ACADEMIC ASSOCIATES

WACE 3A & 3B

PHYSICS

TRIAL EXAMINATION PAPER 2

Student Name: ______________________________

Date: ____/____/____

Time Commenced: ______________

Time allowed for this paper

Reading time before commencing work: Ten minutes
Working time for paper: Three hours

Materials required for this paper

- Physics Formulae Sheet – this is located at the end of this book.

Materials to be provided by the candidate

Standard Items: pens, pencils, eraser, correction fluid, ruler, highlighters.

Special Items: non-programmable calculators satisfying the conditions set out by the Curriculum Council for this course.

STRUCTURE OF THIS PAPER

Section	Number of questions available	Number of questions to be answered	Suggested working tme (minutes)	Marks available	Percentage of exam
Section One: Short response	13	13	50	54	30
Section Two: Problem solving	7	7	90	90	50
Section Three: Comprehension	2	2	40	36	20
					100

Instructions to candidates

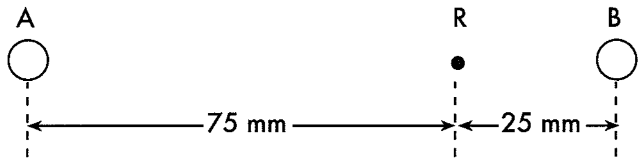
- Write answers in the spaces provided.
- Working or reasoning should be clearly shown when doing calculations.
- Final numerical answers should be quoted to three significant figures.
- Spare pages are included at the end of each trial paper. These can be used for planning your answers or for more space if required.

SECTION ONE: SHORT ANSWER

This section has 13 questions. Answer all questions. Write your answers in the space provided. Suggested working time for this section is 50 minutes. For numerical problems quote your final answer to three significant figures.

Question 1 **(4 marks)**

In the diagram below, A and B are two small insulated spheres 100 mm apart which are capable of retaining electric charge. R is a point 75 mm from A and 25 mm from B.



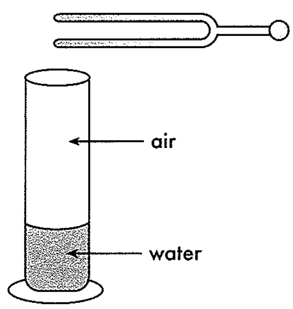
What is the direction of the electric field at R when:

(a) A and B carry positive charges of equal magnitude?

(b) A carries a positive charge and B a negative charge of equal magnitude?

Question 2 **(4 marks)**

A student holds a vibrating 256 Hz tuning fork above a measuring cylinder initially full of water. She then gradually lowers the water height, creating an air column as shown. She observes that the sound produced becomes quite loud for the first time when the length of the air column is 32.0 cm. The student selects a tuning fork of a higher frequency and vibrates it above the 32.0 cm air column. It also produces quite a loud sound.

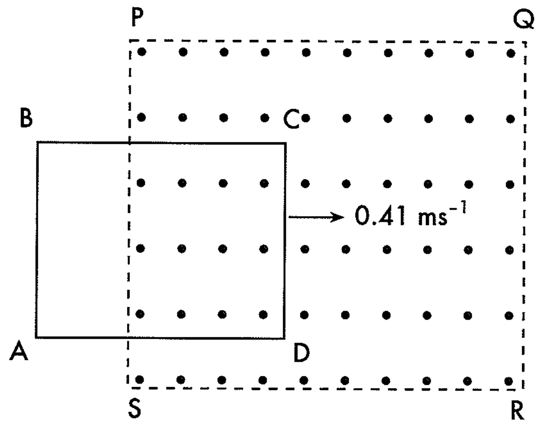


(a) What is a possible frequency for the second tuning fork?

(b) Explain why the sound became loud for the 256 Hz fork when the air column reached a certain length.

Question 3 (3 marks)

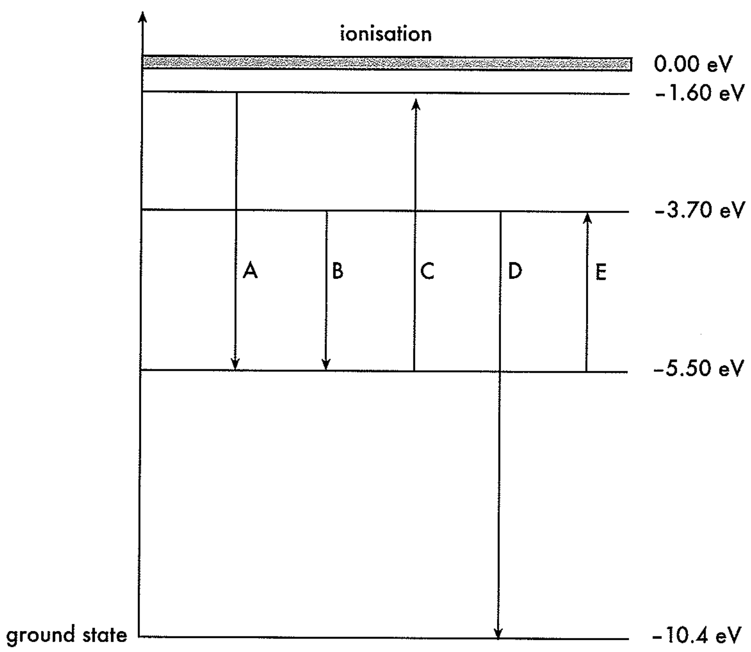
ABCD represents a rigid conducting loop made of metal. Each side of the loop is 2.00 cm long. Within the large square lies a magnetic field of 0.480 T which points directly out of the page. The loop ABCD moves in the direction indicated at a speed of 0.41 ms^{-1}.



Calculate the magnitude of the EMF developed in the section CD of the conductor.

Question 4 (4 marks)

(a) Which transition (A, B, C, D or E) on the energy level diagram below demonstrates the change in atomic energy levels for the emission of a photon of energy 1.80 eV?



atomic energy levels of mercury

(b) Calculate the wavelength of a photon of energy emitted as the excited atom returns from the *second excited energy level* to the ground state. From what section of the electromagnetic spectrum does this radiation come?

Question 5 **(4 marks)**

The observed velocity of an object may differ according to different reference frames. Explain this using the example of two cars moving in the same direction in adjacent lanes at equal speeds which pass a stationary car on the side of the road.

Question 6 **(3 marks)**

(a) What is the name given to a particle that is made up of quarks? (1 mark)

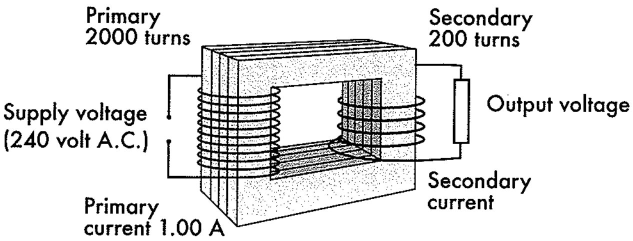
(b) Quarks all have partners called antiquarks. What is: (2 marks)

(i) one common property of a quark and its antiquark?

(ii) one different property of a quark and its antiquark?

Question 7 **(5 marks)**

Consider the diagram below:



(a) Calculate the numerical values of the output voltage and the secondary current. Include the type of voltage (A.C. or D.C.) and the type of current (A.C. or D.C.). Assume the transformer is 100% efficient.

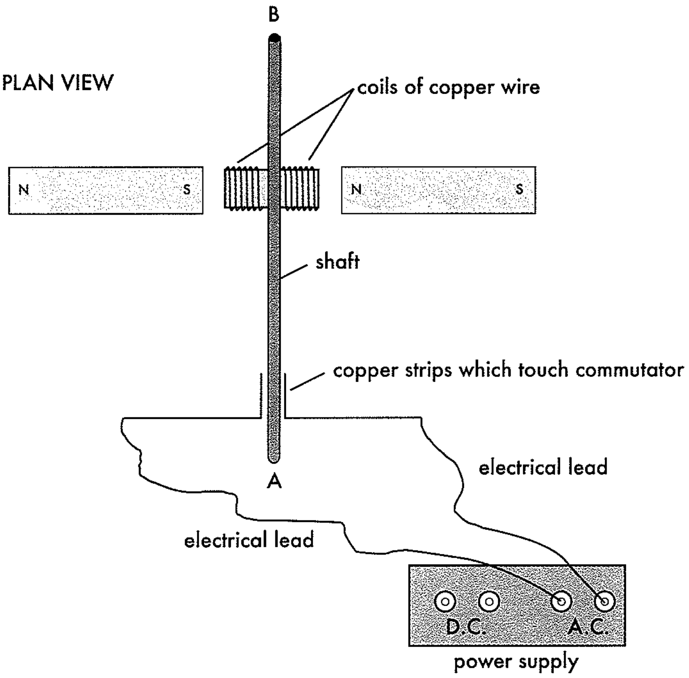
(b) Determine the power input.

(c) What is the power output if the transformer is only 94.9% efficient?

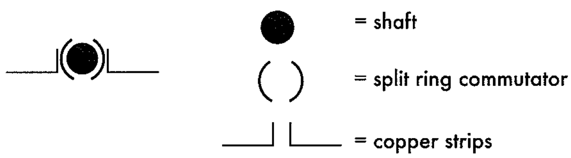
Question 8 **(4 marks)**

The diagrams show a two pole DC motor as constructed by a student.

PLAN VIEW



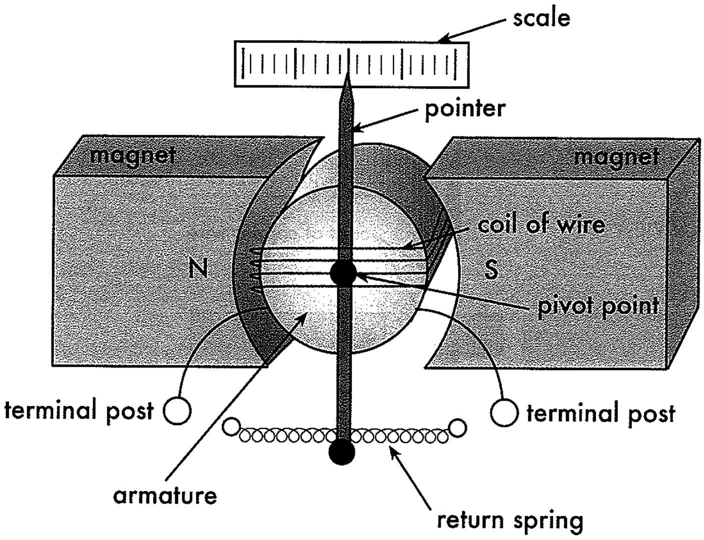
END ELEVATION (looking at end A)



When connected to the power supply, the motor did not work. Give two reasons why.

Question 9 **(4 marks)**

A simple electrical meter is shown below:



Explain how the meter operates when it is connected through the terminal posts to an external circuit. Include in your explanation a reason for the curvature of the permanent magnets around the armature.

Question 10 (4 marks)

The mass of the Moon is 1.2274×10^{-2} times that of the Earth and its radius is 0.27273 times that of the Earth. Compare the acceleration of a 2.55 kg mass very close to the Moon's surface to the acceleration of a 3.55 kg mass very close to the Earth's surface. Assume both the Moon and the Earth are spherical in shape.

Question 11 **(4 marks)**

A pram (baby-stroller) and baby together weigh 140 N. The diagram below shows the position of the centre of gravity (G) of the baby and pram.

In order to lift the front wheels up and over a roadside kerb whilst moving forward, the pusher exerts a downward force (F) on the handle. Calculate the minimum value of F.

Question 12 (4 marks)

Use Lenz's Law in each case below to determine which end of coil Q (A or B) becomes positive.

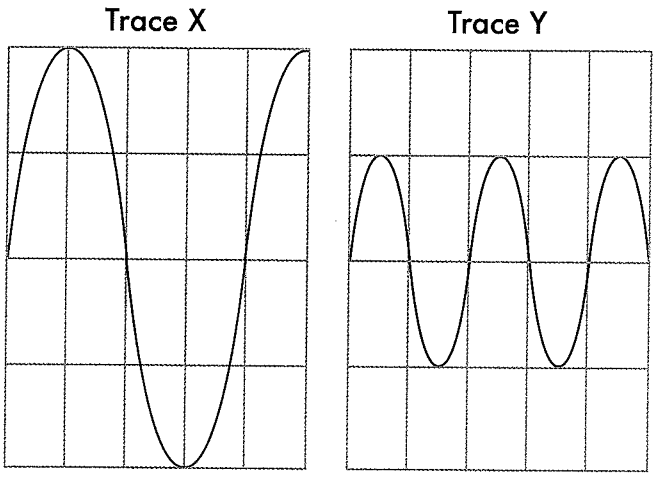
(a) Magnet moves towards coil Q.

(b) Switch S is closed and current flows in coil P.

Question 13 **(7 marks)**

The output of a microphone placed in front of a sound source is fed into a cathode ray oscilloscope. Traces X and Y were both obtained using the same settings on the CRO.

Trace X corresponds to sound wave X and trace Y corresponds to sound wave Y.



(a) Which of the following do the traces represent?

(A) pressure variation versus time of a transverse wave
(B) displacement versus time of a transverse wave
(C) pressure variation versus time of a longitudinal wave
(D) displacement versus distance of a transverse wave

(b) Calculate the ratio of $\frac{\text{amplitude of X}}{\text{amplitude of Y}}$

(c) Calculate the ratio $\frac{\text{wavelength of X}}{\text{wavelength of Y}}$

(d) Calculate the ratio $\frac{\text{frequency of X}}{\text{frequency of Y}}$

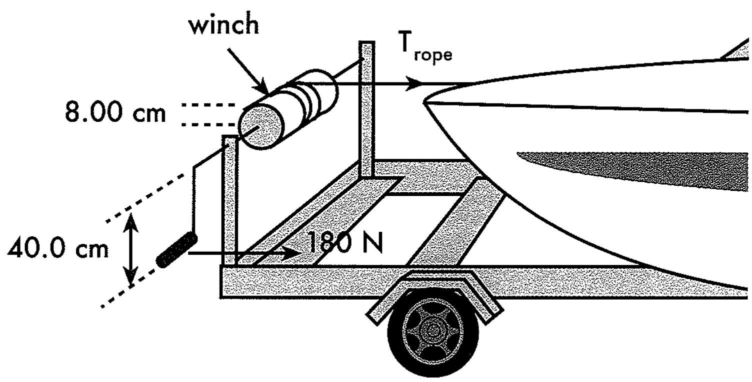
SECTION TWO: PROBLEM-SOLVING

This section has seven compulsory questions. Suggested working time for this section is 90 minutes. Final numerical answers should be quoted to three significant figures.

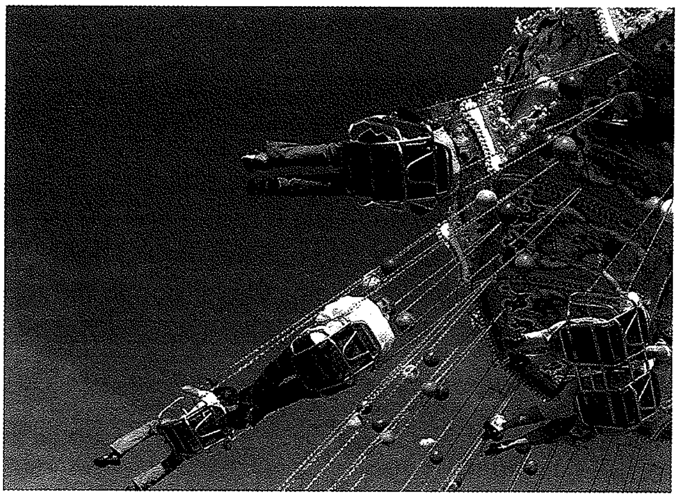
Question 14 **(10 marks)**

(a) A winch consisting of a circular drum turned by a handle (similar to the one in the diagram) is used to pull a boat onto a trailer. The drum has a radius of 8.00 cm and the handle is 40.0 cm long. A rope is wound around the drum and attached to the boat. When a force of 180.0 N is applied at right angles to the handle, what is the tension in the rope?

(3 marks)



(b) A popular side show ride consists of a carousel with chairs suspended from light chains around its circumference (as seen in the photo). Assume that the circular path is only horizontal.



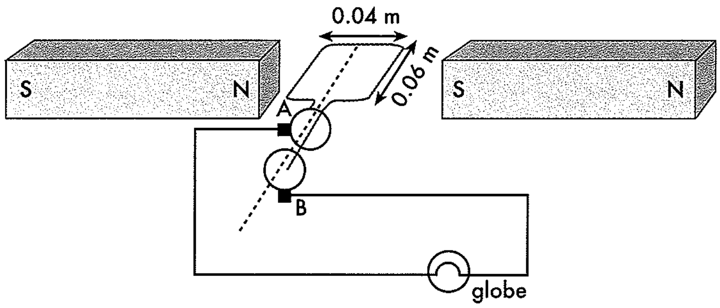
Once the carousel is turning at full speed, the chain makes an angle of 50.0° with the vertical. You can assume that for this example the combined mass of the chair and passenger is 200 kg and that the radius of revolution is 15.0 m.

(i) Sketch and label a vector diagram to show all relevant forces acting on the passenger.
(2 marks)

(ii) Determine the tension in the light chain suspending the chair. (2 marks)

(iii) Determine the period of revolution necessary for this ride. (3 marks)

Question 15 **(16 marks)**



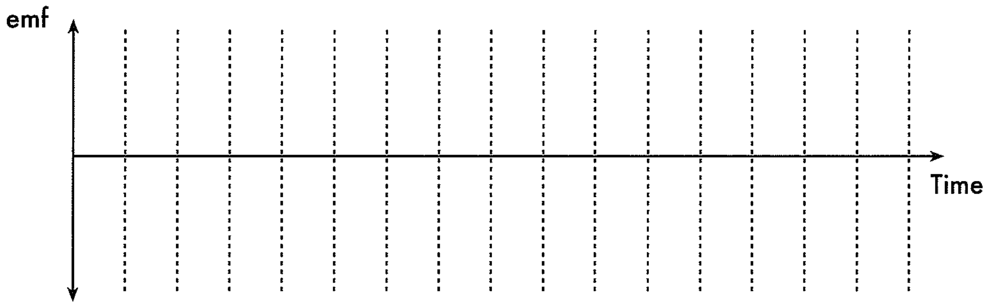
The coil shown above consists of 50 identical turns (in the same plane) placed in a magnetic field of 0.500 T. The coil can rotate about the axis shown and a small test globe is connected to the ends of the coil.

When the plane of the coil is first positioned (as shown), it is rotated anticlockwise at 2.00 revolutions per second.

(a) What type of generator does this diagram represent? (You must give a reason for your choice.) (2 marks)

(b) On the diagram, show the direction of the current in the coil and mark the positive output terminal of the coil, at the instant illustrated. (2 marks)

(c) Carefully construct a graph to show how the emf varies with time through two revolutions of rotation (from the position shown). (3 marks)



(d) What is the average EMF generated across the globe? (3 marks)

(e) Carefully describe (a diagram will help) how you could modify the simple generator so that the globe would not flicker when the coil is rotated. (2 marks)

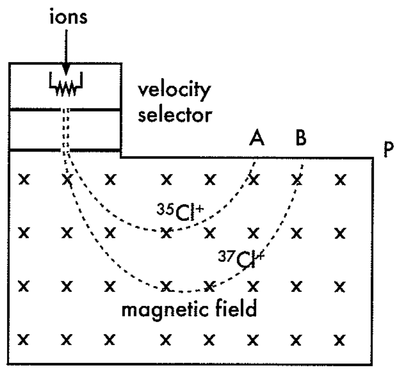
(f) Carefully describe four practical changes that could easily be made that would increase the brightness of the globe. (4 marks)

Question 16 **(10 marks)**

A beam of gaseous ions can be separated into components with different values of mass divided by charge. The result is a mass spectrum. Most measurements are made with singly charged positive ions so the spectrum is divided simply according to mass.

When the ion beams are detected with an electrometer, the instrument is called a mass spectrometer.

The diagram below shows a mass spectrometer. A stream of singly charged positive ions of the chlorine isotopes $^{35}Cl^{+}$ and $^{37}Cl^{+}$ emerge from the slit with a speed of 2.50×10^{3} ms^{-1}. They are then deflected by a magnetic field of uniform flux density 2.00 mT.



The mass of $^{35}Cl^{+}$ is 5.81×10^{-26} kg and the mass of $^{37}Cl^{+}$ is 6.14×10^{-26} kg.

(a) Explain why ions move in a circular (or semi circular) path. (2 marks)

(b) Derive the relationship $r = \frac{mv}{Bq}$ for the radius of the path of an ion moving through a magnetic field.

(3 marks)

(c) Calculate the separation distance between the paths of the ions when detected (i.e. the distance A to B).

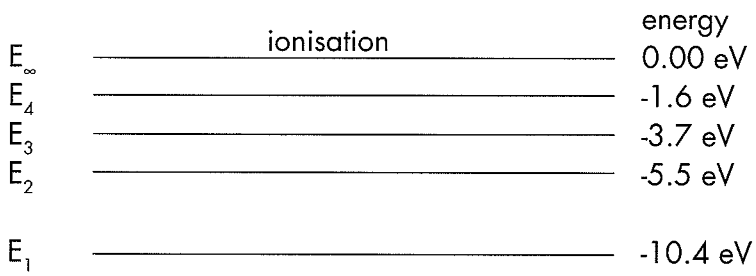
(5 marks)

Question 17 **(14 marks)**

(a) A microwave oven has an output of 700 W at a frequency of 2450 MHz. Make an estimate of the number of photons needed in the time taken to heat a cup of coffee.

(3 marks)

(b) Fluorescent tubes contain low pressure mercury gas which is excited by the rapid movement of electrons between their ends. Shown are some of the energy levels of a mercury atom.



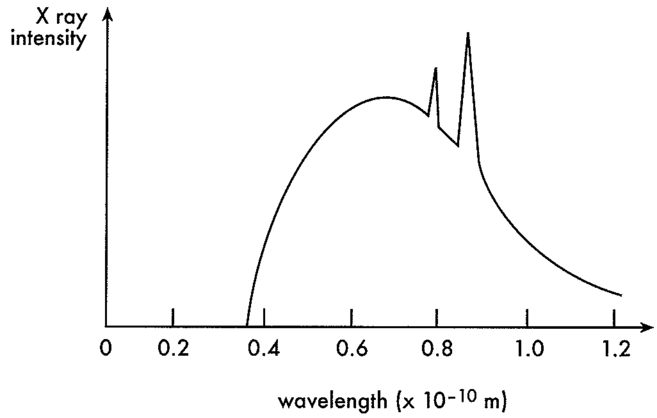
(i) Calculate the shortest wavelength produced when the atom is bombarded with 7.0 eV electrons.

(4 marks)

(ii) To what region of the electromagnetic spectrum do the photons produced in (i) belong?

(1 mark)

(c) The graph shows the spectrum obtained when a molybdenum anode in an X-ray tube is bombarded with electrons accelerated across a potential difference of 34.0 kV.



(i) What is the minimum wavelength of the emitted X rays? (1 mark)

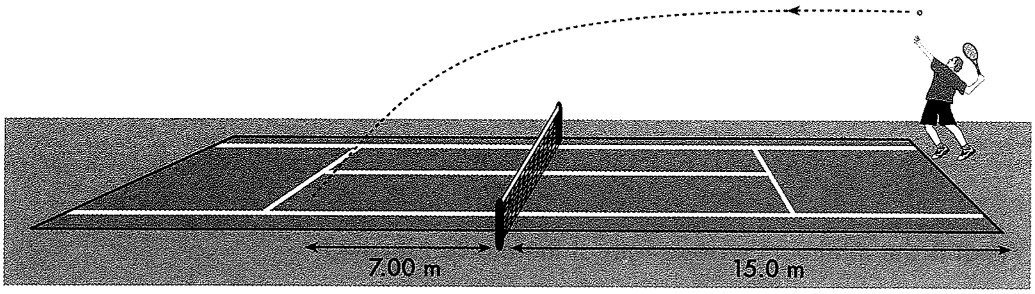
(ii) Use the 34.0 kV accelerating voltage to show why there are no X rays of wavelength lower than that shown. (3 marks)

(iii) Briefly describe two uses of X rays. (2 marks)

Question 18 **(14 marks)**

At serve, a tennis player aims to hit the ball horizontally with sufficient speed to clear the net, land in the service zone and (hopefully) make it difficult for the opponent to return.

Assume that there is negligible air resistance and that the ball travels along the marked centre line. Assume that the ball is hit at a height of 2.50 m above the ground.



(a) What is the minimum speed required to just clear the 0.900 m high net when launched from 2.50 m above the ground? (5 marks)

(b) If the serve just clears the net, where will the ball land? (Will it be "good" – i.e. within 7.00 m?) (5 marks)

(c) If the serve just clears the net, with what velocity will the ball hit the court? (4 marks)

Question 19 **(12 marks)**

(a) Drops of water are thrown tangentially off the rim of a rotating umbrella which makes 2.00 revolutions in 5.00 s. The rim is 1.00 m in diameter and is held horizontally 1.22 m above the ground. Find the diameter of the circle in which the water drops meet the ground.

(6 marks)

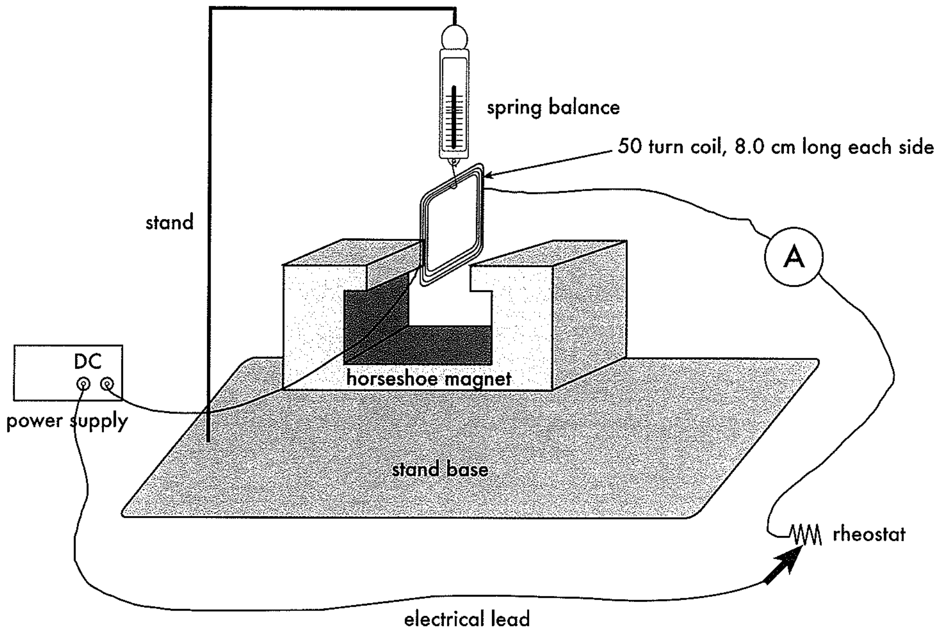
(b) (i) Calculate the centripetal force at the equator on a body of mass 1.00 kg. (3 marks)

(ii) Hence show that the ratio $\frac{\text{weight of a body at the equator}}{\text{weight of same body at the pole}} = 0.997$

(For this question, assume that the Earth is a perfect sphere) (3 marks)

Question 20 **(14 marks)**

The diagram below shows a square coil containing 50 turns with a side of length 8.0 cm suspended from a spring balance between the poles of a magnet. The coil is in series with the power supply, ammeter and rheostat.



The following data was obtained when a current I passed through the coil producing a downward force F on the coil.

I(A)	0.0	1.0	2.0	3.0	4.0	5.0
F(N)	1.8	2.0	2.2	2.4	2.6	2.8

(a) Draw a graph of force (vertical axis) vs current (horizontal axis) using the axes drawn on the graph paper. (3 marks)

(b) Determine the slope of the graph and use this value to calculate the magnetic field strength (B) between the poles of the magnet.

(4 marks)

(c) Use your graph to determine the weight of the coil. (2 marks)

(d) If the direction of the current through the coil is reversed, calculate the value of I for which the reading on the spring balance will be zero.

(3 marks)

(e) Using your graph predict the value of I for F = 0. (2 marks)

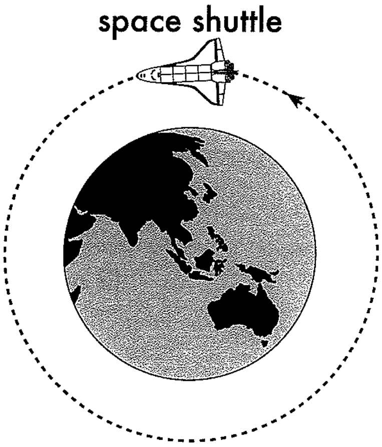
SECTION THREE: COMPREHENSION

This section contains **two** compulsory questions. Write your answers in the space provided.

Suggested working time for this section is 40 minutes

Question 21 **(20 marks)**

ORBITING ASTRONAUTS



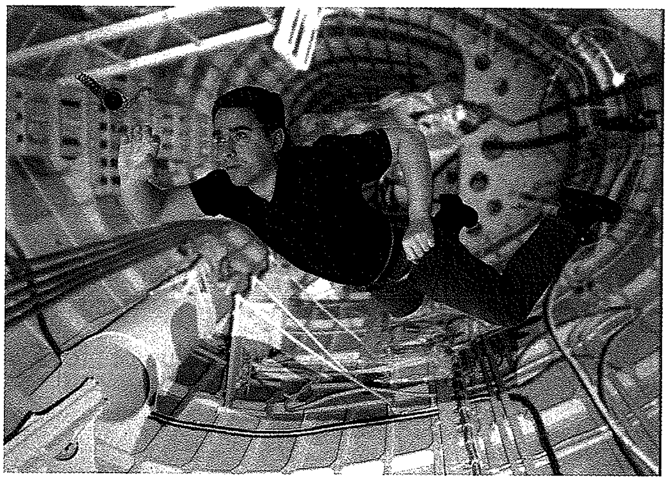
When astronauts are in orbit several hundred kilometres above the Earth's surface where gravity is still reasonably strong, they appear to "float" as if gravity didn't exist.

For a typical shuttle orbit of 400 km, the gravitational field strength is 8.73 Nkg^{-1} (compare this to 9.8 Nkg^{-1} at the Earth's surface).

Of course the astronauts are not really weightless, since true weightlessness never actually occurs. A small non-zero gravitational field strength still exists even in deep outer space.

The astronauts are said to be "apparently weightless". This occurs when objects move with an acceleration equal to that of the gravitational field strength, i.e. when objects are in "free fall". A similar situation could exist on the Earth if you happened to be travelling in an elevator whose cable severed. Both the elevator and its occupant would accelerate downwards at the same rate of 9.8 ms^{-2}. The reaction or normal force between the lift occupant and the lift floor would be zero. If you held a pen in front of your nose and released it, it too would accelerate down at 9.8 ms^{-2} and remain in front of your nose as you would be hurtling downwards in the free-falling lift. Within the lift reference frame, it would seem that gravity was non-existent.

Above Earth, at an altitude of 400 km, where the gravitational field strength is 8.73 Nkg^{-1} the astronauts and their space shuttle orbit at a speed that provides them with a centripetal acceleration of 8.73 ms^{-2}.



This is exactly the same situation as that of falling freely in the elevator shaft. When you and the lift were falling at 9.8 ms^{-2}, (the actual rate determined by the gravitational field strength), you were in a state of "apparent weightlessness". The astronauts and their space shuttle all have an acceleration of 8.73 ms^{-2}, the rate towards the Earth governed by the gravitational field strength at the altitude of 400 km. There is zero reaction force between the astronauts and the floor (or ceiling) of their space shuttle. They too are in a state of "apparent weightlessness" as they orbit the Earth. The only difference is that the astronauts have a velocity that is directed at right angles to their acceleration.

(a) Is it possible for an astronaut to experience *true weightlessness*? Explain using the principles of Physics.

(3 marks)

(b) What is *apparent weightlessness*? (2 marks)

(c) What does Newton's First Law predict? (3 marks)

(d) Use calculations to show that this space shuttle experiences an acceleration of approximately 8.70 ms^{-2} during orbit. (4 marks)

(e) Calculate the orbit velocity (in kilometres per hour) of this space shuttle. (3 marks)

(f) Calculate the period of revolution of this space shuttle during orbit. Express your answer in minutes. (3 marks)

(g) What is the frequency of revolution of this space shuttle during orbit? Express your answer in Hertz.

(2 marks)

Question 22 **(16 marks)**

Hubble's law states that the recession velocity (v) for a galaxy is proportional to its distance from the Earth(r)

i.e. $v \propto r$

$\therefore$ $v = (\text{constant})\, r$ ..... (i)

where v = recessional velocity (measured in kms-1)

r = distance from Earth to the galaxy (measured in Mpc)

The distances to stars and galaxies are so large that astronomers use a more meaningful set of units rather than kilometres. The astronomical unit (AU), the light year and the parsec (pc) are all distance units used in astronomy.

The astronomical unit (AU)

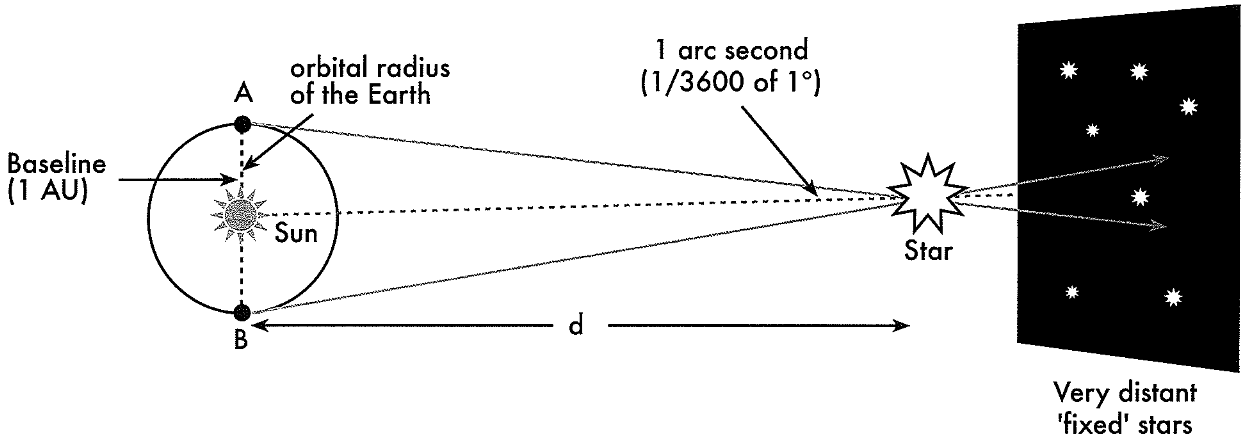
This is the average distance from the Earth to the Sun. 1 AU = 1.496×10^8 km. Interestingly this distance is used in defining the parsec. The AU unit is particularly useful in stating distances within our solar system.

The light year

This is the distance travelled by light in a vacuum in one year. 1 light year = 9.46×10^{12} km. The light year is particularly useful in stating distances to the stars. For example the distance to Alpha Centauri is 4.3 light years. This measurement not only tells us the distance to a star but the time taken for the light to reach us. Hence when we view the light from Alpha Centauri we are viewing the light that left the star 4.3 years ago.

The parsec (pc)

This is the distance to a star that would have a parallax of 1 second of arc (1/3600 of a degree) using the average distance from the Earth to the Sun as a baseline. 1 pc = 3.086×10^{13} km. This is 3.26 light years. This unit is very useful when measuring astronomical distances using parallax.



The parsec. One parsec is the distance that would subtend 1 arc second of angle using the average Earth Sun distance (1 AU) as the baseline. The star under observation appears to move against a "fixed" background of very distant stars. 1 parsec (pc) is 3.26 light years or 3.086×10^{13} km.

(a) Complete the following table:

	Distance (km)	Distance (AU)	Distance Light years	Distance Parsec (pc)
Earth-Moon distance	3.84×10^5			
Earth-Sun distance	1.50×10^8			
Pluto-orbit Sun distance		39.4		

(9 marks)

(b) If the constant in equation (i) is called Hubble's constant, H, find its value from the data below.

Galaxy Number	Distance (Mpc)	Recessional velocity (kms^{-1})
1	1.99	129
2	21.5	1652
3	7.36	657
4	18.4	1509
5	12.6	1048

(7 marks)

Additional working space

Additional working space

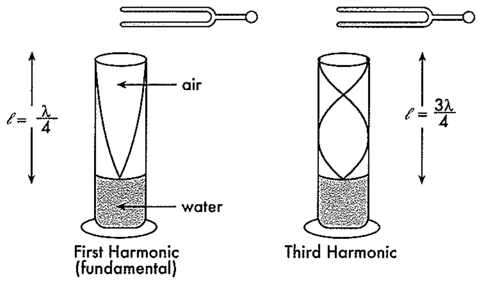
END OF PAPER

SOLUTIONS TO TRIAL PAPER

Section One: Short Answer

1. (a) to the left (in direction from R to A) ✓✓
   (b) to the right (in direction from R to B) ✓✓

2.
(a)



f $= 3f_0 = 3(256)$ ✓✓

$= 768$ Hz

OR $5f_0$ = (1280 Hz)

$7f_0$ = (1792 Hz) etc....

(b) A standing wave is set up at certain lengths, causing sound to resonate. ✓✓

3.

emf = $B\ell v$ ✓
= $(0.480)(2 \times 10^{-2})(0.41)$ ✓
= 3.9×10^{-3} volt ✓

4.

(a) *B* ✓

(b) $\frac{hc}{\lambda} = E$

$\therefore \lambda = \frac{hc}{E} = \frac{(6.63 \times 10^{-34})(3.00 \times 10^{8})}{(10.4 - 3.70)(1.6 \times 10^{-19})}$ ✓

$= 1.86 \times 10^{-7}$ m *(in the ultraviolet region)* ✓✓

5. Consider two cars X and Y. The driver of X on looking at driver Y thinks that Y has low velocity. Driver X thinks this is true if he/she has no vision of external reference points such as trees etc. ✓

On the other hand, a stationary observer looking at car Y can conclude that car Y is travelling at a high velocity. ✓

Both viewpoints are correct – the difference in observed velocity is dependent on differing reference frames for each observer. ✓✓

6. (a) Hadron ✓
   (b) (i) same mass ✓
   (ii) opposite charge ✓

7.

(a) $\frac{V_s}{V_p} = \frac{N_s}{N_p}$ $\qquad \frac{I_s}{I_p} = \frac{N_p}{N_s}$

$\therefore V_s = (240)\left(\frac{200}{2000}\right) = 24.0$ volt (A.C.) ✓✓

$\therefore I_s = (1.00)\left(\frac{2000}{200}\right) = 10.0$ A (D.C.) ✓

(b) $P = VI = (240)(1.00) = 240$ W ✓

(c) $P_{output} = \frac{94.9}{100}(240) = 228$ W ✓

8. Loops of wire wound around the wrong way (construction of armature is incorrect). ✓✓

AC voltage input (need slip rings instead of split rings) or need to use DC input. ✓✓

9.

- Current enters via terminal posts into coil ✓
- A force is created as a result of the interaction of the magnetic field produced by the current and the fixed magnetic field
(F is given by $F = NBI\ell$) ✓
- This force creates a torque ($\tau = rF$) ✓
- Magnets are curved so as to keep the fixed magnetic field at right angles to the current in the coil for as long as possible to maximise torque. (OR curved magnets concentrate magnetic field in region of coil) ✓

10. "g" $= \frac{GM}{r^2}$ ✓

$= \frac{g_{moon}}{g_{earth}} = \frac{\frac{GM_{moon}}{r^2_{moon}}}{\frac{GM_{earth}}{r^2_{earth}}} = \left(\frac{r_{earth}}{r_{moon}}\right)^2\left(\frac{m_{moon}}{m_{earth}}\right)$ ✓✓

$= \left(\frac{1}{0.27273}\right)^2(1.2274 \times 10^{-2}) = 0.165$ ✓

11. Taking moments about P:

ΣCWM = ΣACM ✓

$\therefore$ (Wt)(0.25) = F(0.3) ✓

$\therefore F = \frac{(140)(0.25)}{0.3}$ ✓

$= 117$ N ✓

12.

(a) B ✓✓

(b) A (only during the time when the switch is 'off' to just 'on') thereafter zero induced current. ✓✓

13. (a) (C) ✓
(b) 2 ✓✓
(c) 2 ✓✓
(d) 0.5 ✓✓

SECTION TWO: PROBLEM-SOLVING

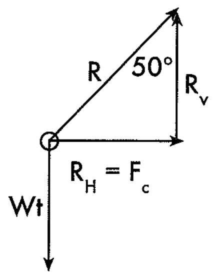
14.

(a) ΣCWM = ΣACWM ✓

$T \times 8.00 \times 10^{-2} = 180 \times 40.0 \times 10^{-2}$ ✓

$T = 900$ N ✓

(b)



✓✓

(i) R = reaction force of the seat
R_v = Wt (weight)
$R_H = F_c$ (centripetal force)

Note: R_v and R_H are components of R

(ii) R = Tension in the light chain

$R_v = W = mg = 200 \times 9.8$
$= 1960$ N ✓

$\cos 50° = \frac{R_v}{R}$

$R = \frac{R_v}{\cos 50°} = \frac{1960}{0.643} = 3049$ N

$= 3.05 \times 10^3$ N ✓

(iii) $F_c = R \sin 50°$
$= 3049 \times \sin 50° = 2336$ N ✓

$\frac{mv^2}{r} = 2336$

$v = \left(\frac{2336 \times 15}{200}\right)^{½} = 13.2\ ms^{-1}$ ✓

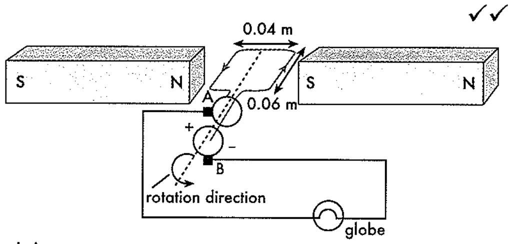
$v = \frac{2\pi r}{T}$

$T = \frac{2\pi r}{v} = \frac{2.\pi \times 15}{13.2}$

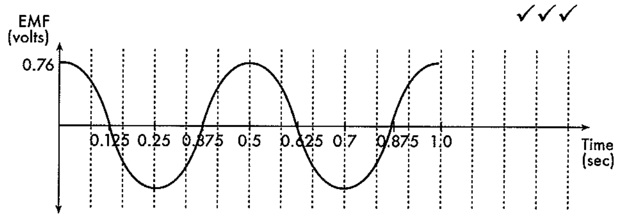
$= 7.12$ s ✓

15. (a) AC generator. The commutator uses slip rings. The PD changes direction. ✓✓

(b) ✓✓



(c) ✓✓✓



(d) emf $= -N\frac{\Delta\varphi}{\Delta t}$ $(\varphi = BA)$

$\therefore emf_{av} = -N\frac{\Delta B.A}{\Delta t}$ ✓

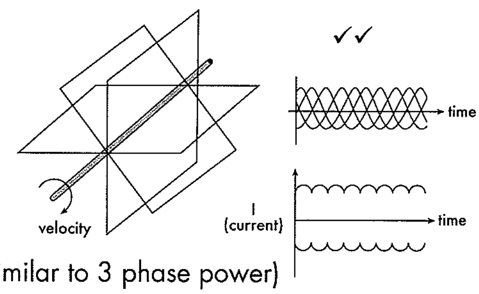
(remember that $\Delta t = \frac{T}{4}$)*

$emf_{av} = \frac{-50 \times (0.5) \times (0.04 \times 0.06)}{\frac{(0.5)}{4}}$ ✓

$\therefore emf_{av} = 0.48$ V ✓

(e) Many more coils each in different planes and curved poles will provide a more even output in the external circuit.

✓✓



(similar to 3 phase power)

The lamp flickers as the current fluctuates (as the induced EMF does)

(f) (1) More turns (N)
(2) Stronger magnet field (B)
(electromagnet)
curved poles
soft iron core
(3) Larger area coil (A)
(4) Turn faster (shorter period)
(5) Less resistant wire (R)
e.g. platinum
(6) Lower rating globe (any four)

16.

(a) Direction of the deflecting force is perpendicular to the direction of motion of the ions. This is the situation for an inwardly directed centripetal force. ✓

Force at 90° to the velocity. Constant force, unbalanced force. ✓

$F_{MAG} = F_C$ ✓

(b) $F = q v B = \frac{mv^2}{r} \therefore r = \frac{mv}{Bq}$ ✓✓

(c) $r(^{35}C\ell^+) = \frac{5.81\times10^{-26}\times2.5\times10^3}{1.6\times10^{-19}\times2\times10^3}$ ✓

$= 4.54 \times 10^{-1}$ m ✓✓

$r(^{37}C\ell^+) = \frac{6.14\times10^{-26} v}{Bq}$

$= 4.80 \times 10^{-1}$ m ✓

$\therefore d_{AB} = 2.58 \times 10^{-2}$ m ✓

17.

(a) Assume coffee takes 2.0 minutes ✓

$E = hf$

$P = \frac{E}{t} = \frac{nE_{photon}}{t}$

$n = \frac{Pt}{E_{photon}} = \frac{Pt}{hf} = \frac{700 \times 120}{6.63 \times 10^{-34} \times 2450 \times 10^6}$ ✓

$= 5.2 \times 10^{28}$ photons ✓

(b) (i) Largest $\Delta E = (-3.7) - (-10.4)$
$= 6.7$ eV ✓

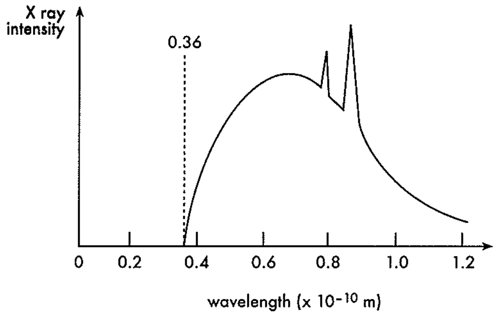
$E = hf = \frac{hc}{\lambda}$ ✓

$\lambda = \frac{hc}{E} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{6.7 \times 1.6 \times 10^{-19}}$ ✓

$= 1.86 \times 10^{-7}$ m ✓

(ii) Ultra violet ✓

(c)



(i) $\lambda = 0.36 \times 10^{-10}$m
$= (0.35 \rightarrow 0.38)$ ✓

(ii) Shortest → highest E(photon) ✓

$E = Vq = hf = \frac{hc}{\lambda}$

$\lambda \text{ (smaller)} = \frac{hc}{Vq} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{34 \times 10^3 \times 1.6 \times 10^{-19}}$ ✓

$= 3.65 \times 10^{-11}$ m ✓

(iii)
- Identifying broken/deformed bones
- Identifying anomalies in soft tissue e.g. cancers
- Identifying welding faults etc. (any two).

18.

(a) $s_v = 2.50 - 0.9$
$= 1.6$ m ✓

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

$1.6 = 0 + \frac{1}{2} 9.8 t^2$ ✓

$t = 0.57143$ s ✓

$V_H = \frac{s}{t} = \frac{15}{0.571}$

$= 26.2$ ms^{-1} ✓✓

(b) s = 2.5 m
t = ?

$s = ut + \frac{1}{2} at^2$ ✓

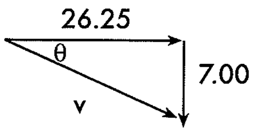
$2.5 = 0 + \frac{1}{2} 9.8 t^2$ ✓

$t = 0.7143$ s ✓

$s_H = v_H \times t$
$= 26.25 \times 0.7143$
$= 18.7$ m ✓

3.70 m past the net on the receiver's side.

(c) $v = u + at$
$= 0 + 9.8 \times 0.7143$
$= 7.00\ ms^{-1}$ ✓



$v = (26.25^2 + 7.00^2)^{½}$
$= (738)^{½}$
$= 27.2\ ms^{-1}$ ✓

$\tan\theta = \dfrac{7}{26.25}$

$\angle\theta = 14.9°$ ✓

Answer : 27.2 ms^{-1} at 14.9° to the ground. ✓

19.

(a) $f = \dfrac{2}{5}$ Hz

$v_H = \dfrac{2\pi r}{t} = 2\pi rf$ ✓

$= 2 \times \pi \times 0.5 \times \dfrac{2}{5} = 1.257\ ms^{-1}$ ✓

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

$1.22 = 0 + \dfrac{1}{2}\ 9.8\ t^2$ ✓

$t^2 = 0.25$

$t = 0.5$ sec ✓

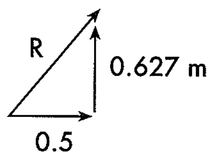
$s_H = v_H \times t = 1.257 \times 0.5$

$= 0.627$ m ✓

$R = \sqrt{0.5^2 + 0.6272}$

$= \sqrt{0.644}$

$= 0.802$ m



Hence diameter = 1.60 m ✓

(b) (i) $F = \dfrac{mv^2}{r}$ $\quad v = \dfrac{2\pi r}{T} = 463\ ms^{-1}$

$= 1.0 \times \dfrac{4\pi^2 r^2}{T^2} \times \dfrac{1}{r}$ ✓

$= \dfrac{1.0 \times 4 \times \pi^2 \times 6.37 \times 10^6}{(24 \times 3600)^2}$

$= 0.0337$ N ✓

(ii) Weight at equator $= mg - F_c$ ✓

$= 1 \times 9.8 - 0.0337$

$= 9.7663$ N

Weight at pole = 9.80 N ✓

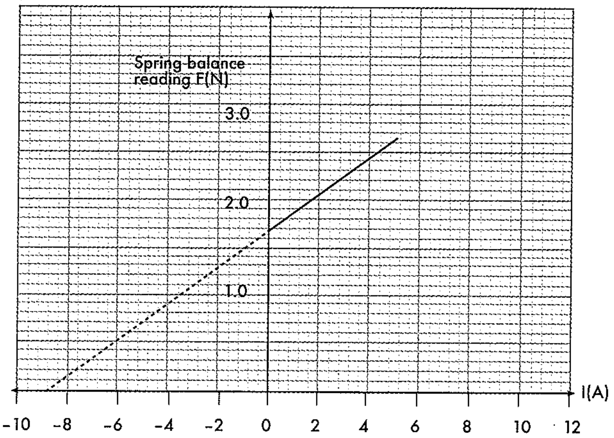
Ratio $= \dfrac{\text{weight of body at equator}}{\text{weight of same body at the pole}}$

$= \dfrac{9.7663}{9.80}$

$= 0.997$ ✓

20.

(a)



✓✓✓

(b) Gradient $= \dfrac{2.8 - 1.8}{5 - 0} = \dfrac{1}{5} = 0.2\ NA^{-1}$ ✓

If $F = IB\ell$

$B\ell = \dfrac{F}{I} =$ gradient $= 0.2$ ✓

$\ell = 50$ turns $\times$ 8 cm $= 4$ m ✓

$B = \dfrac{F}{I} \times \dfrac{1}{\ell} =$ gradient $= 0.2 \times \dfrac{1}{4} = 0.05$ T ✓

(c) When I = 0 ✓
F(N) = 1.8 N ✓

(d) F down = F up ✓
$mg = I\ell B$
$1.8 = I \times 0.08 \times 50 \times 0.05$ ✓
$I = 9.0$ A ✓

(e) –9.0 A ✓✓

21.

(a) No. All masses attract other masses according to the formula. ✓

$$F = \frac{GM_1M_2}{r^2}$$ ✓

Even in deep space, at vast distances from stars, a very small gravitational force exists. ✓

(b) Apparent weightlessness occurs when a mass moves with the same acceleration as determined by the gravitational field. ✓✓

(c) When a mass has no resultant force acting on it, the mass will remain at rest or travel in a straight line at a constant velocity, so the mass experiences no reaction forces from other objects which are in free fall. ✓✓✓

(d) $r_{orbit} = 6.37 \times 10^6 + 0.400 \times 10^6$

$= 6.77 \times 10^6$ m ✓

$$g = \frac{GM_E}{r^2}$$ ✓

$$g = \frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24}}{(6.77 \times 10^6)^2}$$ ✓

$= 8.702$

$= 8.70$ ms^{-2} or (Nkg^{-1}) ✓

(e) $$v = \sqrt{\left(\frac{G M_E}{r_0}\right)}$$ ✓

$$= \left(\frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24}}{6.77 \times 10^6}\right)^{1/2}$$

$= 7676$ ms^{-1} ✓

$$v = \frac{7676 \times 3600}{1000} = 27{,}600 \text{ kmh}^{-1}$$ ✓

(f) $$T = \frac{2\pi r_0}{v}$$ ✓

$$= \frac{2\pi \times 6.77 \times 10^6}{7676}$$ ✓

$= 5542$ s

$$= \frac{5542}{60}$$

$= 92.4$ minutes ✓

(g) $$f = \frac{1}{T}$$

$$= \frac{1}{5542}$$ ✓

$= 1.80 \times 10^{-4}$ Hz ✓

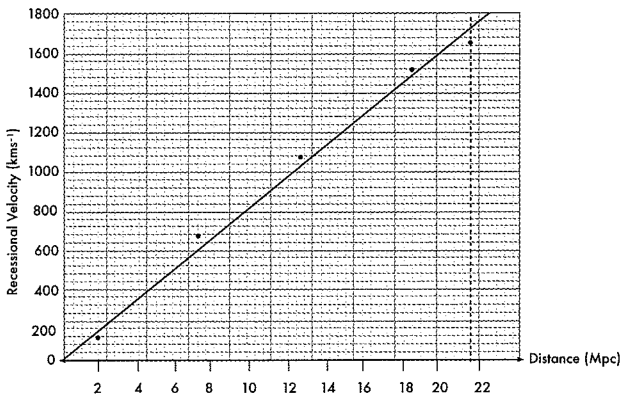
22.

(a)

	Distance (km)	Distance (AU)	Distance Light years	Distance Parsec (pc)
Earth-Moon distance	3.84×10^5	**2.57×10^{-3}**	**4.06×10^{-8}**	**1.24×10^{-8}**
Earth-Sun distance	1.50×10^8	**1.00**	**1.59×10^{-5}**	**4.86×10^{-6}**
Pluto-orbit Sun distance	**5.89×10^9**	39.4	**6.23×10^{-4}**	**1.91×10^{-4}**

✓per answer

(b) ✓✓✓



$$\text{slope of graph} = \frac{\text{rise}}{\text{run}}$$ ✓

$$\cong \frac{1600}{20}$$ ✓

$\therefore H = 80$ kms^{-1} Mpc^{-1} ✓✓