



PHYSICS

YEAR 12

Unit 3

2016

Name: _____

Teacher: _____

TIME ALLOWED FOR THIS PAPER

Reading time before commencing work: Ten minutes

Working time for the paper: Three hours

MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER

To be provided by the supervisor:

- This Question/Answer Booklet; ATAR Physics Formulae and Data Booklet

To be provided by the candidate:

- Standard items: pens, pencils, eraser or correction fluid, ruler, highlighter.
- Special items: Calculators satisfying the conditions set by the SCSA for this subject.

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 this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Short answer	10	10	50	54	30
Section Two: Extended answer	7	7	90	90	50
Section Three: Comprehension and data analysis	2	2	40	36	20
			Total	180	100

Instructions to candidates

- The rules for the conduct of Western Australian external examinations are detailed in the *Year 12 Information Handbook 2016*. Sitting this examination implies that you agree to abide by these rules.
- Write answers in this Question/Answer Booklet.
- When calculating numerical answers, show your working or reasoning clearly. Give final answers to **three** significant figures and include appropriate units where applicable.

When estimating numerical answers, show your working or reasoning clearly. Give final answers to a maximum of **two** significant figures and include appropriate units where applicable.
- You must be careful to confine your responses to the specific questions asked and follow any instructions that are specific to a particular question.
- Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.
 - Planning: If you use the spare pages for planning, indicate this clearly.
 - Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Refer to the question(s) where you are continuing your work.

SEE NEXT PAGE

Section One: Short response**30% (54 marks)**

This section has **ten (10)** questions. Answer **all** questions. Write your answers in the space provided.

When calculating numerical answers, show your working or reasoning clearly.

Give final answers to three significant figures and include appropriate units where applicable.

When estimating numerical answers, show your working or reasoning clearly. Give final answers to a maximum of two significant figures and include appropriate units where applicable.

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Suggested working time for this section is 50 minutes.

Question 1**(4 marks)**

Kepler's 3rd law of planetary motion is:

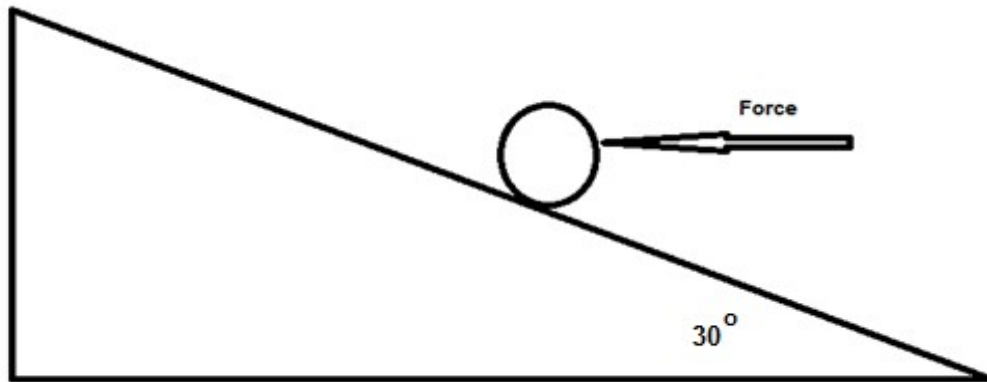
$$T^2 = \frac{4\pi^2}{GM} r^3$$

Derive this formula using at least two other equations from the supplied data sheet. Show ALL steps in your working.

SEE NEXT PAGE

Question 2**(6 marks)**

A spherical, 2.00 kg ball, rests on a plane with a slope of 30.0° as shown in the diagram below.

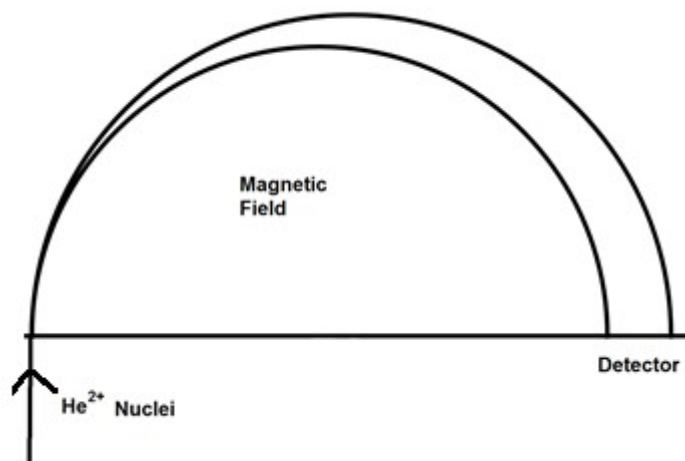


- a) Calculate the minimum horizontal force that will prevent the ball moving down the frictionless plane. (3 marks)
- b) The horizontal force is removed. Calculate the magnitude of the normal reaction force provided by the plane on the ball. (3 marks)

SEE NEXT PAGE

Question 3**(7 marks)**

A mass spectrometer is used to calculate the mass of charged particles. One such machine is being used to measure the proportion of ${}^3_2\text{He}^{2+}$ and ${}^4_2\text{He}^{2+}$ nuclei in a beam of particles that have been accelerated to a speed of $5.11 \times 10^6 \text{ m s}^{-1}$. The magnetic field strength is $5.21 \times 10^{-1} \text{ T}$.



- a) Show the direction of the magnetic field on the diagram. (1 mark)
- b) Place a "4" on the path followed by the ${}^4_2\text{He}^{2+}$ nucleus. (1 mark)
- c) Calculate the mass of the ${}^4_2\text{He}^{2+}$ given that the radius of its path is $2.01 \times 10^{-1} \text{ m}$.

(3 marks)

- d) **Estimate** the radius of the path followed by the ${}^3_2\text{He}^{2+}$ nucleus.

(2 marks)

SEE NEXT PAGE

Question 4**(7 marks)**

The volume of a hydrogen atom is $1.99 \times 10^{-31} \text{ m}^3$. Assume the atom is a sphere and the electron travels along its surface.

Volume of a sphere $V = \frac{4}{3} \pi r^3$

Find the radius of the atom

(2 marks)

Calculate the force between the proton and the electron:

a) Gravitational.

(2 marks)

b) Electromagnetic

(2 marks)

c) Net force.

(1 mark)

SEE NEXT PAGE

SEE NEXT PAGE

Question 5**(4 marks)**

Juliette (43.2 kg) decided to build a seesaw using a 4.12 m uniform beam. She was accompanied by her friend, Julian (61.2 kg) and her sister, Georgina (21.6 kg). If the fulcrum is 1.80m from Julian and 2.00m from Juliette where would Georgina have to sit in order to create an equilibrium?

Question 6**(6 marks)**

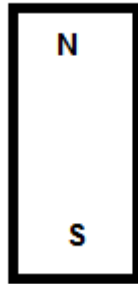
- a) On the following diagram, draw the magnetic fields. Draw at least ten lines.

(4 marks)

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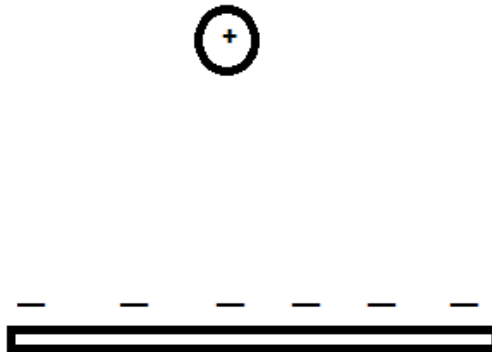
Steel ball



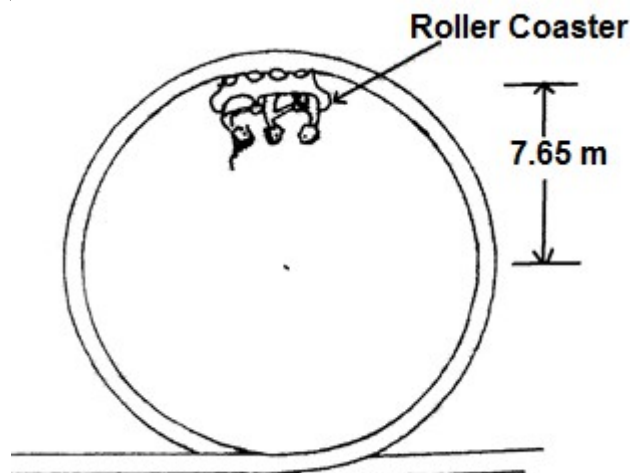
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Question 6 continued

- b) Draw the electric fields of the following diagram. Draw at least ten lines.
(2 marks)

**Question 7****(6 marks)**

A roller coaster with three passengers has a mass of 9.73×10^2 kg. The participants experience being upside down at the top of the circular track of a “loop the loop” showground ride. The centre of mass of the roller coaster and passengers is 15.3 m from the bottom of the ride. It is travelling at a constant speed of 12.3 m s^{-1} .



- a) Calculate the magnitude of the force that the rails at the top of the ride exerts on the coaster plus passengers.
(5 marks)

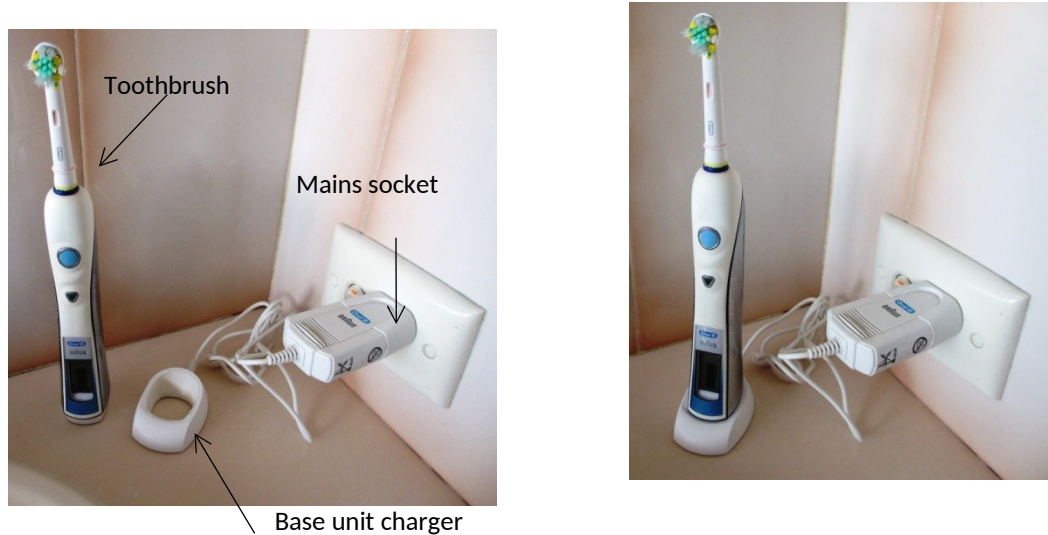
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- b) On the diagram above, draw a vector to indicate the direction of the force of the rail acting on the coaster plus passengers. (1 mark)

Question 8

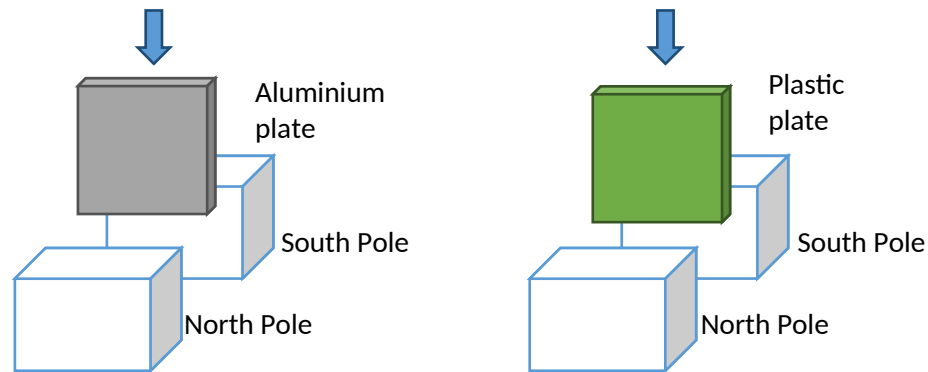
(4 marks)

The photographs show a rechargeable electric toothbrush and its plastic base unit charger.



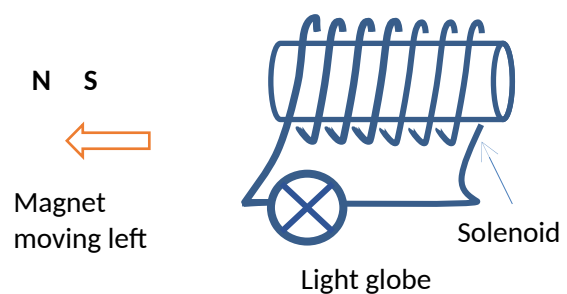
The base unit charger is connected to a mains socket. When the toothbrush is placed into the base unit, as shown in the second photograph, the battery in the toothbrush can be recharged even though there is no direct electrical connection between the toothbrush and the charger. Explain how this is possible by reference to appropriate Physics principle.

SEE NEXT PAGE

Question 9**(4 marks)**

- a) When an aluminium plate is dropped through a magnetic field in a vacuum, its rate of descent is less compared to an identically shaped plastic plate. Explain why this is so. (3 marks)

- b) The diagram shows a magnet being pulled away from a solenoid that is connected to a light globe.



- i. Indicate the direction of induced current in the solenoid. Draw arrow on the diagram and label it 'current'.

(1)

SEE NEXT PAGE

Question 10**(6 marks)**

The diagram shows a typical induction hotplate which is common used in households. It can heat water in a saucepan without using flame.



- a) Explain how these hotplates can heat water in a saucepan. Include in your answer what material should the saucepan to be made for it to work best. (4 marks)

- b) Does the hotplate get hot? Explain. (2 marks)

End of Section 1

SEE NEXT PAGE

Section Two: Problem-solving 50% (90 Marks)

This section has **seven (7)** questions. You must answer **all** questions. Write your answers in the space provided.

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Suggested working time for this section is 90 minutes.

Question 11**(12 marks)**

Two six-year-old children sit next to each other with their shoulders touching. Each of them has a mass of 20kg.

- a) **Estimate** the gravitational force between them. (3 marks)

- b) Draw the gravitational field of only one of the children. (Use at least 6 field lines.) (3 marks)

SEE NEXT PAGE

Question 11 continued

- c) One of these two children climbs on top of a shelf that is one metre above the ground. **Estimate** the child's total mechanical energy when they are standing upright on the shelf.

(3 marks)

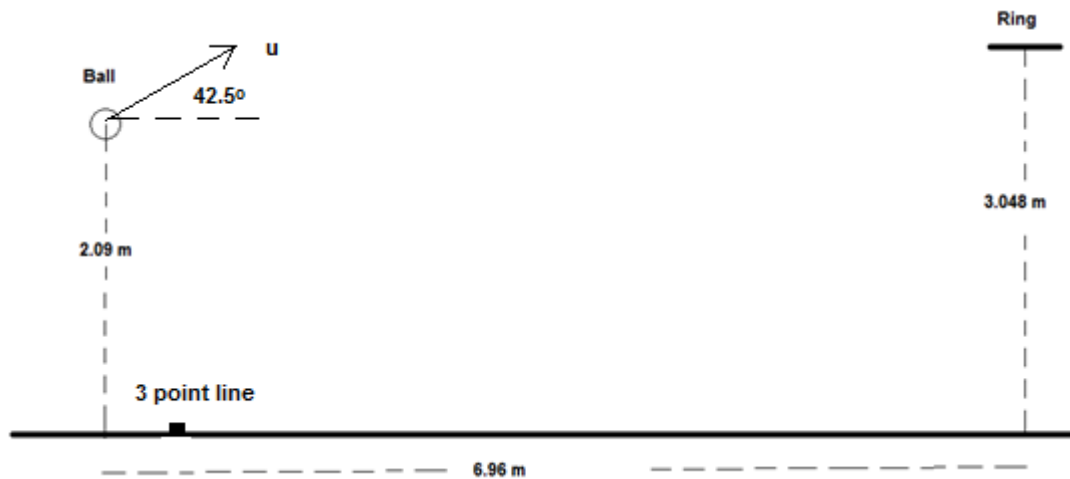
- d) The child steps off the shelf. When their centre of mass is 0.700 m above the ground estimate their velocity and kinetic energy.

(3 marks)

SEE NEXT PAGE

Question 12**(17 marks)**

The Perth Wildcats basketball team is two points down and Nat Jawai has the ball in centre court. He puts up the shot and scores three points.



- a) In the space below, draw a diagram of the ball showing the force/s acting on it whilst in flight. Assume no air resistance. (2 marks)

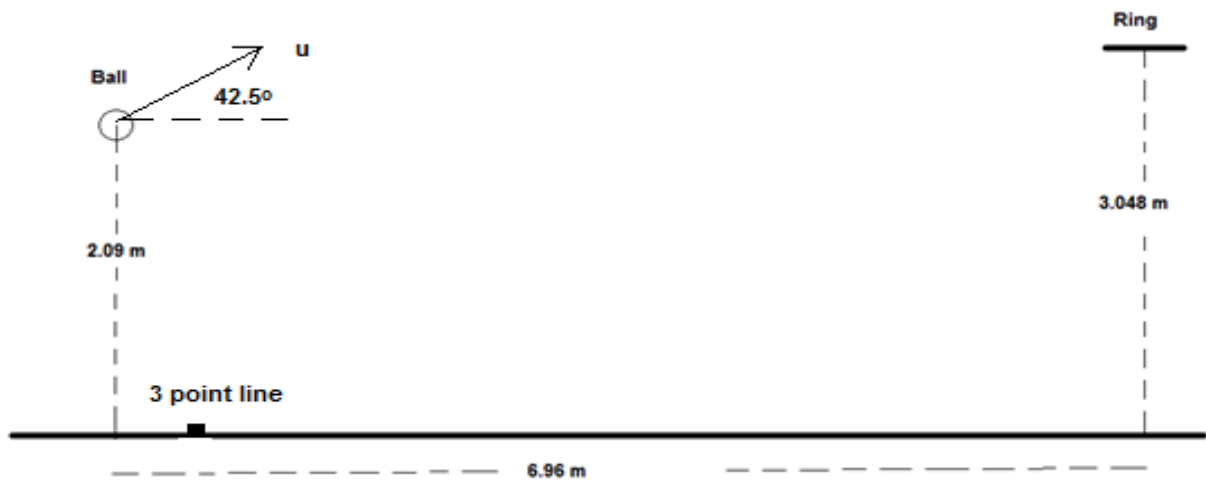
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- b) He propels the ball at an angle to the horizontal of 42.5° . What is the initial speed of the ball as shown in the diagram? (6 marks)

- c) Calculate the velocity as it passes through the ring in order to score the three points to win the game. (7 marks)

- d) On the diagram below, draw the path of the ball with and without air resistance. Assume that the basketball is launched with the same initial velocity.

(2 marks)



e)

SEE NEXT PAGE

Question 13**(11 marks)**

At the centre of the Milky Way is a black hole known as Sagittarius A*. It has a mass equivalent to 4.31 billion Suns. It is 26 500 light years from the Sun. A light year is the distance light would travel in one year.

- a) Calculate the gravitational force between the black hole and the Sun.

(3 marks)

- b) Using this force (from part a), to calculate the orbital speed of the Sun around the black hole.

(3 marks)

SEE NEXT PAGE

- c) The Sun moves around the black hole (assume circular orbit) with a speed of $2.20 \times 10^2 \text{ km s}^{-1}$. Calculate the centripetal force involved in creating this orbit.

(2 marks)

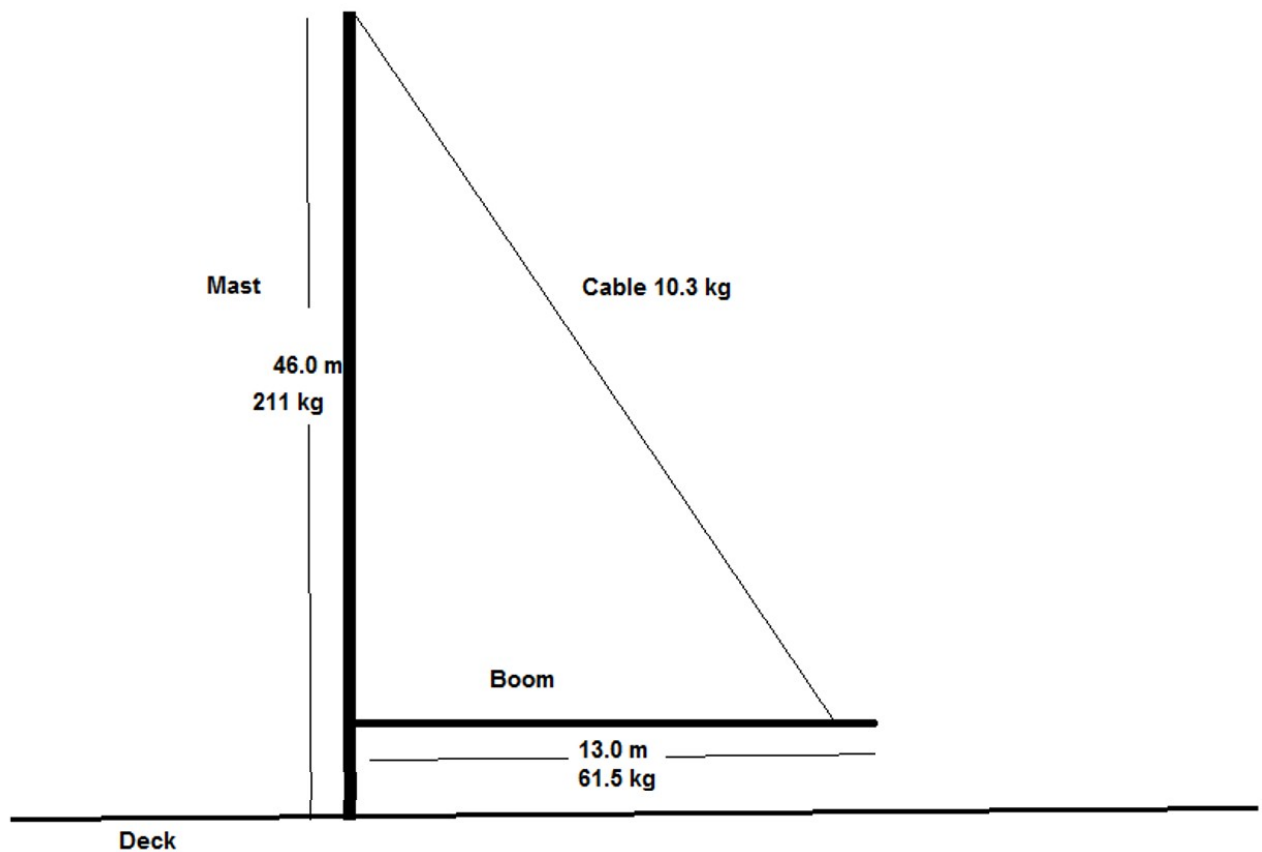
- d) Compare the values of part b) and c). Explain why they are different.

(3 marks)

SEE NEXT PAGE

Question 14**(14 marks)**

A yacht is moored in a marina being prepared for the Sydney to Hobart race. The uniform boom is 1.50 m above the deck and the uniform cable is attached 1.20 m from the end of the boom (mass 61.5 kg). A 50.0 kg weight is attached at the free end of the boom to prevent sudden movement.



- a) Draw a free body diagram of the boom, showing all forces acting on it.

(4 marks)

SEE NEXT PAGE

b) Calculate the tension in the cable.

(4 marks)

c) Calculate the force exerted by the mast on the boom.

(5 marks)

SEE NEXT PAGE

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- d) Is there any benefit if the cable attachment to the boom is shorter, i.e. less than 13 m? (1 mark)

Question 15

(17 marks)

AC and DC generators are important technological devices.

- a) Using labelled diagram/s illustrate how an AC generator creates an AC voltage. (5 marks)

SEE NEXT PAGE

b) At which stage of the cycle is maximum emf generated? Explain. (4 marks)

c) Explain the difference in design necessary to change the AC generator to a DC generator. Use diagrams. (5 marks)

d) The equation

$$emf_{rms} = \frac{emf_{max}}{\sqrt{2}}$$

is used to calculate the maximum emf created in an AC generator. Explain, using an appropriate voltage vs time graph, what is the importance of $\sqrt{2}$ in this equation.

(3 marks)

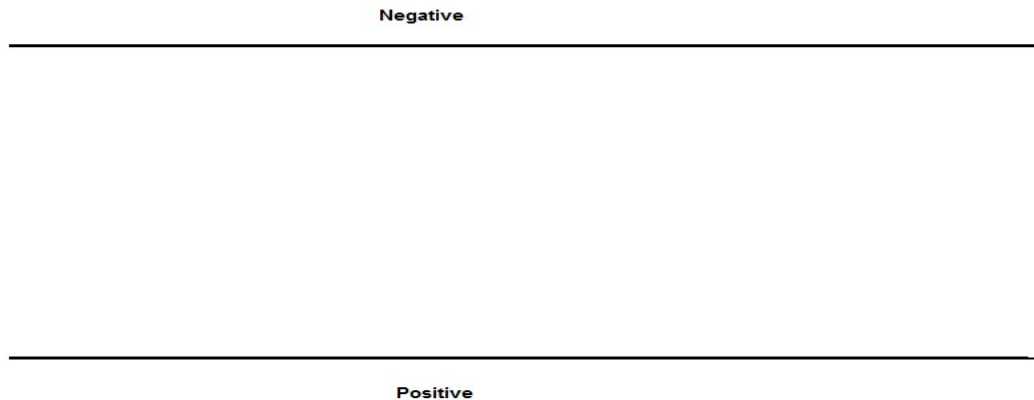
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Question 16**(14 marks)**

Two parallel charged plates are set up as in the diagram below.

- a) Draw the electric field between the plates.

(3 marks)

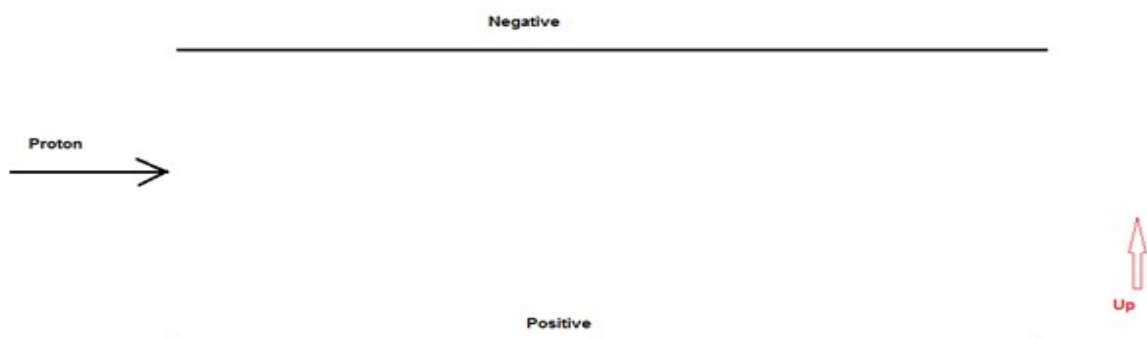


- b) A proton is fired, with a velocity of $8.67 \times 10^7 \text{ m s}^{-1}$, into the space between the 0.500 m long plates as shown below. The plates are 20.0 mm apart and the potential difference between the plates is $3.00 \times 10^3 \text{ V}$.

The experiment is placed vertically to the ground and the proton is effected by gravity.

Calculate the total force acting on the proton as it travels between the plates.

(4 marks)



SEE NEXT PAGE

- c) Calculate the velocity at which the proton leaves the gap between the plates.
(5 marks)
- i) Using the total force, find the acceleration

ii) Find the vertical velocity

iii) Find the horizontal velocity

iv) Find the total velocity

- d) Calculate the vertical displacement of the proton whilst it is between the plates.
(2 marks)

SEE NEXT PAGE

Question 17**(5 marks)**

A truck is being driven around a roundabout, of radius 75.0 m, and it rolls over.

- a) Explain, referring to centre of mass, why the truck would roll over. (2 marks)

- b) Road engineers bank roads to help prevent such situations occurring. What angle must the road in part a) be banked to allow the driver to travel through the roundabout, safely, at 10.0 m s^{-1} . At the safe speed the truck corners without relying on friction between the wheels and the road. (3 marks)

End of Section 2

SEE NEXT PAGE

Section Three: Comprehension and Data Analysis**20% (36 Marks)**

This section contains **two (2)** questions. You must answer both questions. Write your answers in the space provided.

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Suggested working time for this section is 40 minutes.

Question 18**Circular Motion****(18 marks)**

Many everyday examples rely on circular motion. Satellites for weather observations, GPS, communications and monitoring activities is one such group. Some others include spin dryers in washing machines, separating blood samples into its components in a centrifuge and mass spectrometers.

Centrifugal force does not exist in an inertial frame of reference and is generally considered to be a “mythical” or inertial force. In the past, it was sometimes defined as the reaction force to the centripetal force. Centrifugal is based on the Latin word which means flight (moving away from centre), centripetal comes from the Latin for seeking (moving towards centre).

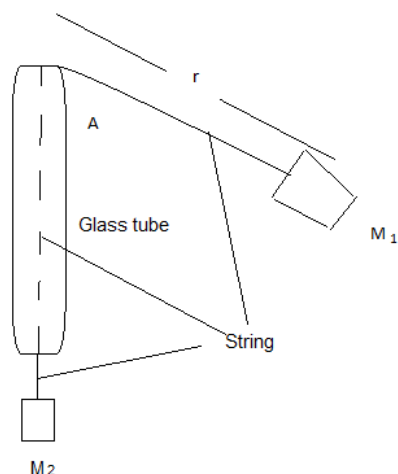
A satellite orbiting the Earth in a circular orbit is always falling towards the Earth yet maintains the same altitude.

Rockets are used to place satellites in their respective orbits. Satellites that have orbits parallel to Earth’s equator are generally launched in an easterly direction from the east coast close to the equator.

Geostationary satellites are usually launched in this manner. These satellites are a significant reason that we can receive continuous TV signals from the other side of the world. Pay TV companies also use geosynchronous satellites as well as cable to provide services to their customers. They are also valuable in weather services as each satellite monitors a set part of the Earth’s surface.

An experiment to demonstrate the forces involved in circular motion is set up as follows:

SEE NEXT PAGE



A student holds the glass tube and swings the rubber stopper (M_1) in a circle maintaining a constant radius. The force (tension in the string) is provided by the mass (M_2). Another student measures the time taken for 25 revolutions.

The following is a set of results for one such experiment.

M_1 has a mass of 38.3 g
 r is 61.3 cm

Trial	Force of M_2 (N)	Time for twenty (25) revolutions (s)	Period (s)	Velocity ² (m ² s ⁻²)
1	0.50	34.1	1.36	8.0
2	1.50	19.7		
3	2.50	15.3		
4	3.50	12.9		
5	4.50	11.4		
6	5.50	10.3		

a) Complete the two incomplete columns. Assume the string is swung horizontally.

(1 mark)

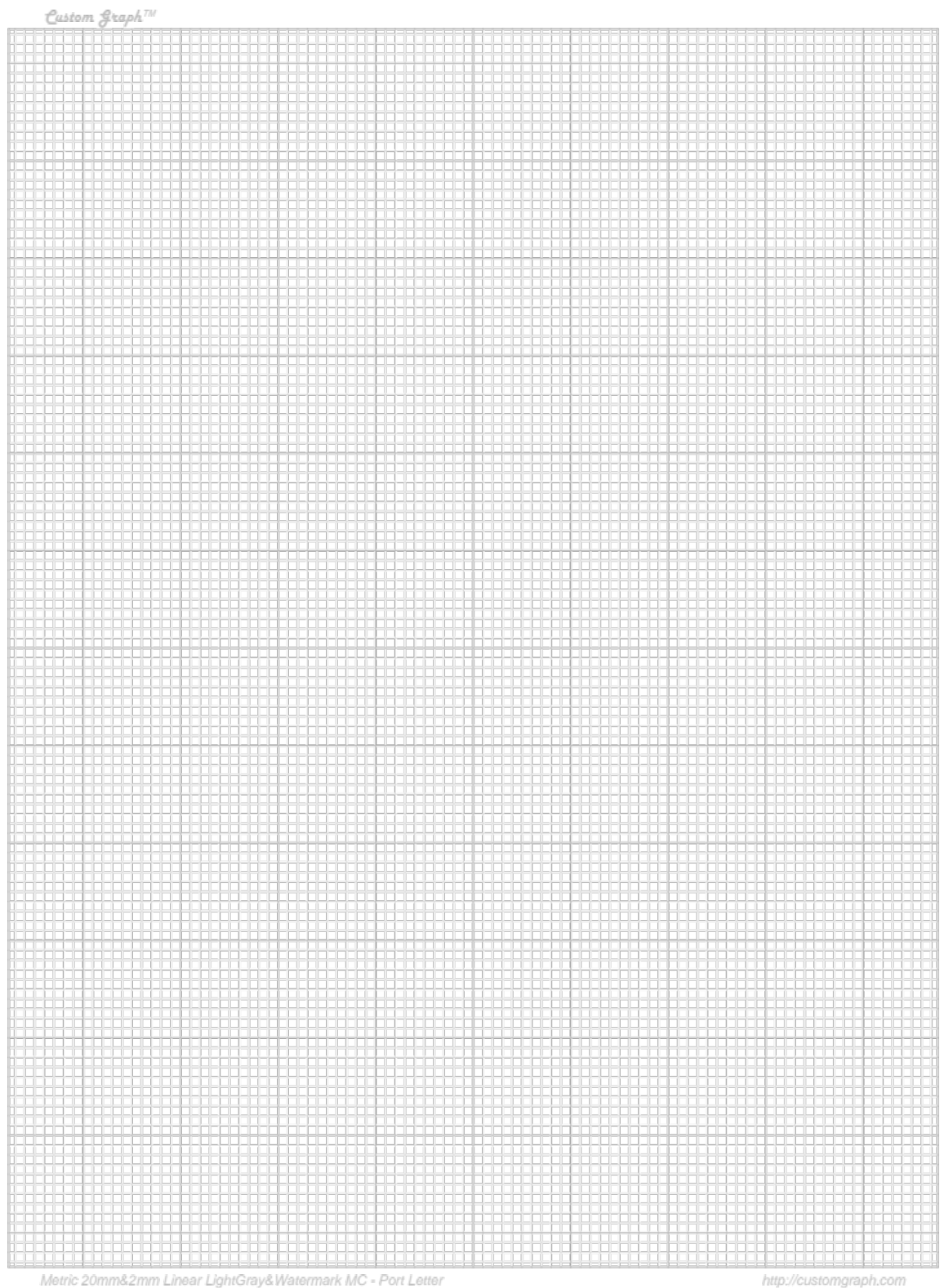
b) Which is the independent variable?

(1 mark)

SEE NEXT PAGE

Plot the data. (3 marks)

TITLE: Force and velocity² graph



SEE NEXT PAGE

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- c) Plot a line of best fit. (1 mark)
- d) Find the gradient of $F \propto V^2$. (2 marks)
- e) What is the important information of the gradient? (1 mark)
- f) No matter how fast you can reasonably make M_1 travels it will never have a horizontal string. Explain. (1 mark)
- g) A satellite that is constantly falling can maintain a circular path around the Earth at a constant altitude. Use a diagram help to explain why this occurs. (3 marks)

SEE NEXT PAGE

- h) Explain why, that when a satellite is in a circular orbit around the Earth, the centre of its orbit must be the centre of mass of the Earth. Use diagrams. (2 marks)

- i) Whilst falling, the satellite could be said to be weightless. Explain. (3 marks)

SEE NEXT PAGE

Question 19**AC/DC: Rock Band or Electricity Wars****(18 marks)**

Edison and Tesla, two great scientists found themselves on the opposite sides of the debate whether to use DC (Edison) or AC (Tesla).

Edison to prove his point that AC was too dangerous electrocuted an elephant and advocated that AC be used for the electric chair. Further he built 121 DC power stations in the United States of America. The Boulder power station in the Goldfields of Western Australia was originally a DC power station. Unfortunately, users of this power had to be within 2 km of the station.

AC power could be readily converted from low to high voltages and back again so it could be transferred long distances with lower energy losses.

Much of our electronics today use DC power and when the AC is converted to DC about 3% energy is lost in the form of heat. Also LEDs which use DC suffer from flicker which reduces their lives, and solar panels produce DC current which is converted to AC using inverters. DC can now be converted to high voltages relatively easily and voltages for transmission of up to 800 kV have been achieved.

An issue with high voltage is the “skin effect” which means that at high voltages the current travels on the outside of the wire which effectively increases the resistance of the wire. This then requires that more expensive multi-strand wires are required to transmit the power.

Further many places use UPSs (Uninterruptable Power Supplies) which convert AC to DC (batteries) then back to AC and then back to DC to run the electronics.

Should we convert our power supplies to DC which is safer, much of our electronics use DC already and much of the green energy produced is DC and would be more compatible with a DC grid.

On the reverse many of our appliances are AC based and our power stations are all built to provide AC. Converting them would be a huge expense.

The South/West power grid operated by Western Power extends from Kalbarri (600 km North of Perth) to Ravensthorpe (530 km SE of Perth) across to the coast, with an extension to Kalgoorlie.

Synergy is the electricity generator and retailer for the grid. They charge domestic customers 23.36630 cents per unit. A unit is a kilowatt hour.

A power station can generate 6.00×10^2 MW of energy at 30.0 kV. This is then sent to a sub-station where the voltage is increased to 3.30×10^2 kV. This is then transported at that voltage over large distances. It then comes to a series of sub-stations that step down the voltage to 33.0 kV, then 11.0 kV, 6.00 kV and finally about 4.00×10^2 V. Each transformer stage loses approximately 1.00% (ie 99% efficient).

The power is distributed from the last sub-station as three phase power down the streets. Most houses opt for one phase ($\sim 2.40 \times 10^2$ V) at a frequency of 50.0 Hz.

Large voltage wires are usually multi-strand aluminium cables surrounding an iron core which provides the tensile strength. The resistance of the wire is $1.02 \times 10^{-4} \Omega \text{ m}^{-1}$.

SEE NEXT PAGE

- a) Explain why multi-strand wires are used in large voltage power lines. (2 marks)
- b) Calculate the energy lost in transmitting 3.30×10^2 kV AC electricity from the generator to sub-station 1 to a town which is 151 km away. (7 marks)

SEE NEXT PAGE

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- c) Calculate the loss over a year in possible revenue that Synergy loses because of this loss of energy? (4 marks)

- d) What is the voltage of three phase power in Western Australia? (1 mark)

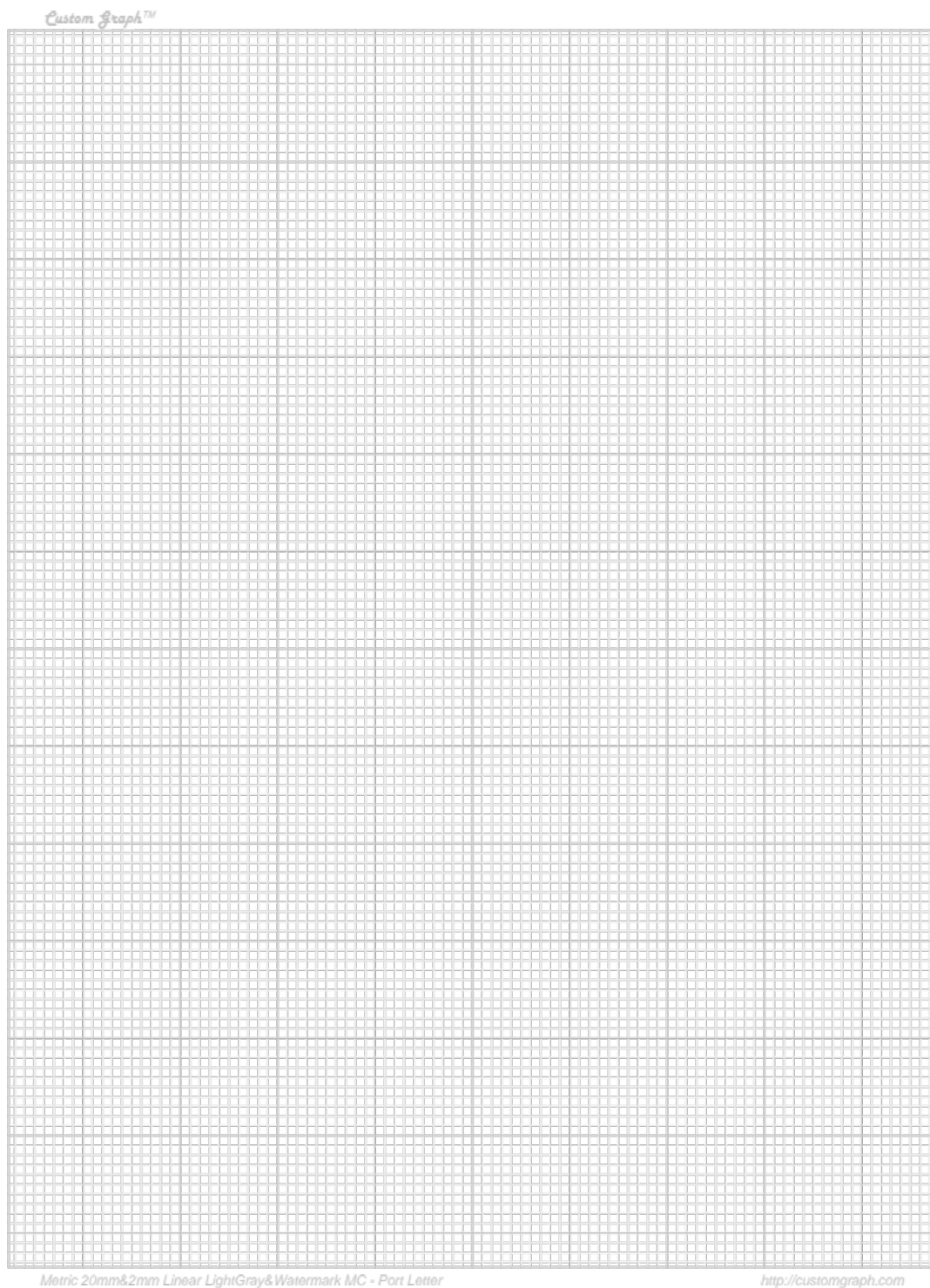
- e) Explain the cause of the “flicker” in LEDs. (3 marks)

- f) Why does DC lose less power in transmission than AC? (1 mark)

End of Section 3

End of examination
SEE NEXT PAGE

Additional graph if required.



SEE NEXT PAGE

SEE NEXT PAGE

SEE NEXT PAGE