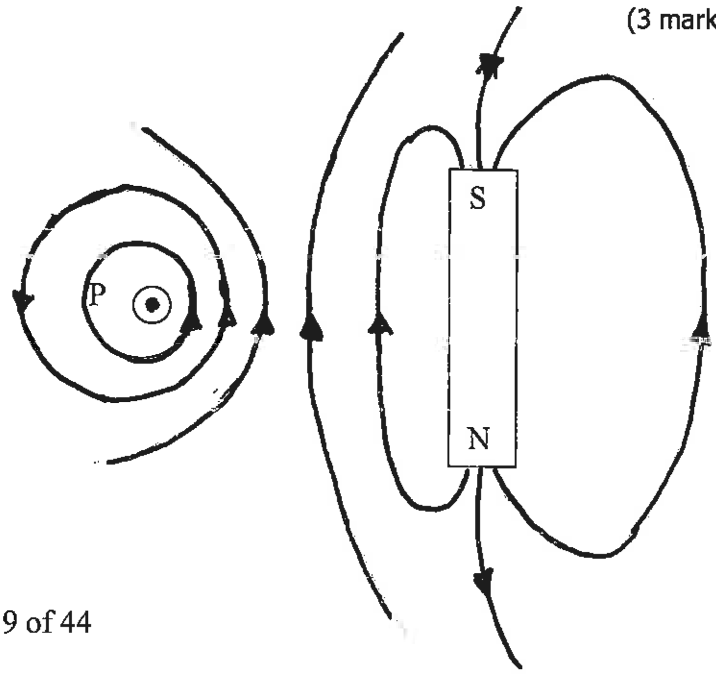
11a) Which of the arrows (A-F) best shows the direction of the magnetic force on the wire at the point P?

D (REPELLED)

(1 mark)

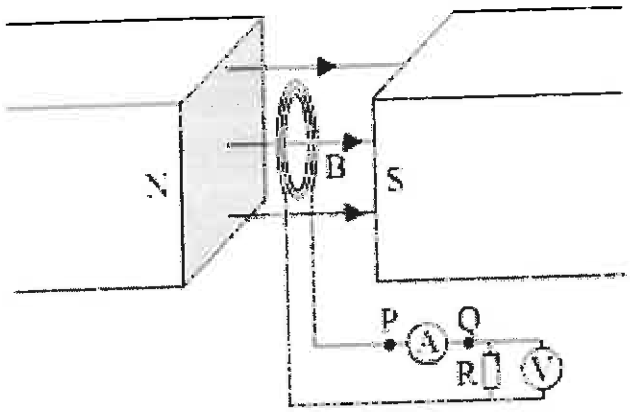
11b) Carefully sketch the resulting magnetic field associated with this interaction (as viewed from above) on the diagram provided below.

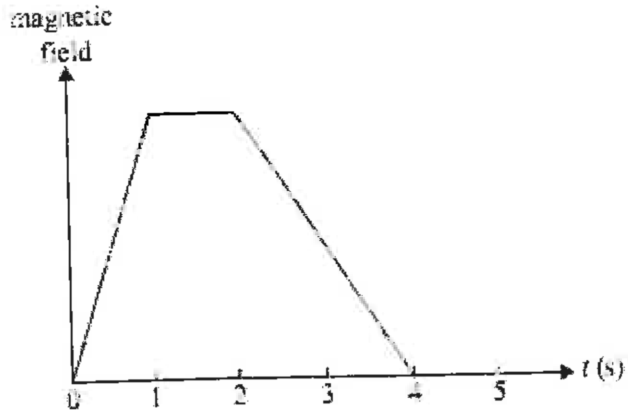
(3 marks)



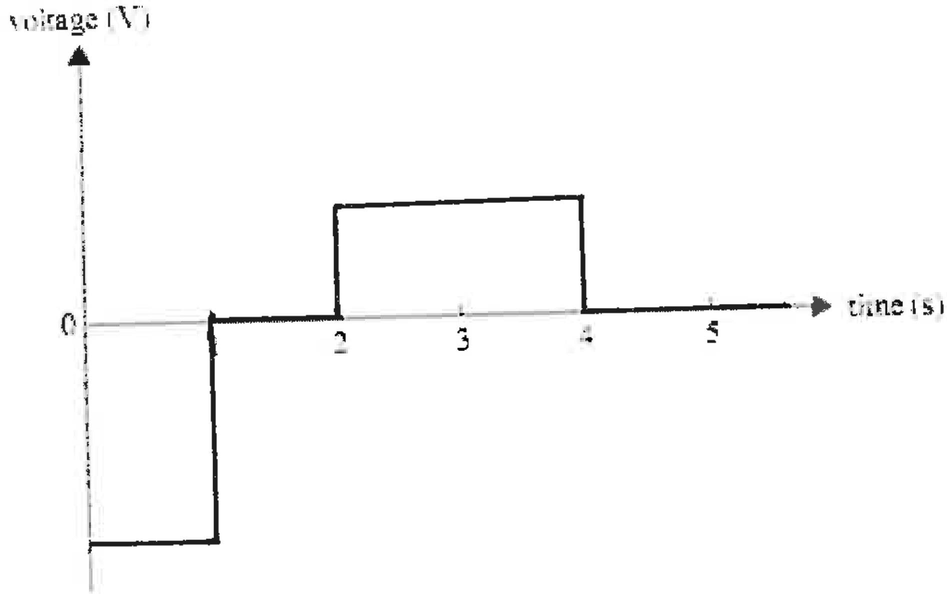
QA12. [4 Marks]

The diagram provided shows an experiment where the voltage induced in a coil by a time-dependent magnetic field is measured. The voltmeter measures the voltage induced in the coil as a function of time. The coil has 120 turns. The magnetic field varies with time as shown in the graph below.





12a) Sketch a graph for the corresponding voltage against time as measured by the voltmeter.



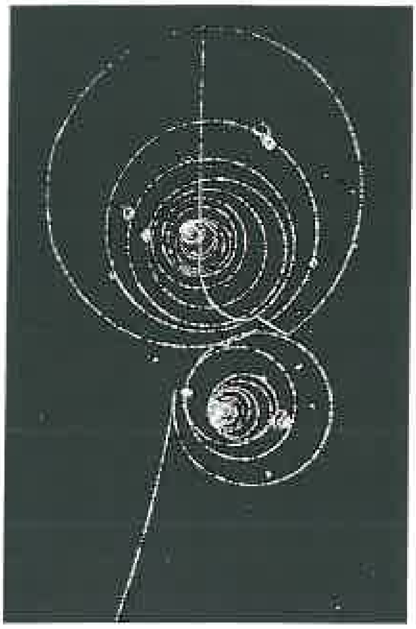
12b) As the magnetic field is being reduced, in what direction (P → Q or Q → P) will the current flow through the ammeter A ? Carefully explain your answer.

THE ORIGINAL FLUX WAS FROM LEFT TO RIGHT AND WAS DECREASING. TO OPPOSE THIS CHANGE IN FLUX, A CURRENT WAS REQUIRED FROM Q → P IN ORDER TO INCREASE THE FLUX.

(2 marks)

QA13. [3 Marks]

When a charged particle enters a magnetic field within a cloud chamber, the trails of droplets of condensed gas indicates that it has moved in a circular pathway. Explain why it moves this way rather than in a straight line.

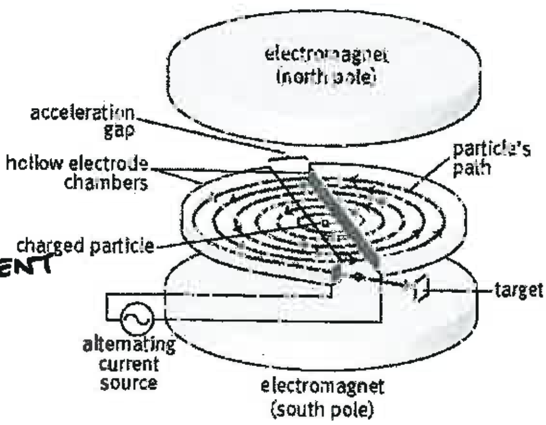


THE CHARGED PARTICLE HAS MAGNETIC FIELD (AS IT IS MOVING). THIS INTERACTS WITH THE MAGNETIC FIELD WITHIN THE CLOUD CHAMBER. THIS INTERACTION RESULTS ON THE CHARGE EXPERIENCING A FORCE. SINCE THIS FORCE ACTS PERPENDICULAR TO THE CHARGE'S MOTION, A CIRCULAR PATH IS DESCRIBED.

(3 marks)

QA14. [4 Marks]

14a) List two specific uses of a cyclotron.



- SOURCE OF HIGH ENERGY BEAMS
- P.E.T IMAGING – PRODUCING ISOTOPES
- PARTICLE THERAPY FOR CANCER TREATMENT
- NUCLEAR PHYSICS EXPERIMENTS

(2 marks)

14b) Briefly describe the role of electric and magnetic fields in the operation of a cyclotron.

AN ALTERNATING ELECTRIC FIELD ATTRACTS PARTICLES FROM SIDE TO SIDE (D'S). A MAGNETIC FIELD (GENERATED BY TO ELECTROMAGNETS) BENDS EACH PARTICLE INTO A HORIZONTAL SPIRAL, FORCING IT TO ACCELERATE IN ORDER TO KEEP UP WITH OSCILLATING ELECTRIC FIELD. THE CIRCULAR PATH KEEPS THE SIZE OF CYCLOTRON CONFINED. THE PARTICLE IS RELEASED TO COLLIDE WITH TARGET WHEN IT REACHES PEAK ACCELERATION.

(2 marks)

PHYSICS

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Semester Two Examination
SECTION B
Question/Answer Booklet

Teacher:
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Name:

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Section B	

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Data and Constants Sheet

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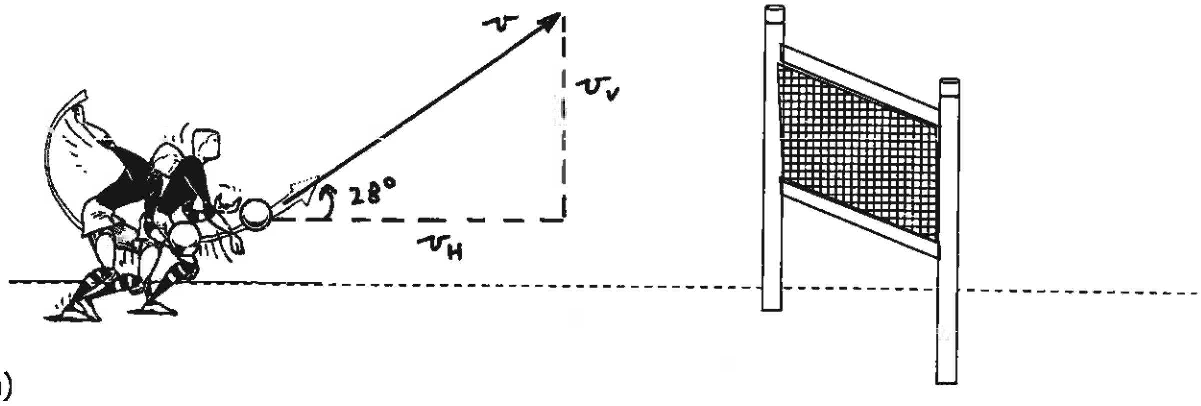
SECTION B : Problem Solving

Marks Allotted: 90 marks out of 180 (50%). Attempt ALL **7 questions** in this section. Answers are to be written in the spaces provided.

QB1. [13 Marks]

The top of a volley-ball net is 2.40 m above the ground. To serve the ball over the net a player strikes the ball causing it to leave the hand at an angle of 28.0° to the horizontal and with a speed of 12.2 ms^{-1}. The ball is served 9.20 m from the net and at a height of 1.35 m from the ground.



1a)
Determine how far above or below the top of the net the ball will be located on reaching the net.

FROM THE HORIZONTAL: $v_H = s_H / t = v.\cos\theta$

$\therefore t = s_H / v.\cos\theta = \frac{9.20}{12.2 \cos 28°}$

$\therefore t = 0.852$ s

FROM THE VERTICAL: $s_V = u_V t + \frac{1}{2} g t^2$

$= (v.\sin\theta.t) + (\frac{1}{2} g t^2)$

$= (12.2 \times \sin 28° \times 0.852) + (\frac{1}{2} \times 9.8 \times (0.852)^2)$

$= 4.88 - 3.56$

$\therefore s_V = 1.32$ m

$\therefore$ THE HEIGHT ABOVE THE NET $= (1.35 + 1.32) - 2.40$

$= 0.27$ m (ABOVE)

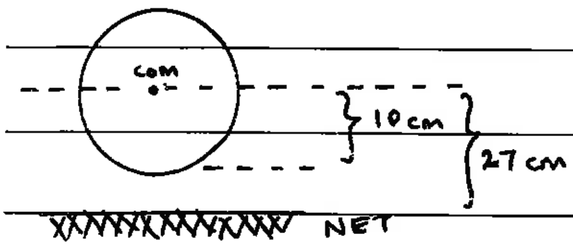
(7 marks)

1b) Will the volley-ball clear the net? You must support your answer to be awarded full marks.

THE DISTANCE BETWEEN THE BALL'S C.O.M AND THE NET IS 27 cm

THE RADIUS OF A TYPICAL VOLLEY BALL IS APPROX 10 cm

THEREFORE, THE BALL CLEARS THE NET BY 17 cm ∴ A GOOD SERVE!



(2marks)

1c) Is the ball rising or falling as it reaches the top of the net? You must support your answer with all essential working details in order to be awarded full marks.

USING $v_v = u_v + g.t$

$= (v.\sin\theta) + (g.t)$

$= (12.2 \times \sin 28^\circ) + (-9.8 \times 0.852)$

$= 5.73 - 8.35$

$= -2.62\ ms^{-1}$

ie $v_v = 2.62\ ms^{-1}$ DOWNWARDS

IN OTHER WORDS, THE BALL IS FALLING AS IT REACHES THE NET

(AN EXCELLENT SERVE!)

(4 marks)

ALTERNATIVELY:

TIME TO REACH APEX: 0.585 s

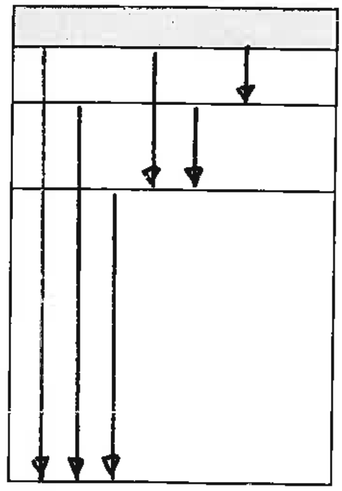
SINCE $t_{NET} > t_{APEX}$

$0.852 > 0.585$ s

THEN BALL IS FALLING

QB2. [14 Marks]

Some energy levels of the mercury atom are shown in the diagram.



2a) Determine the maximum number of lines which could appear in the line emission spectrum of mercury if its atoms may have a maximum energy level equal to E4 (-0.86 eV).

6 (AS SHOWN)

(1 mark)

2b) What is the longest wavelength which could be found in that line emission spectrum?

THE LONGEST WAVELENGTH = LOWEST FREQUENCY = SMALLEST TRANSITION

$\therefore E_4 \rightarrow E_3$ PRODUCES THE LONGEST WAVELENGTH

$\therefore \Delta E = h c/\lambda$

$\therefore \Delta E = (2.47 - 0.86) \times 1.6 \times 10^{-19}$

$= 2.58 \times 10^{-19}$ J

$\therefore \lambda = \dfrac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{2.58 \times 10^{-19}}$

$\therefore \lambda_{MAX} = 7.71 \times 10^{-7}$ m $= 771$ nm

(3 marks)

2c) Mercury atoms in the ground state are bombarded with electrons. What is the minimum velocity of these bombarding electrons that will ionise a mercury atom?

$E = 10.42$ eV $= 10.42 \times 1.6 \times 10^{-19} = 1.67 \times 10^{-18}$ J

$E_K = \Delta E = \frac{1}{2} m v^2$

$\therefore v^2 = \dfrac{2 . \Delta E}{m}$

$= \dfrac{2 \times 1.67 \times 10^{-18}}{9.11 \times 10^{-31}}$

$\therefore v = 1.91 \times 10^{6}$ ms^{-1}

(3marks)

2d) A beam of light containing only visible wavelengths is passed through a sample of mercury vapour. Assuming all atoms to be in the ground state, which wavelengths will have a reduced intensity in the observed spectrum? Provide a reason for your answer and show all working.

PHOTONS CAN ONLY BE ABSORBED COMPLETELY (OR NOT AT ALL) FROM GROUND.

PHOTONS THAT ARE ABSORBED ARE SCATTERED AND THEIR INTENSITY IN THE ABSORPTION SPECTRUM IS REDUCED – APPEARING AS DARK LINES.

THE MINIMUM ENERGY = $E_1 \rightarrow E_2$

$\Delta E = 10.42 - 4.71 = 5.71\ eV = 9.14 \times 10^{-19}\ J$

SINCE $E = \frac{hc}{\lambda}$ THEN $\lambda = \frac{hc}{E}$

$= \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{9.14 \times 10^{-19}}$

$\therefore \lambda = 2.17 \times 10^{-7}\ m = 217\ nm$

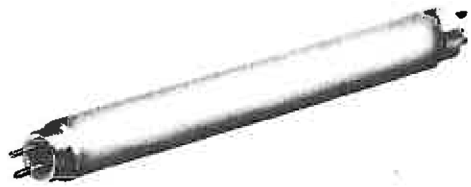
THIS WAVELENGTH IS IN THE U.V REGION OF THE EMR SPECTRUM

ALL OTHER ABSORPTIONS ARE ALSO NOT IN THE VISIBLE REGION

$\therefore$ NO WAVELENGTHS FROM THIS VISIBLE LIGHT SOURCE WILL BE LESS INTENSE.

(4 marks)

2e) A fluorescent tube is essentially a mercury discharge tube. Briefly describe and carefully explain how it produces visible light.



LARGE POTENTIAL DIFF. ACROSS ELECTRODES

=> ELECTRONS FROM CATHODE TO ANODE

=> $V = W/q = \Delta E_k/q$ POSSESS HIGH SPEED / KINETIC ENERGY.

=> THESE ELECTRONS BOMBARD GAS => ENERGY ABSORBED BY Hg ATOMS

=> ATOM ELECTRON EXCITED AND TRANSITIONS RELEASE MANY U.V PHOTONS

=> U.V PHOTONS ARE ABSORBED BY PHOSPHOR COATING OF TUBE

=> ENERGY / PHOTONS RELEASED BY FLUORESCENT COATING VIA MULTIPLE TRANSITIONS OF SMALLER ENERGY QUANTA / LOWER FREQUENCY CORRESPONDING TO VISIBLE FREQUENCIES => VISIBLE LIGHT INTENSITY INCREASES.

ESSENTIALLY: FLUORESCENT PROCESS WHERE UV => VISIBLE

(3 marks)

QB3. [13 Marks]

In 1928 George Thompson conducted an experiment firing electrons at aluminium foil. X rays and electrons passing through the foil were diffracted. The X ray photons had a frequency of 3.59×10^{17} Hz and the power of the X ray source was 15.0 kW

3a) If the electrons were to have the same energy as the X rays used in this experiment, at what minimum speed would they need to travel?

USING $E = hf$ AND $E = \Delta E_K = \frac{1}{2}mv^2$

THEN $hf = \frac{1}{2}mv^2$

$\therefore v^2 = \frac{2 \times h.f}{m}$

$= \frac{2 \times 6.63 \times 10^{-34} \times 3.59 \times 10^{17}}{9.11 \times 10^{-31}}$

$\therefore v^2 = 5.23 \times 10^{14}$

$\therefore v = 2.29 \times 10^{7} \ ms^{-1}$

(4 marks)

3b) Calculate how many photons leave the X ray source each second.

SINCE $P = E/t$

THEN $E_T = P.t = 15.0 \times 10^3 \times 1$

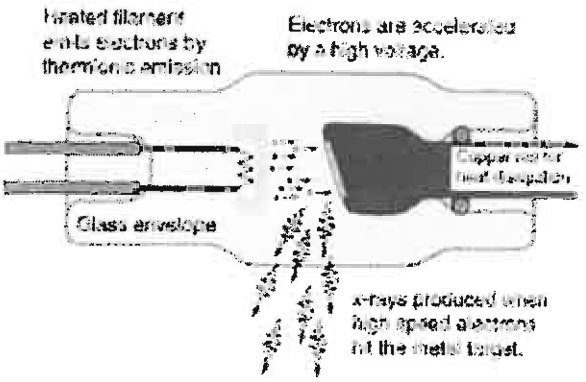
$\therefore$ n° PHOTONS $= E_T/E_X = E_T/h.f$

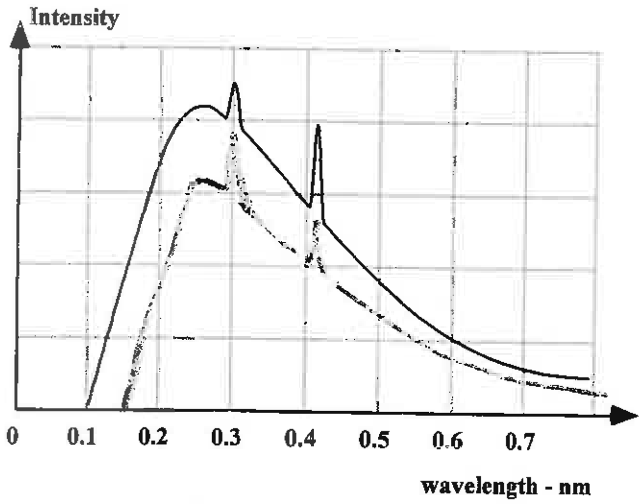
$= \frac{15.0 \times 10^3}{6.63 \times 10^{-34} \times 3.59 \times 10^{17}}$

$\therefore$ n° PHOTONS $= 6.30 \times 10^{19}$ PHOTONS PER SECOND

(3 marks)

The diagram below shows an X-ray spectrum for a particular target anode.





3c) With reference to the graph, determine the accelerating voltage of the X-Ray tube.

$\lambda_0 = 0.1 \times 10^{-9}$ m (from graph)

SINCE $E = hc/\lambda = V.q$

THEN $V = \frac{hc}{\lambda q} = \frac{6.63 \times 10^{-34} \times 3.00 \times 10^{8}}{0.1 \times 10^{-9} \times 1.6 \times 10^{-19}}$

$\therefore V = 1.24 \times 10^{4}$ V $= 12.4$ kV

(3 marks)

3d) On the graph above, sketch the effect of using a lower accelerating potential than that WHICH was determined in part (c). $V \propto 1/\lambda$

(1 mark)

3e) With reference to the graph, briefly explain what causes the two intensity peaks shown.

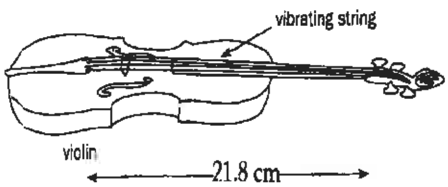
ON COLLISION WITH BOMBARDING ELECTRONS, ELECTRONS FROM INNER SHELLS OF TARGET ATOMS ARE EJECTED. THE EJECTED ELECTRONS ARE REPLACED BY ELECTRONS FROM OUTER/HIGHER SHELLS AND THE ATOM RELEASES THE ENERGY OF SUCH TRANSITIONS AS A PHOTON OF EQUIVALENT ENERGY. THESE SPECIFIC EMISSIONS SUPERPOSE WITH THE INTENSITIES OF THE BREMSSTRAHLUNG / BRAKING RADIATION AND GIVE RISE TO PEAKS CHARACTERISTIC OF THAT TARGET METAL.

(2 marks)

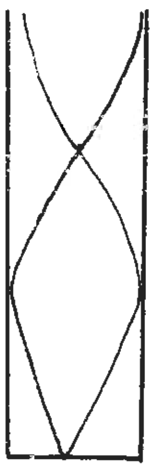
QB4. [14 Marks]

The highest string on a violin produces a note of frequency 6.60×10^2 Hz when vibrating in its fundamental mode. The violin string has a length of 21.8 cm.

During a break in rehearsal Mary blows softly over the top of a bottle and notices that she produces a note with a much lower pitch. However, when she blows strongly she can produce a note of the same pitch as the violin. She reasons that the air column in the bottle is sounding its 1st overtone when it has the same frequency as the violin.



4a) Draw and label diagrams to illustrate the respective modes of vibration occurring in the violin string and the air column within the bottle when they are sounding the same note.



BOTTLE:
$\ell = 3\lambda/4$
2ND MODE OF VIBRATION
(3RD HARMONIC)

VIOLIN:
$\ell = \lambda/2$
1ST MODE OF VIBRATION
(1ST HARMONIC)

(2marks)

4b) Determine the length of the air column in the bottle.

SINCE $f_{B2} = 660$ Hz AND $\ell = 3\lambda/4$

THEN USING $v = f\lambda$ AND $\lambda = \frac{4}{3}\ell$

$\therefore \ell = \frac{3 \times v}{4 \times f} = \frac{346 \times 3}{660 \times 4}$

$\therefore \ell = 0.393$ m

$\simeq 39.3$ cm (IGNORING END CORRECTION)

(4marks)

4c) Determine the frequency of the sound produced when Mary blows softly over the bottle.

THE 2ND MODE OF VIBRATION IN THE BOTTLE (CLOSED PIPE) IS THE 3RD HARMONIC ! i.e $f_v = f_{B2} = 3 \times f_{B1}$

$\therefore f_{B1} = f_v/3$

$= 660/3$

$\therefore f_{B1} = 220 \text{ Hz}$

(2marks)

4d) Determine the speed of the progressive wave in the violin string.

IN THE STRING ! SINCE $\lambda = 2 . l = 2 \times 0.218$

$= 0.436 \text{ m} = 43.6 \text{ cm}$

USING $v = f\lambda$

$= 0.436 \times 660$

$\therefore v = 288 \text{ ms}^{-1}$

(2marks)

4e) If the string on the violin was tightened so that its frequency changed by 4.00 Hz. Describe **quantitatively** and carefully explain what is observed when the violin and bottle (1st overtone) are sounded together. Name this phenomenon.

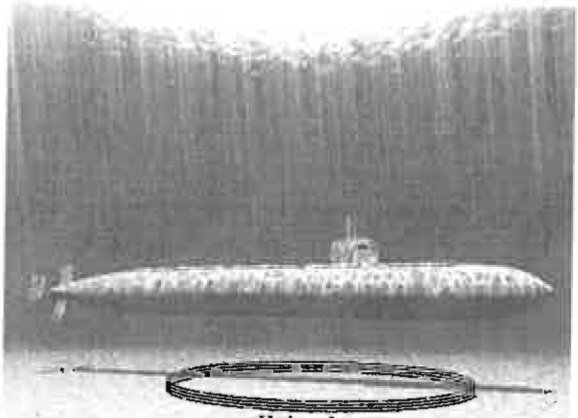
- THERE IS A RISE AND FALL IN THE AMPLITUDE OF SOUND (BEATS)
- 4 BEATS PER SECOND WILL BE HEARD ($f_{BEATS} = 4 \text{ Hz}$)
- THE PHENOMENON IS "BEATS"
- BEATS ARE DUE TO REGULAR CHANGE IN PERCEIVED LOUDNESS AS A RESULT OF CONSTRUCTIVE AND DESTRUCTIVE INTERFERENCE AS THE SOUND WAVES SUPERPOSE.

(4marks)

QB5. [12 Marks]

During the Second World War it was common to guard harbours using a coil of very large area laid across the entrance to the harbour.

This device was intended to detect the presence of a submarine by the voltage induced as the submarine passed over the harbour-loop.



5a) Carefully explain how such a voltage might be induced.

AS THE SUBMARINE MOVES OVER THE HABOUR LOOP, IT BRINGS ABOUT A CHANGE IN THE MAGNETIC FIELD "THREADING" OR "LINKING" THE LOOP. THERE WILL BE LESS FLUX WITHIN THE AREA OF THE LOOP. SINCE THE CHANGE IN FLUX GIVES RISE TO AN EMF ACCORDING TO FARADAY'S LAW OF INDUCTION : $\mathcal{E} = \frac{N\Delta\phi}{t}$

THE CHANGE IN FLUX ($\Delta\phi$) INDUCES AN EMF IN THE LOOP.

(3marks)

5b) If, as a submarine passes, the flux passing perpendicularly through a 50 turn loop changes at a rate of 8.00×10^{-3} weber per second, what emf would be induced in the loop?

GIVEN $N = 50$ AND $\Delta\phi/t = 8.00 \times 10^{-3}$ Wb s^{-1}

USING $\mathcal{E} = \frac{N\Delta\phi}{t}$

$= 50 \times 8.00 \times 10^{-3}$

$\therefore \mathcal{E} = 0.400$ V

$= 400$ mV

(3marks)

5c) At the site of this harbour, natural variations in the vertical component of the Earth's magnetic field might occur at the rate of 3.00 x 10^{-10} tesla per second.

What is the maximum area the harbour loop must have if the naturally induced voltage is to remain below 1% of that induced by the submarine?

FOR EARTH'S FIELD VARIATION: $\Delta B / t = 3.00 \times 10^{-10}$ T s^{-1}

SINCE $\varepsilon \propto \Delta B$

THEN $\Delta B / t = \frac{100}{1} \times 3 \times 10^{-10}$ T s^{-1}

USING $B = \phi / A$ THEN $\phi = B.A$

THUS $\Delta\phi / t = \Delta B . A / t$

$\therefore$ $A = \Delta\phi / \Delta B$

$= \frac{8.00 \times 10^{-3}}{3.00 \times 10^{-8}}$

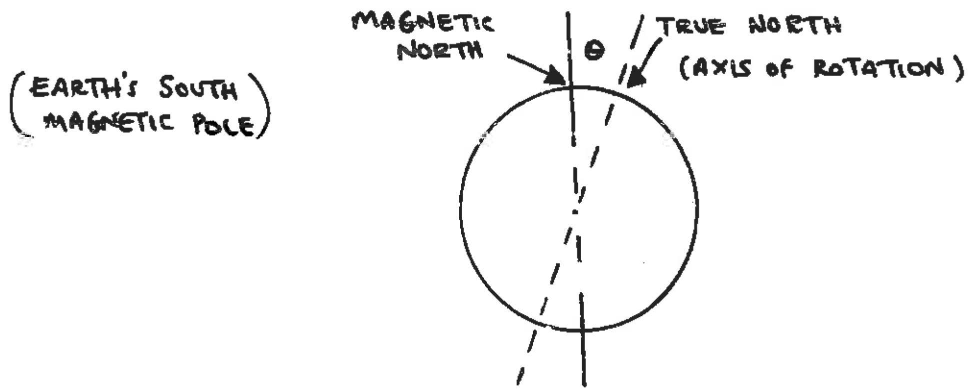
$\therefore$ $A = 2.67 \times 10^{5}$ m^2

(4marks)

5d) Briefly describe or clearly illustrate what the angle of declination represents in reference to the Earth's magnetic field.

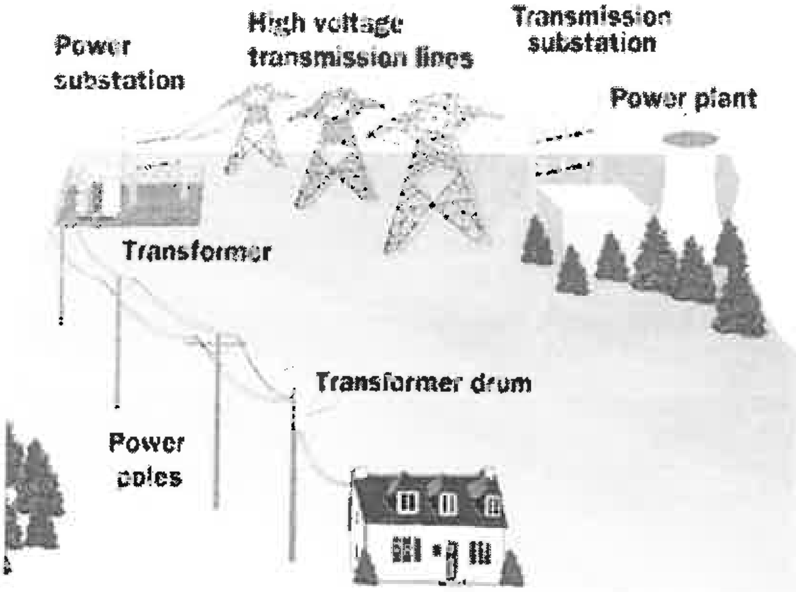
θ, THE ANGLE OF DECLINATION MEASURES THE ANGLE BETWEEN MAGNETIC NORTH AND TRUE (GEOGRAPHICAL) NORTH.

(2marks)



QB6. [12 Marks]

A power plant generates electricity at 25.0 kV. The voltage is then increased to 4.00×10^2 kV at the transmission substation. High voltage transmission lines carry electrical energy over a distance of 50.0 km to the power substation where the voltage is reduced down to a lower voltage. The high voltage transmission lines have an overall resistance of 1.50 Ω. In total, 5.00×10^2 MW of power is output from the power plant to the transmission lines.



6a) Determine the current that flows through the high voltage transmission lines.

USING $P = V.I$

THEN $I = P/V$

$= \frac{5.00 \times 10^8}{4.00 \times 10^5}$

$\therefore I = 1.25 \times 10^3$ A

(2marks)

6b) What are the main reasons for supporting the 400 kV power lines on very high, strongly constructed (and very expensive) pylons?

THE CABLES MUST BE SUPPORTED A LARGE DISTANCE FROM THE GROUND. IF NOT, THE ELECTRIC FIELD INTENSITY CREATED WOULD RESULT IN SIGNIFICANT LEAKAGE AND REPRESENT A SIGNIFICANT DANGER.

(2marks)

6c) What is the percentage power loss in transmission to the power substation?

USING $P_{LOSS} = I^2 R$

$= (1.25 \times 10^3)^2 \times 1.50$

$= 2.34 \times 10^6$ W $\equiv$ 2.34 MW

% LOSS $= \frac{LOSS}{SUPPLY} \times 100$

$= \frac{2.34 \times 10^6}{500 \times 10^6} \times 100$

$= 0.47\%$

(3marks)

6d) Determine the voltage of the high voltage transmission lines at the power substation.

USING $V_D = I . R$

$= 1250 \times 1.5$

$\therefore V_D = 1.88 \times 10^3$ V $\equiv$ 1.88 kV

$\therefore V_{PS} = V_{SS} - V_D$

$= (400 - 1.88) \times 10^3$

$\therefore V_{PS} = 398 \times 10^3$ V $\equiv$ 398 kV

(3marks)

6e) Briefly describe the underlying principles to explain operation of transformers.

- FARADAY'S LAW OF MAGNETIC INDUCTION
- VOLTAGE IS CHANGED BETWEEN PRIMARY AND SECONDARY COILS
- ALTERNATING CURRENT PROVIDES ALTERNATING/CHANGING FIELD
- EMF "CHANGED" IN PROPORTION TO Nº WINDINGS RATIO PRIMARY : SECOND
- ENERGY/POWER IS TRANSMITTED BETWEEN PRIMARY : SECONDARY CIRCUITS

($P = V.I$ $\quad V_P/V_S = N_P/N_S$)

(2marks)

QB7. [12 Marks]

The Doppler shift in the wavelength of light emitted by galaxies can be used to measure the speed with which they are moving towards or away from the Earth. Like the Sun, galaxies emit a wide range of wavelengths. The analysis of the absorption spectra of light from galaxies can have two spectral lines missing due to the absorption by calcium ions as light passes through the gases surrounding galaxies.

The Doppler shift relationship is $z = \frac{\Delta\lambda}{\lambda}$

It can also be shown that: $z = \frac{v}{c_0}$

Where
z = red shift
$\Delta\lambda$ = change in wavelength (moving source) (nm)
λ = wavelength of stationery source (nm)
v = recessional speed of galaxy (m s^{-1})
c_0 = speed of light in a vacuum (m s^{-1})

The spiral galaxy NGC 1357 in the constellation Eridanus is visible in the western sky between January to April.

The wavelength of one of the calcium absorption lines in the spectrum from NGC 1357 is 399.72 nm.

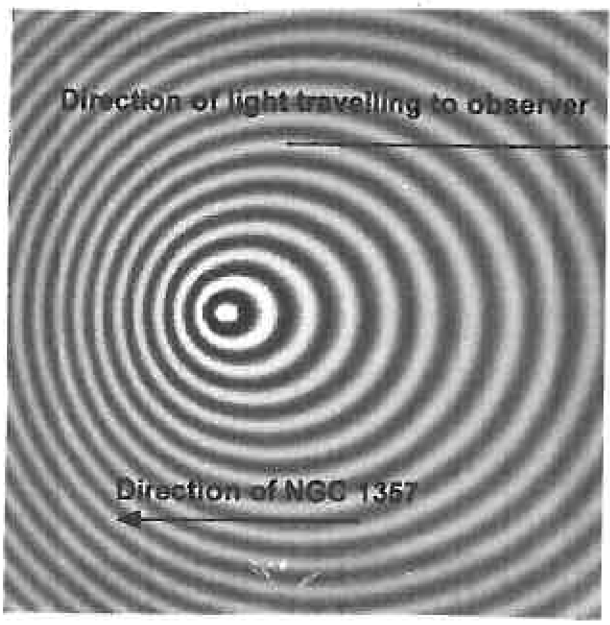
The same line in the calcium spectrum measured in a laboratory on Earth is 396.85 nm.

7a) Is NGC 1357 moving towards or away from the Earth?

AWAY (RED SHIFTED)

(1mark)

7b) Justify your answer to (a) by providing a brief explanation and a supporting diagram.



THE WAVELENGTH OF THE CALCIUM LINE IN THE SPECTRUM FROM NGC 1357 HAS INCREASED. THIS CHARACTERISTIC OF A SOURCE MOVING AWAY FROM OBSERVER – SHIFTED TOWARD RED.

DIAGRAM: • WAVELENGTH CHANGES CLEAR
• REFERENCE TO OBSERVER

(4marks)

7c) Calculate the velocity of NGC 1357 relative to the Earth.

USING $\Delta\lambda = \lambda_{SHIFTED} - \lambda_{REST}$ AND $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$

THEN $v = \frac{\Delta\lambda \times c}{\lambda}$

$= \frac{(399.72 - 396.85) \times 3 \times 10^8}{396.85}$

$\therefore v = 2.169 \times 10^6 \ ms^{-1}$

(2marks)

7d) A star has a recessional velocity of 58.9 km s^{-1}. Calculate the 'red shift' that would be expected in the calcium 396.849 nm absorption line from this star.

USING $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$

THEN $\Delta\lambda = \frac{v\lambda}{c}$

$= \frac{58.9 \times 10^3 \times 396.85 \times 10^{-9}}{3 \times 10^8}$

$\therefore \Delta\lambda = 7.791 \times 10^{-11}$ m {* ACCEPT $z = 1.963 \times 10^{-4}$}

(2marks)

Edwin Hubble analysed the red shifts of various galaxies in 1920 and discovered the following relationship (known as Hubble's Law) :

$$V_{galaxy} = H_0.d$$

Where
v_{galaxy} = recessional speed of galaxy (km s^{-1})
d = distance to galaxy (Mpc)
H_0 = Hubble's constant (km s^{-1} Mpc^{-1})

7e) Calculate the distance to the NGC 1357 galaxy in light-years given that Hubble's constant is known to be 74.2 km s^{-1} Mpc^{-1}, and 1 Mpc = 3.261 x10^6 light-years.

USING $v = H_0 . d$

THEN $d = \frac{v}{H_0} = \frac{2.169 \times 10^3 \ kms^{-1}}{74.2 \ kms^{-1} Mpc^{-1}}$

$\therefore d = 29.23$ Mpc

$\therefore d = 29.23 \times 3.261 \times 10^6$

$\therefore d = 9.53 \times 10^7$ ly

i.e $d \equiv 95.3$ million light-years

(3marks)

PHYSICS

Year 12, 2012

Semester Two Examination

SECTION C

Question/Answer Booklet

Teacher:
JAA / MV

Name:

EXAMINERS USE ONLY	
Section C	

TIME ALLOWED FOR THIS PAPER

Reading time before commencing work: Ten minutes

Working time for paper: Three hours

MATERIAL REQUIRED/RECOMMENDED FOR THIS PAPER

TO BE PROVIDED BY THE SUPERVISOR

This Question/Answer Booklet comprising **12** pages

Data and Constants Sheet

INSTRUCTIONS TO CANDIDATES

Answers to questions involving calculations should be evaluated and given in decimal form.

Quote the final answers to no more than four significant figures.

Despite an incorrect final result, credit may be obtained for method and working, provided these are clearly and legibly set out.

Questions involving working should be answered with a complete, logical, clear sequence of reasoning showing how the final answer was arrived at; correct answers which do not show working will **not** be awarded full marks.

Questions containing the instruction **estimate** may give insufficient numerical data for their solution. Students should provide appropriate figures to enable an approximate solution to be obtained.

SECTION C : Comprehension and Interpretation

Marks Allotted: 36 marks out of 180 (20%). Attempt BOTH questions in this section.
Candidates are reminded of the need for clear and concise presentation of answers.
Diagrams (sketches), equations and/or numerical results should be included where appropriate.

QC1 [18 marks]

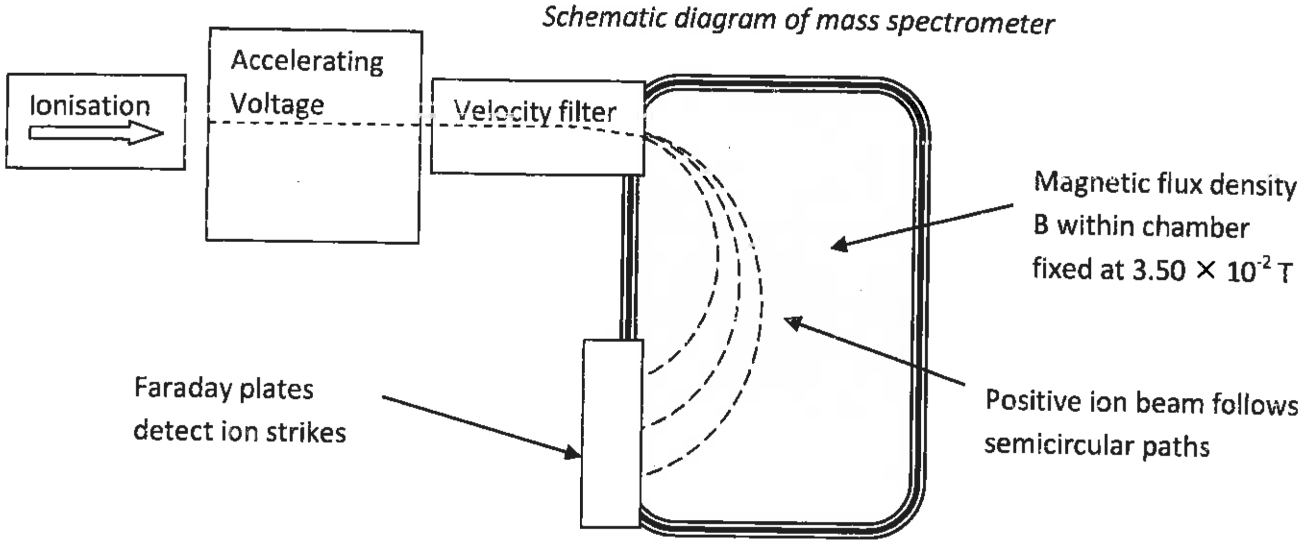
Experimental Analysis and Interpretation

Using a mass spectrometer for a crime scene investigation.

Australian Federal Police have isolated an element found at a crime scene. They think the element may be sodium or potassium so have asked the forensic laboratory to run tests on the element to identify it. The laboratory is able to ionise the element to give it a single positive charge. They then accelerate the ions through a potential difference (Vd) and by use of a velocity filter are able to send ions that have reached their maximum kinetic energy into a mass spectrometer. When the ions enter the mass spectrometer they are acted on by a uniform magnetic field and follow a semi –circular path.

Technicians conduct a series of tests and measure the radius of circular motion for different values of potential difference used to accelerate the charged ions.

Schematic diagram of mass spectrometer



The table below shows the results obtained when the magnetic flux density B in the mass spectrometer was fixed at 3.50 × 10^{-2} T. Measurements of radius have been expressed with an uncertainty of ± 5% and radius squared with an uncertainty ± 10%.

Potential difference V_d (volts)	Radius of circular path (metres)	Radius squared (metres squared)
200	0.270 ± 0.014	0.073 ± 0.007
400	0.370 ± 0.019	0.137 ± 0.014
600	0.490 ± 0.025	0.240 ± 0.024
800	0.530 ± 0.053	0.281 ± 0.028
1000	0.620 ± 0.027	0.384 ± 0.038
1200	0.670 ± 0.034	0.449 ± 0.045

VALUES ✓
SIGNIFICANT FIGURES ✓
UNCERTAINTY FORMAT ✓

It can be shown that the radius r of circular motion for an ion of mass m and charge q, entering the mass spectrometer at speed v and being deflected by a magnetic field of flux density B is as follows:

$$r = \frac{m.v}{q.B}$$

Use the following known data to answer the following questions :

Mass of a potassium K^+ ion = 6.49×10^{-26} kg

Mass of sodium Na^+ ion = 3.82×10^{-26} kg

1a) Use the equation $r = \frac{m.v}{q.B}$ and other equations on the formulae and constant sheet that link the kinetic energy in (joules) attained by a mass of charge **q** (coulombs) in a potential difference $\mathbf{V_d}$ (volts) and derive the following expression:

$$r^2 = \frac{2.m}{q.B^2}.V_d$$

SINCE $r = \frac{mv}{B.q}$

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

SINCE $\Delta E_k = W = V.q = \frac{1}{2} mv^2$

THEN $V = \frac{mv^2}{2.q}$

THUS $r^2 = \frac{m^2 v^2}{B^2 q^2} = \frac{2m}{B^2 q} \times \frac{mv^2}{2q}$

$\therefore$ $r^2 = \frac{2m}{B^2 q} \times V$ (Q.E.D)

(3marks)

The equation follows the format **y = mx + c** for values of r^2 plotted against V_d

1b) Complete the table by filling in the values of radius squared $\mathbf{r^2}$ with the appropriate uncertainty range. Two values have been done for you.

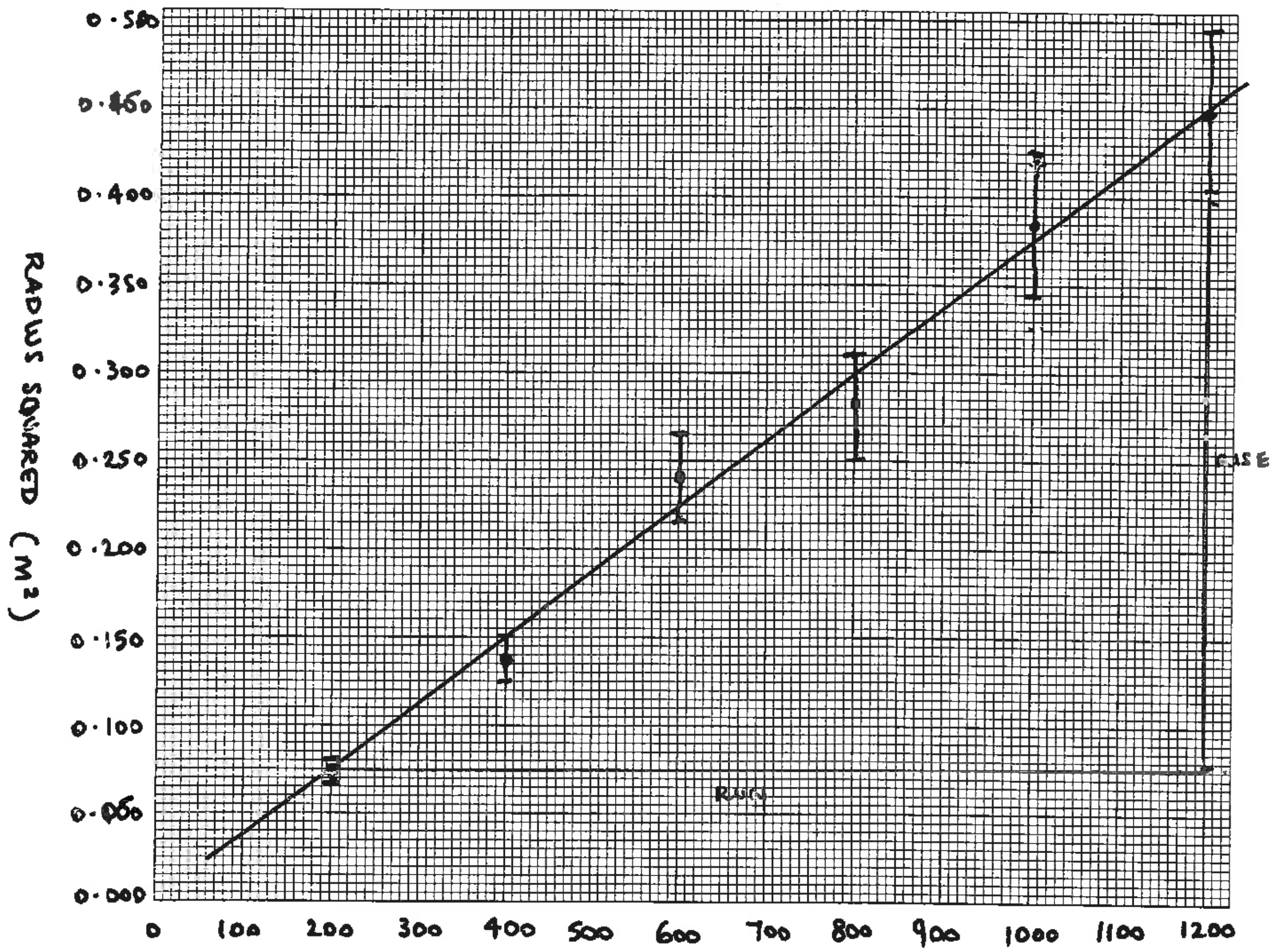
CORRECT VALUES ✓
SIGNIFICANT FIGURES ✓
UNCERTAINTY FORMAT ✓

(3marks)

1c) Plot the graph of $\mathbf{r^2}$ (vertical axis) versus **Potential difference $\mathbf{V_d}$** (horizontal axis) on the Graph paper provided. Include error bars and a line of best fit. (5marks)

If you need to make a second attempt, spare graph paper is at the end of this question. Indicate clearly if you have used the second graph and cancel the working on the first graph.

RADIUS^2 VERSUS POTENTIAL DIFFERENCE



✓ AXES LABELLED / UNITS
✓✓ ACCURATE PLOTS
✓ LINE OF BEST FIT ✓ ERROR BARS

(5marks)

1d) Calculate the gradient of your line of best fit from your graph showing all working.

✓ RISE AND RUN TAKEN FROM LINE OF BEST FIT (ON A BIG TRIANGLE)

$$\text{GRADIENT} = \frac{\text{RISE}}{\text{RUN}} = \frac{0.450 - 0.075}{1200 - 200} \checkmark$$

$\therefore$ GRADIENT $= 3.75 \times 10^{-4}\ m^2 V^{-1}$

$\simeq 4.00 \times 10^{-4}\ m^2 V^{-1}$ ✓

(3marks)

1e) Use the value of the gradient that you obtained to determine the identity of the charged ion. (If you could not obtain a gradient use the numerical value 4.00×10^{-4})

SINCE GRADIENT $= \frac{r^2}{V}$ AND $r^2 = \frac{2mV}{B^2q}$

THEN GRADIENT $= \frac{2m}{B^2 q} = 4.00 \times 10^{-4}$

$\therefore \quad m = \frac{4.00 \times 10^{-4} \times B^2 . q}{2}$

$\therefore m = 2.00 \times 10^{-4} \times (3.50 \times 10^{-2})^2 \times 1.60 \times 10^{-19}$

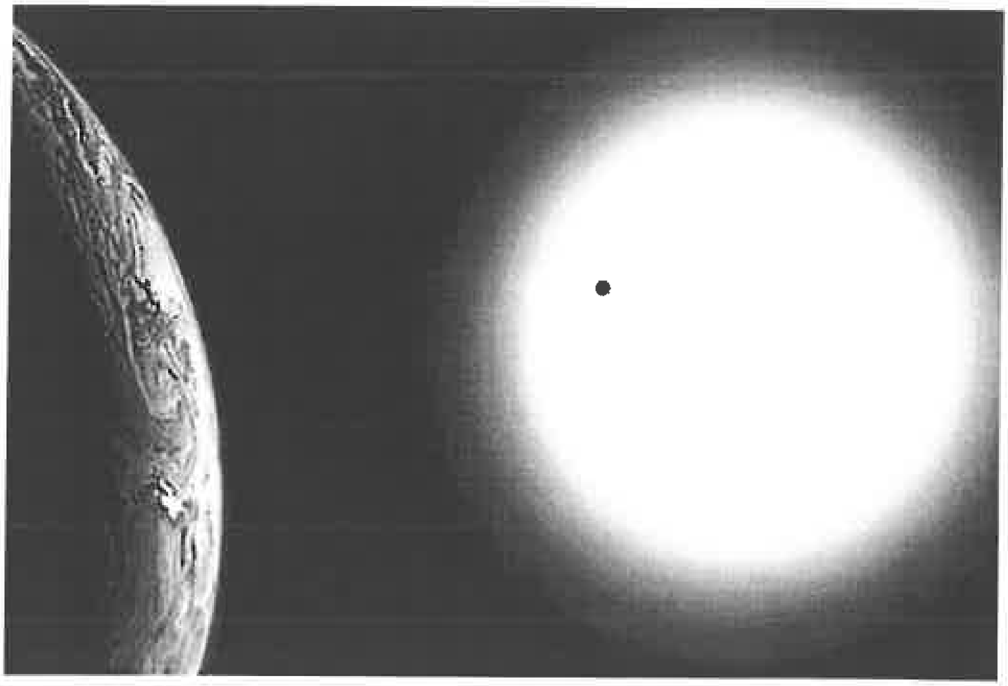
$\therefore m = 3.92 \times 10^{-26}$ kg

$m_{Na^+} = 3.82 \times 10^{-26}$ kg $\therefore$ CHARGED ION IS Na^+

(4marks)

QC2 [18 marks]

The Transit of Venus



Paragraph 1

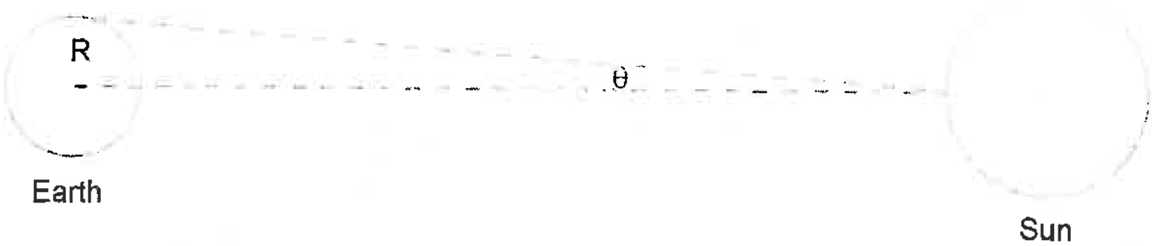
Nearly four centuries ago a young astronomer by the name of Jeremiah Horrocks made history by predicting and observing the transit of Venus. A transit is when a planet passes between the Earth and the Sun appearing as a dark spot moving across the Sun's surface. Only Mercury and Venus are between the Earth and the Sun. The last time Venus transited the Sun was June 8th 2004 and the next time will be 5th June 2012. It takes about 30 mins for the complete transit. The orbital planes of Venus and the Earth around the Sun are not identical and this affects the times between transits. No one alive had ever seen a transit before the June 8th 2004 observation yet the next will be in 2012 on the 6th June at 10.09 pm in Perth.

Paragraph 2

The fact Horrocks could predict its transit with accuracy and also calculate the Earth- Sun distance is a testimony to the precision he took his measurements with. The distance from the Earth to the Sun is known as one astronomical unit [AU].

Paragraph 3

The path of Venus across the Sun depends on where the viewing takes place. It is different at the equator as compared to what you would view in Perth. By combining observations at different latitudes and knowing the radius of the Earth it is possible to deduce the solar parallax angle θ and hence deduce the Earth - Sun distance.



Paragraph 4

It is recommended that you observe the Sun at least a day or so before the transit time in case there are sunspots. Sunspots are areas on the Sun's surface that have a darker colour than the surrounding area. Remember never look at the Sun directly either with your eye or through a telescope. Use a telescope or a pair of binoculars to project the image onto a piece of card.

Questions

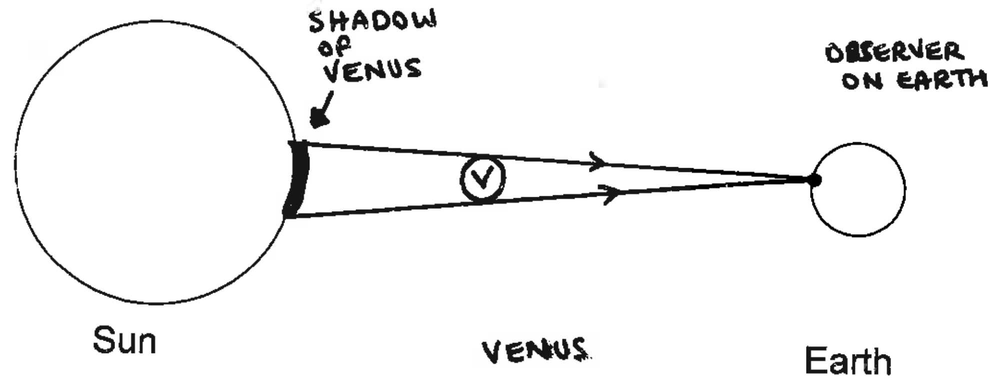
1. Which other planets can have a transit path when viewed from Earth? Explain your choice.

EITHER, THOSE BETWEEN THE EARTH AND THE SUN

MERCURY AND VENUS ONLY

(2marks)

2. Draw a picture to illustrate your understanding of the transit of Venus using the diagram below.



(2marks)

3. Using your data sheet calculate the Earth – Moon distance in AU.

SINCE $d_{S\to E} = 1$ AU BY DEFINITION

THEN $\frac{d_{S\to E}}{d_{M\to E}} = \frac{1.50\times10^{11}}{3.84\times10^{8}} = \frac{1}{0.0025}$ AU

$\therefore d_{M\to E} = 0.0025$ AU

(2marks)

4. What does the expression "the orbital planes are not identical" mean? Use this idea to explain why the Venus transit is an irregular event.

THE ORBITAL PLANES ARE INCLINED TO EACH OTHER

THEREFORE, VENUS, THE EARTH AND THE SUN ARE RARELY ALIGNED

FOR THE TRANSIT TO BE OBSERVED.

(2marks)

5. Calculate the time, in seconds, for Venus to orbit the Sun if the Sun – Venus distance is known to be 1.08×10^{11} m.

SINCE $F_G = F_C$ THEN $\frac{G \cdot M_s M_v}{r^2} = \frac{M_v v_v^2}{r}$ AND $v = \frac{2\pi r}{T}$

$= \frac{4\pi^2 r}{T^2}$

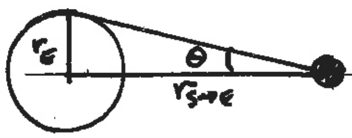
$\therefore T^2 = \frac{4\pi^2 r^3}{G M_s}$

$\therefore T^2 = \frac{4\pi^2 (1.08 \times 10^{11})^3}{6.67 \times 10^{-11} \times 1.99 \times 10^{30}}$

$\therefore T = 1.93 \times 10^7$ s

(3marks)

6. If the solar parallax angle was 2.5×10^{-3} degrees then calculate the Earth – Sun distance.



USING $\tan\theta = \text{opp}/\text{adj} = \frac{r_E}{r_{S\to E}}$

THEN $r_{S\to E} = \frac{r_E}{\tan\theta}$

$= \frac{6.37 \times 10^6}{\tan 2.5 \times 10^{-3}}$

$\therefore r_{S\to E} = 1.46 \times 10^{11}$ m

(3marks)

7. Why, if you want accurate results, would you choose two locations on Earth separated by as large a distance as possible?

SO THAT THE TRIANGLE USED TO CALCULATE THE SOLAR PARALLAX ANGLE θ IS AS LARGE AS POSSIBLE IN ORDER TO MINIMISE ERROR.

(2marks)

8. Why are you advised to view the sunspots before the transit observation and why should you never view the Sun directly?

SO AS NOT TO CONFUSE THE SUNSPOTS ON THE SUN'S SURFACE WITH THE PLANET VENUS.

THE SUN'S HIGH ENERGY EMR RAYS WILL DAMAGE YOUR EYE IF VIEWED DIRECTLY.

(2marks)