Physics 3A3B

Stage 3 Written Paper Semester One 2012

CHURCHLANDS SENIOR HIGH SCHOOL

Student Name: ANSWERS

Teacher Name: MASSANG

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

Materials required/recommended for this paper

To be provided by the supervisor
This Question/Answer Booklet
Formulae and Constants Sheet

To be provided by the candidate
Standard items: pens, pencils, eraser, correction fluid, ruler, highlighters

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

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	15	15	54	60	30
Section Two: Extended answer	9	9	90	100	50
Section Three: Comprehension and data analysis	2	2	36	40	20
				Total	100

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year* 12 *Information Handbook 2011.* Sitting this examination implies that you agree to abide by these rules.

2. Write answers in this Question/Answer Booklet.

3. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

4. Working or reasoning should be clearly shown when calculating or estimating answers. Answers should be given to the appropriate number of significant figures. Answers not given to the appropriate number of significant figures may result in marks being deducted.

5. 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 at the top of the page.

- 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. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Section One: Short response 30% (60 Marks)

This section has 15 questions. Answer **all** questions. Write your answers in the space provided. 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.
Suggested working time for this section is 54 minutes.

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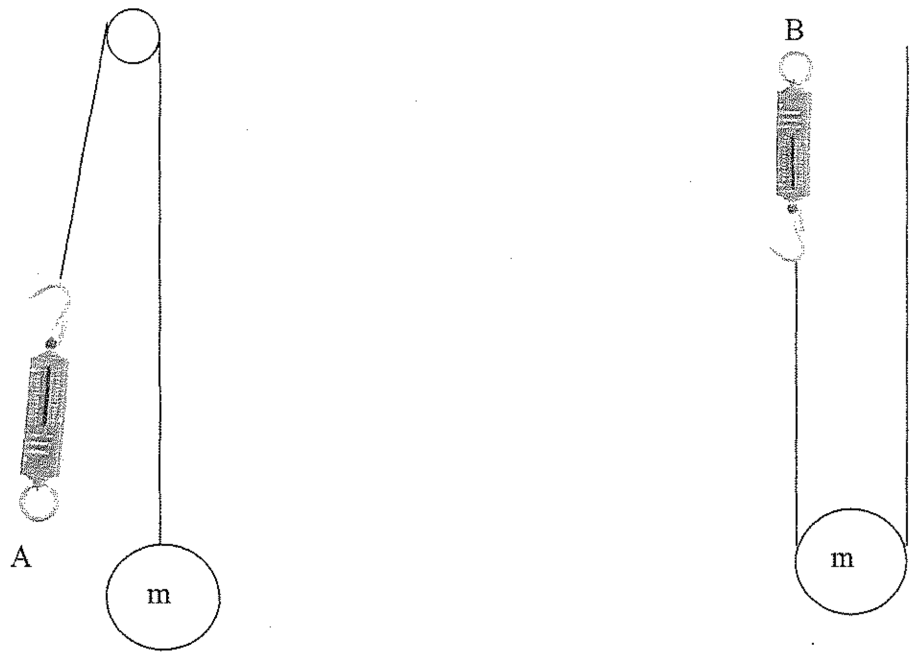
1. (4 marks)



In the above diagrams, the suspended mass is 15.0 kgs. What would each of the spring balance read? Write a justification for your answer.

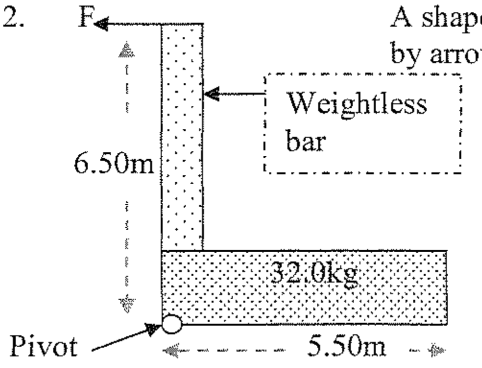
Spring balance A: Reading 15.0kg or 14.7 N. (1)

Justification Has to support full equalizing force. (1)

Spring balance B: Reading 7.50 kg or 73.5N. (1)

Justification The weight is now supported by two wires. (1)

2. A shape (shown below) is balanced at the pivot. Find the force (indicated by arrow F) needed to keep the system in balance. (4 marks)



$\Sigma acm = \Sigma cm$ (1)

$F \times 6.50 = 32 \times 9.8 \times 2.25$

$F = 108.6$ N (2) left. (1)

3. Planet X has a mass 3.47 times the mass of the Earth with a radius of 1.28 times of the Earth.

(a) How much different would the surface gravity of planet X be compared to that of the Earth? (3 marks)

$$g_P = \frac{GM}{r^2}$$

$$= \frac{G \times 3.47M}{1.28^2 r^2} \quad (1)$$

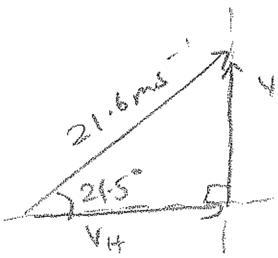
$$= 2.12 \times \text{earth} \quad \text{or} \quad 20.8 \text{ ms}^{-2} \quad (2)$$

(b) If Jacky has an Earth mass of 55.0 kg, how much different would it be if she were on the surface of planet X? (1 mark)

55.0 kg (1)

4. A knife thrower, Liam, throws a spinning knife in the air towards a target. The knife was thrown at an angle of 21.5 ° above the horizontal. The initial velocity of the knife is 21.6 m s^{-1}. It sticks in the middle of the target which is at the same height as it was thrown. (4 marks)

(a) Calculate how long the knife was in the air.



$v_V = 21.6 \sin 21.5$
$= 7.92 \text{ ms}^{-1} \uparrow$

assume ↓ is +ve

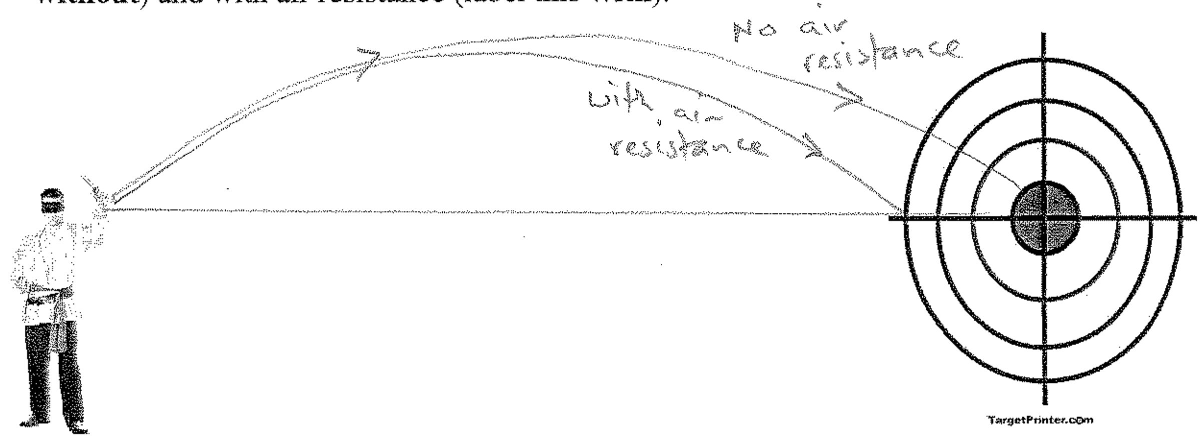
$$s = ut + \tfrac{1}{2}at^2$$

$$0 = -7.92t + \tfrac{1}{2}9.8t^2 \quad (1)$$

$$t = \frac{7.92}{4.9}$$

$$t = 1.62 \text{ secs.} \quad (1)$$

(b) On the diagram below, sketch the shape of the path of the knife without air resistance (label this **without**) and with air resistance (label this **with**).

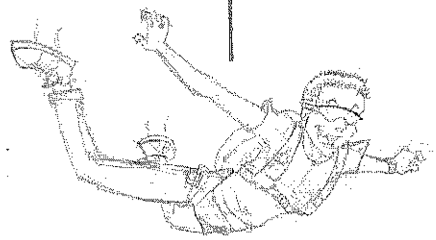


5. Dom is skydiving. He jumps out of an aeroplane at an altitude of 3.00×10^3 m. Just before he activates his parachute at a lower altitude of 1250 m he is travelling at a constant velocity of 56.0 ms^{-1}. Draw forces acting on Dom at this point on the following free body diagram. (4 marks)

2

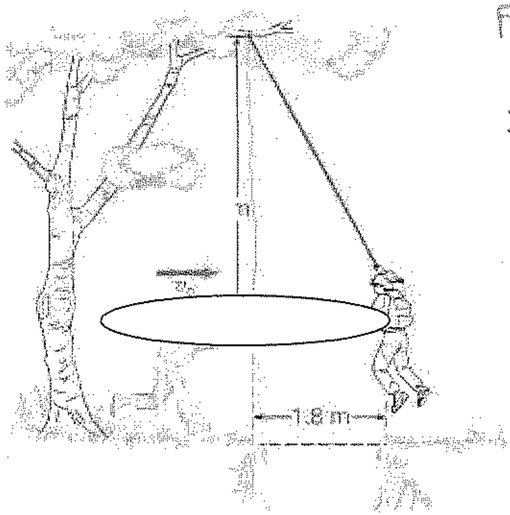
Force of friction 1

- arrows must be equal
- must use a ruler
- must be vertical



Force of gravity 1

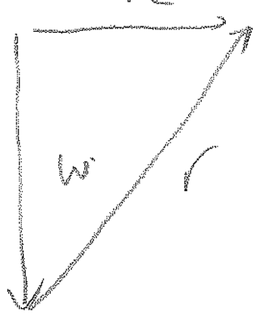
6. Bianca is swinging on a rope in a circle. She has a mass of 55.0 kg. She is travelling in a horizontal circle of radius 1.80 m. If the centripetal force was measured to be 21.3 N, how fast was Bianca travelling? (4 marks)



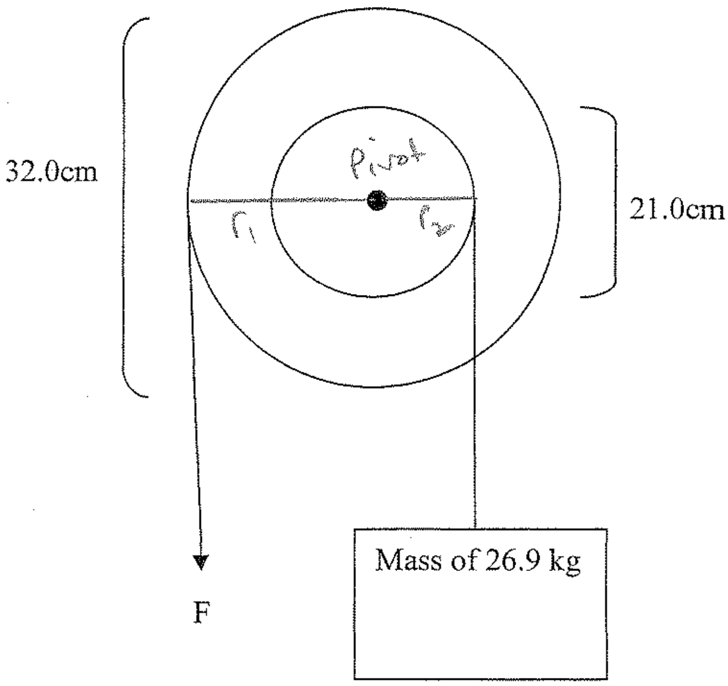
$F_c = \frac{mv^2}{r}$ 1

$\frac{21.3 \times 1.8}{55} = v^2$ 1

$v = 0.835 ms^{-1}$ 2



7. Pulleys systems are usually used to make work a little easier to do or enable a larger distance to be covered for a little input distance. . Consider the following diagram of a pulley system and calculate how much effort is needed to keep it stationary. (4 marks)



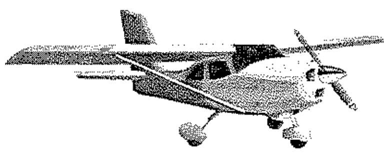
$\Sigma acm = \Sigma cm$

$F \times r_1 = m \times g \times r_2$ 1

$F \times 0.16m = 26.9 \times 9.8 \times 0.105$ 1

$F = 173N$ 2

8. A plane of wingspan 9.50 m travels at 127 ms^{-1} E at the equator. The Earth's magnetic field strength at the equator is 2.50×10^{-5} T. What emf would build up in the wings? Can this emf be used by the plane. Explain. (4 marks)



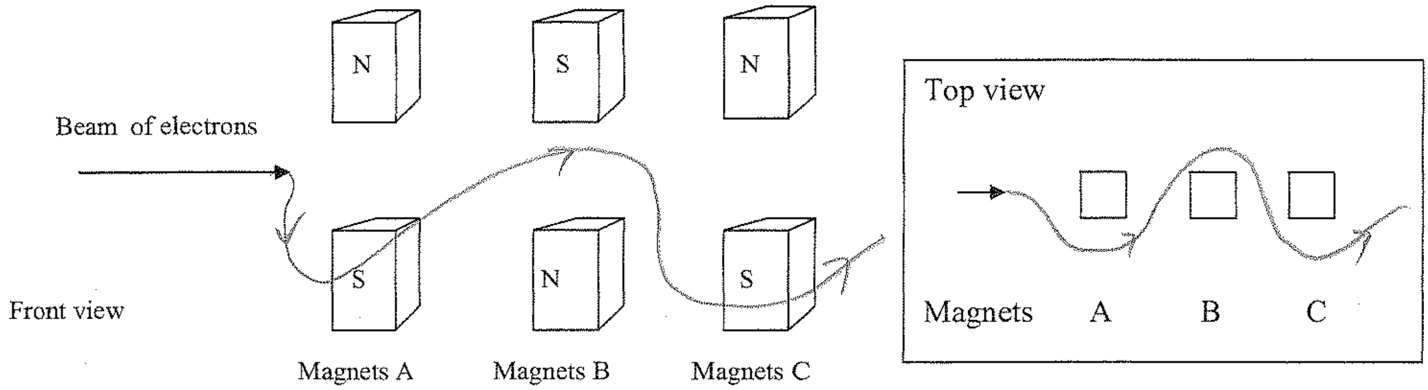
$emf = Blv$

$= 2.50 \times 10^{-5} T \times 9.5 \times 127$ 1

$= 0.0302\ V$ 2

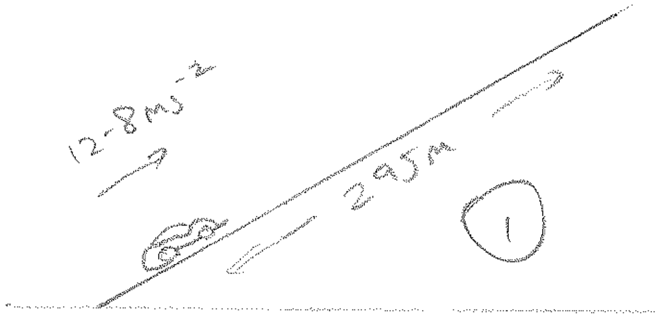
This emf cannot be used because the whole circuit moves in the field. 1

9. An electron beam is passed through a set of magnets with alternating polarities. Complete the diagram showing the path of the beam as it passes between the magnets and emerges from the other side. (3 marks)



−1 for every mistake
must have arrows. (−1)

10. Mudra drives her Ferrari up an inclined road. The road has and angle of 12.5° to the horizontal and is 295 m long. Her car accelerates up the incline at 12.8 ms^{-2} from rest. How long would it take Mudra to reach the end of the road? (4 marks)



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

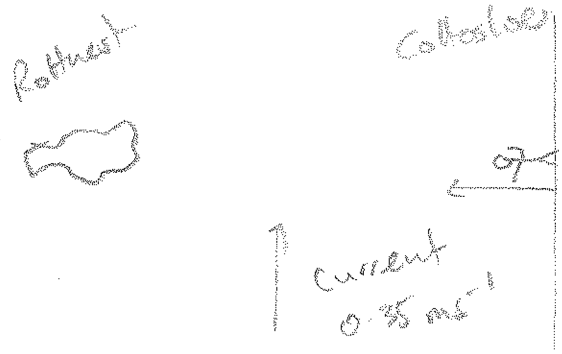
$295 = 0 + \frac{1}{2}\, 12.8\, t^2$

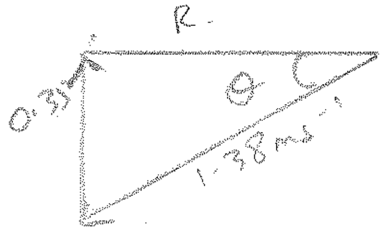
$t = \sqrt{\frac{295}{6.4}}$ 1

$t = 6.79$ secs 2

11. Adam is going to compete in the Rottnest Channel swim. The distance to Rottnest from Cottesloe is 18.0 km. He can swim at a steady pace of 1.38 ms^{-1}. To begin this race, Adam will start at Cottesloe beach and swim due west to reach Rottnest. Unfortunately, on this day there is an ocean current moving northerly at 0.35 ms^{-1}. (5 marks)

(a) In which direction must Adam swim to reach Rottnest?





$\sin\theta = \frac{0.35}{1.35}$

$\theta = 15.0°$

Direction he has to swim
W 15.0° S.

(b) How long does it take Adam to complete the journey?

$V_R = 1.38\,ms^{-1} \cos 15°$

$V_R = 1.33\,ms^{-1}$ W

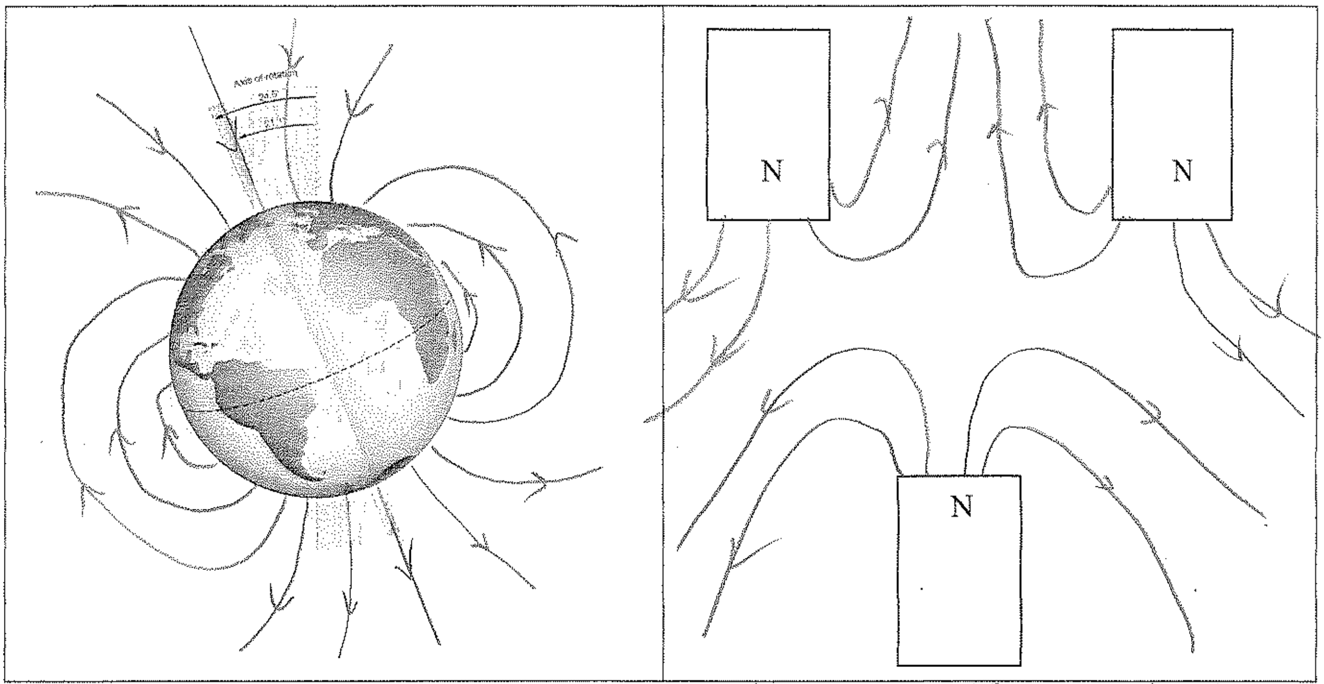
$V = \frac{s}{t}$

$t = \frac{18000}{1.33}$

$t = 13530$ sec.

or 3.76 hrs.

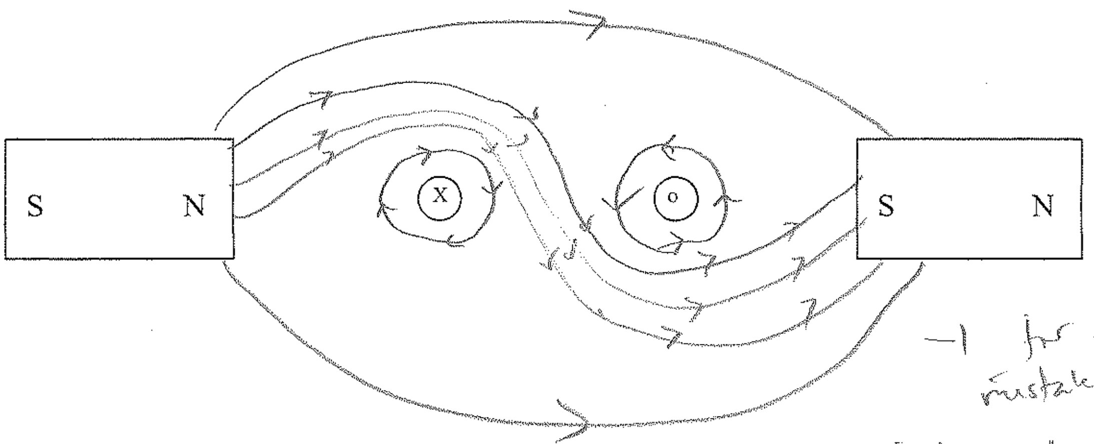
12. On each diagram, show the pattern and direction of the magnetic fields. (4 marks)



lines must not touch or cross. totally wrong if any touch or cross.

① — lines ① — arrows each.

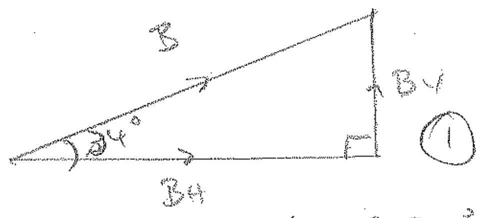
13. For the following diagram of wires and magnets, draw in the field lines and use an arrow to show the net forces acting on the wires. (4 marks)



−1 for each mistake

Ditto above

14. An airplane is on approach into an airport in Indonesia. It is at a steady altitude of 1.00×10^3 m and a ground speed of 92.0 ms^{-1} North. The Earth's magnetic field is 6.22×10^{-5} T with an angle of dip at 34°. The plane has a wingspan of 45.5 m, what EMF would be generated between the wingtips?
(Angle of dip: horizontal = 0° and vertical = 90°) (4 marks)



$B_V = 6.22 \times 10^{-5}\,T \times \sin 34°$

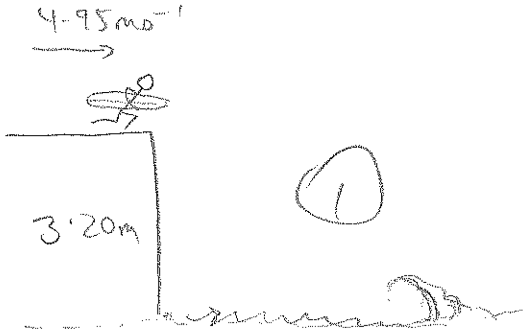
$B_V = 3.4781 \times 10^{-5}\,T$ (1)

$Emf = B l v$ (1)

$= 3.4781 \times 10^{-5} \times 45.5m \times 92ms^{-1}$

$= 0.146\,V$ (1)

15. Ben a keen surfer is standing on top a cliff 3.20 m above the water. To get to the surf he will have to jump off the cliff. Ben decides to make a running jump off the cliff into the water. Ben reached a horizontal velocity of 4.95 ms^{-1} as he ran off the cliff. How far from the base of the cliff did he land? (4 marks)



(1)

vertical

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

$3.20 = 0 + \frac{1}{2} \times 9.8t^2$

$t = \sqrt{\frac{2 \times 3.20}{9.8}}$ (1)

$t = 0.808$ secs.

$v = \frac{s}{t}$

$s = vt$ (1)

$s = 4.95 \times 0.808$

$s = 4.00$ m (1) from base of cliff.

End of Section One

Student Name: ANSWERS

Teacher Name: MASSANG

Section Two: Problem-solving 50% (100 Marks)

This section has nine (9) questions. You must answer all questions. Write your answers in the space provided.

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.

Suggested working time for this section is 90 minutes.

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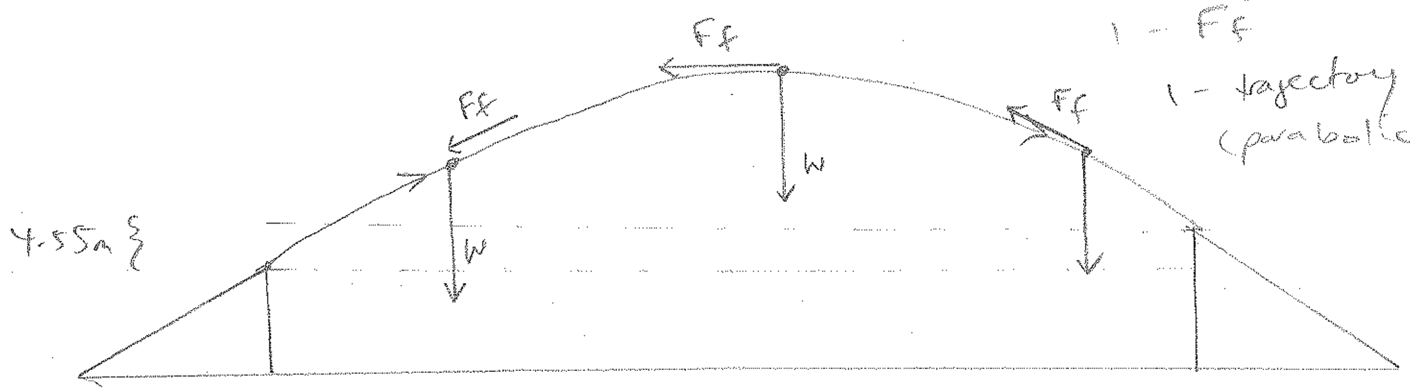
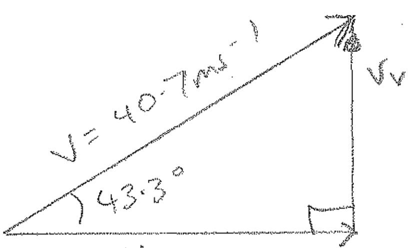
1. Wendy is a motorcycle stunt rider. She wants to use her motorcycle to jump across a river 163 m wide. The take off ramp is 4.55m lower than the landing ramp. (14 marks)

   (a) Sketch the trajectory of Wendy and her motorcycle as she attempts this stunt. Show the forces acting on Wendy at three different points of her journey: one just after take-off, one at her highest point and one before she lands. (4 marks)

2 - weight vector
1 - Ff
1 - trajectory (parabolic)



   (b) The take off ramp is angled at 43.3° to the horizontal and Wendy can attain a take- off velocity of 40.7 ms^{-1}. Calculate the horizontal and vertical components of her velocity. (2 marks)



$V_H = V \cos\theta$

$V_H = 40.7 \times \cos 43.3$

$= 29.6 \text{ ms}^{-1}$ 1

$V_V = V \sin\theta$

$= 40.7 \sin 43.3$

$= 27.9 \text{ ms}^{-1}$ 1

(c) How long is Wendy in the air during this jump? (4 marks)

assume ↓ is +ve

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

$-4.55 = -27.9t + \frac{1}{2} \times 9.8t^2$

$0 = 4.9t^2 - 27.9t + 4.55$

$t = 5.53$ sec

(d) Was Wendy successful in her attempt to jump over the river? (Show all working.) (4 marks)

$v_H = \frac{s_H}{t}$

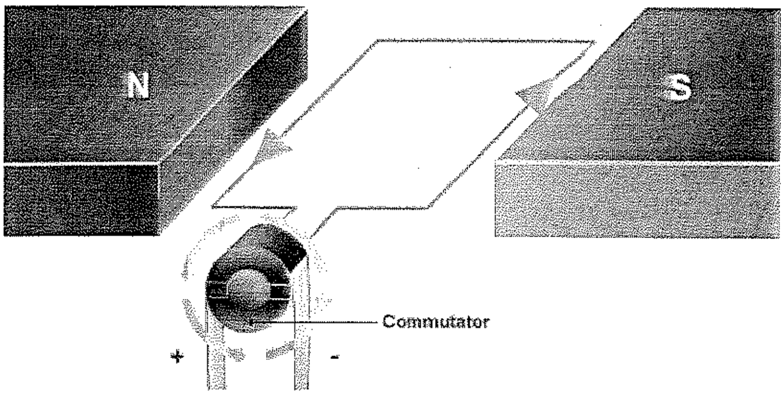
$s_H = v_H \times t$

$= 29.6 \times 5.53$

$= 163.7$ m

Yes, Wendy makes the jump (Yay she survives!)

2. An electric motor is made to spin at 75.0 rpm (revolutions per minute). The dimensions of the armature (loop) in the motor are 4.75 cm by 2.20 cm. The longer sides are perpendicular to the field. The magnets have a field strength of 9.22×10^{-2} T. There are 251 coils in the armature. The measured maximum force per side is 1.565 N. (13 marks)



(a) Determine the Current supplied to the loop via the commutator that would cause the motor to spin at 75.0 rpm. (3 marks)

$F = NBIl$

$1.565 = 251 \times 9.22 \times 10^{-2} \times I \times 0.0475\,m$

$I = \dfrac{1.565}{9.22 \times 10^{-2} \times 251 \times 0.0475}$

$I = 1.42\,A$

357 A if not divided by 251 coils.

(b) How much torque does the motor produce? (2 marks)

$\tau = Fr_\perp$

$= 1.565\,N \times (0.011\,m)$

$= 0.0172\ Nm$

For 2 sides:

$2 \times 0.0172\ Nm$

$= 0.0344\ Nm.$

(c) State what would happen to the rate of rotation (provide a numerical value) if the following changes were made:

75 rpm

(i) The current was increased by a factor of 2. (2 marks)

150 rpm

$F \propto I$

$\therefore$ if $2I$

$\therefore 2F.$

$F = 3.13N$

$\tau = (2Fr_\perp)$

$= (2 \times 3.13 \times 0.011)$

$= 0.0689\ Nm$, $\times 2$

twice as fast.

(ii) The spinning radius was reduced to half. (2 marks)

37.5

$\tau \propto r_\perp$

$\therefore$ if $r_\perp = \frac{1}{2}$

$\tau = \frac{1}{2}.$

$\therefore \tau = 0.172\ Nm$

will turn twice as slow.

$\times \frac{1}{2}.$

(iii) The number of coils were reduced by a factor of four. (2 marks)

18.75

$F \propto N$

if $N \times \frac{1}{4}$,

$\therefore F \times \frac{1}{4}$

$F = 0.39N$

$\therefore \tau \propto F$

$\tau = \frac{1}{4}F$

$\tau = 0.088\ Ns.$

will spin 4 ~~times~~ slower ~~faster~~.

(iv) The magnetic field strength was increased by a factor of 3. (2 marks)

225

$F \propto B.$

if $B \times 3.$

$\therefore F \times 3$

$F = 4.695N$

$\tau \propto F$

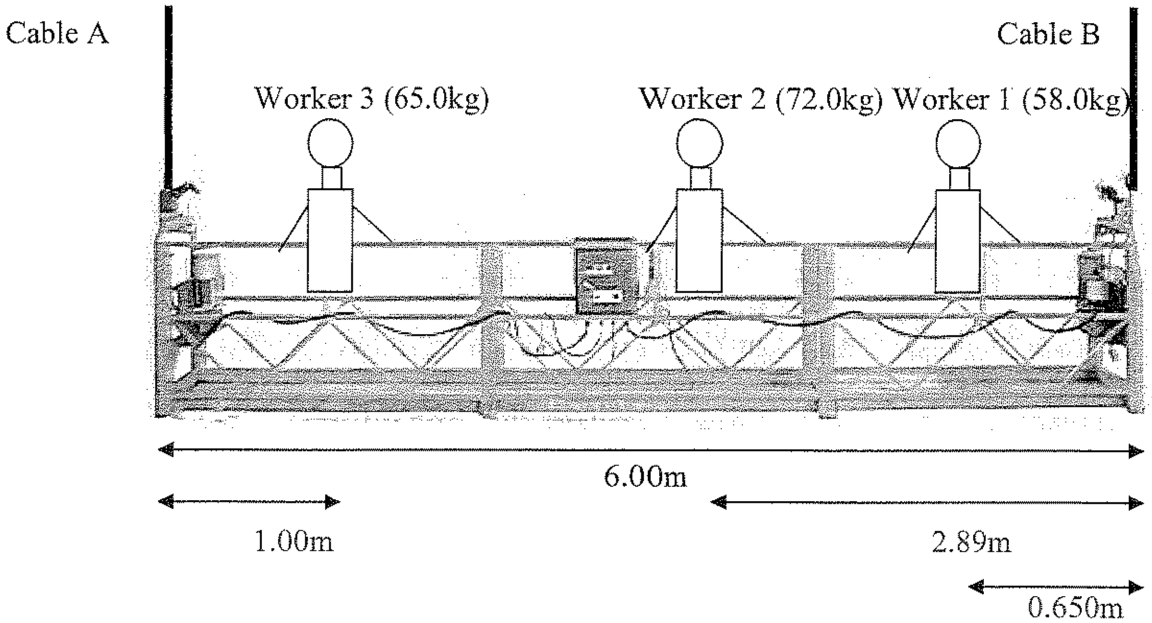
$F \times 3.$

$\therefore \tau \times 3$

$\tau = 0.103\ Nm..$

will spin 3x faster.

3. Three window washer are working on a suspended gantry of mass 275 kg lifted above the ground several floors in the air as shown by the following diagram: (10 marks)



(a) Calculate the tensions in each of the cables. (5 marks)

use cable A as pivot

$\Sigma cm = \Sigma acm$

$65\times9.8\times1 + 72\times9.8\times3.11 + 58\times9.8\times5.35 + 275\times9.8\times3 = F_B \times 6$ (1)

$637 + 2194.4 + 3040.94 + 8085 = F_B \times 6$

$F_B = 2326.2\,N$

SF $= 2330\,N \uparrow$ (1)

assume ↓ as +v

$\Sigma F_v = 0$

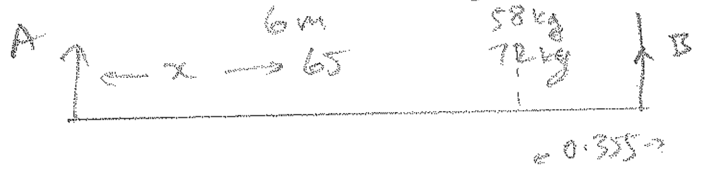
$0 = F_A + W_3 + W_2 + W_1 + G + F_B$ (1)

$0 = F_A + 637 + 705.6 + 568.4 + 2695 - 2330\,N$ (1)

$F_A = -2276\,N$

or $F_A = 2280\,N \uparrow$ (1)

(b) At one point of the cleaning process, two of the window cleaners (worker 1 and worker 2) are 0.355 m from cable B. The manufacturer of the cables specify a breaking strain of 3126 N. The third worker on the gantry walked towards cable B. What is the closest distance to cable B can the third worker get to before the cable reaches breaking strain? (5 marks)



use A as pivot

$\Sigma cm = \Sigma acm$

$275\times9.8\times3 + 65\times9.8\times x + (58+72)9.8\times5.645 = 18144N\times6$

8085 7191.73

$x = \frac{18144 - 8085 - 7192}{65\times9.8}$

$x = 4.50$ m from A. 14.6.9m

or 1.50 from B.

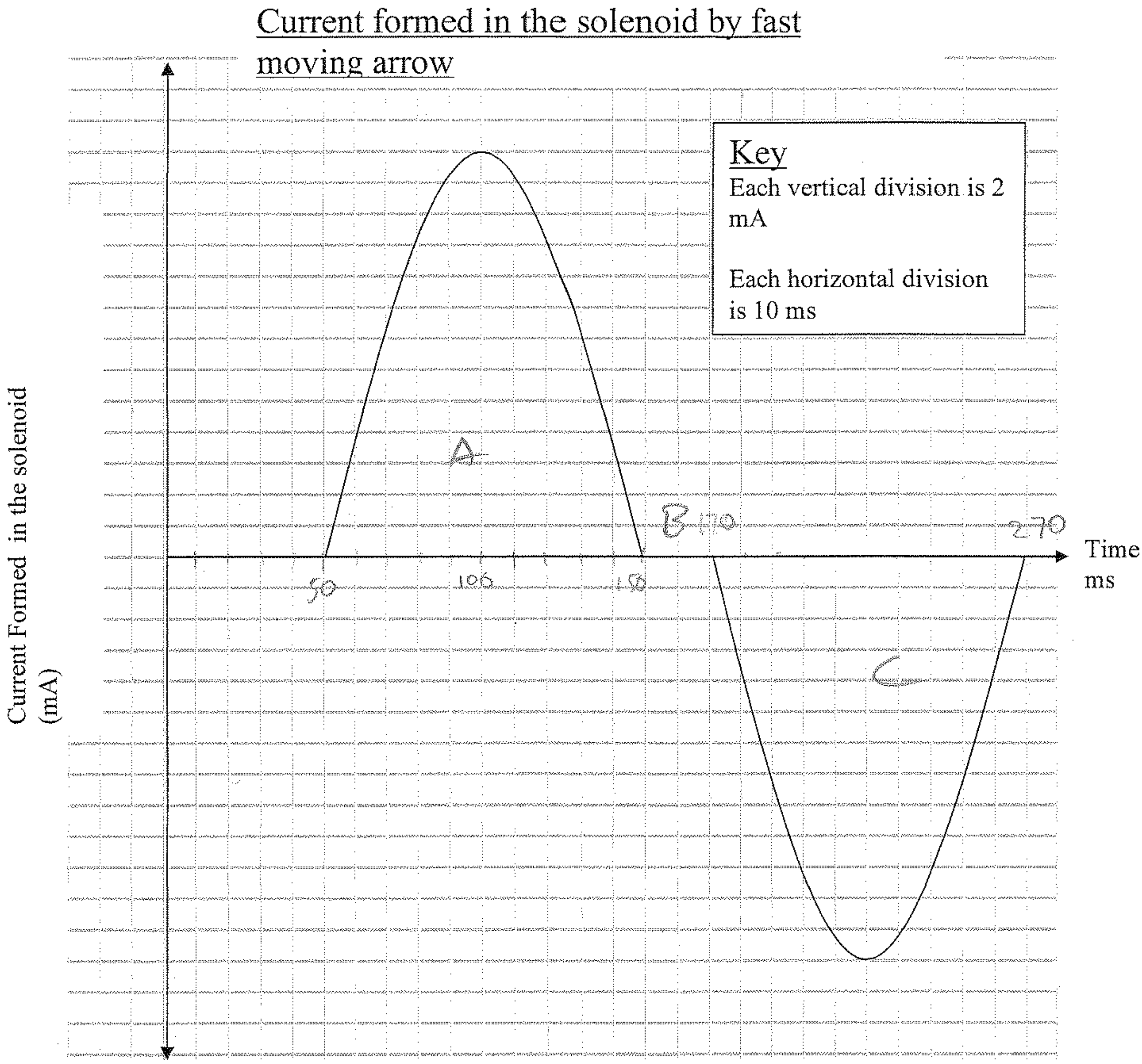
Never breaks.

if uses 3126N

$x = 5.46$ m from A

or 0.538 from B.

4. A very accurate archer, Saumya, fires a horizontal arrow, with the arrowhead being a strong magnet (the south pole at the tip), through a small wire coil (solenoid) which is connected to an ammeter. The results from the ammeter of the arrow approaching, being in and then leaving the solenoid are shown in the graph below. (12 marks)



(a) Explain why the graph would have this particular shape. (3 marks)

A – As the S field increases, according to Lenz's law it should induce an increasing opposite field. ①
– Faraday's law says that a changing field will induce a current (emf)

① B – No current is produced when the magnet is in the solenoid.

① C – As the arrow is leaving, the solenoid will experience a reducing field. This would induce a current in the opposite direction.

(b) If the solenoid has a length of 0.450 m, How fast was the arrow travelling? (2 marks)

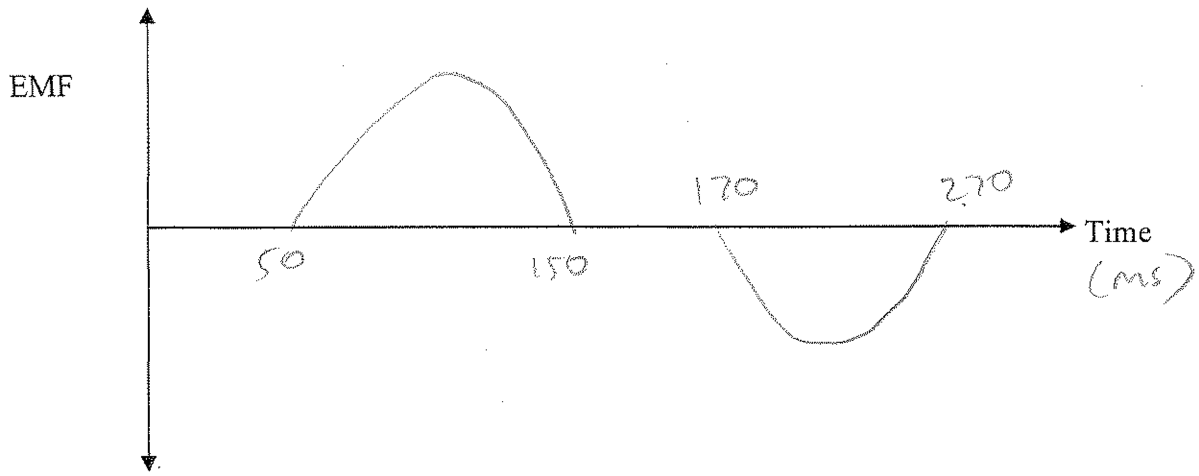
$t = 20ms$
$= 20 \times 10^{-3} s$

$v = s/t$

$v = \frac{0.450m}{20 \times 10^{-3}}$

$v = 22.5 ms^{-1}$

(c) Sketch a diagram of the EMF that would have corresponded to the current graph above? (2 marks)



(d) Identify and explain the physical law you used for constructing your graph. (2 marks)

Ohm's Law. 1

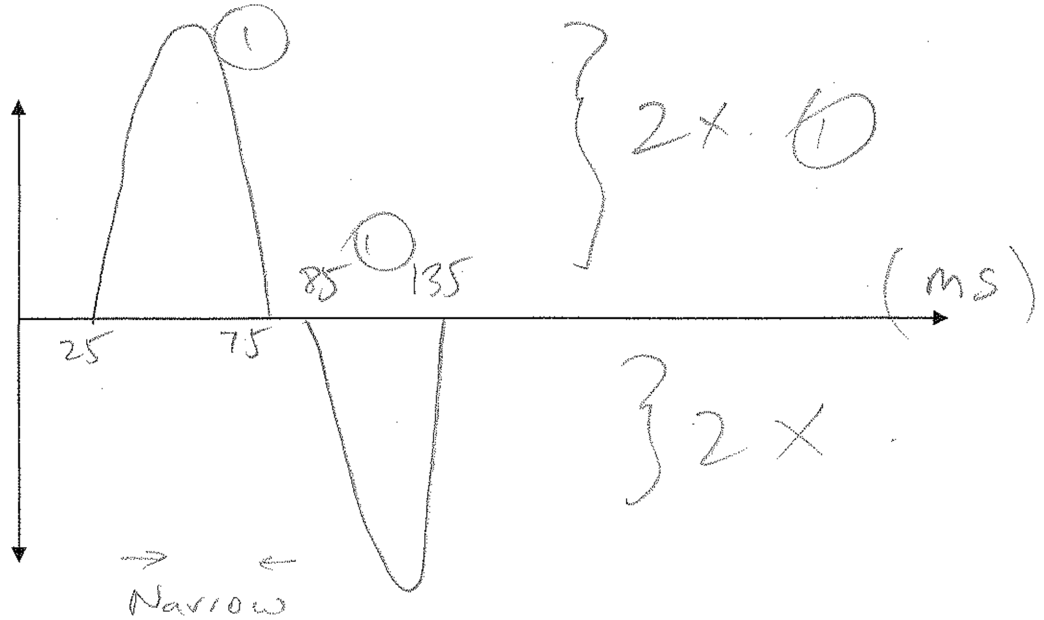
$V \propto I$

$R = \frac{V}{I}$

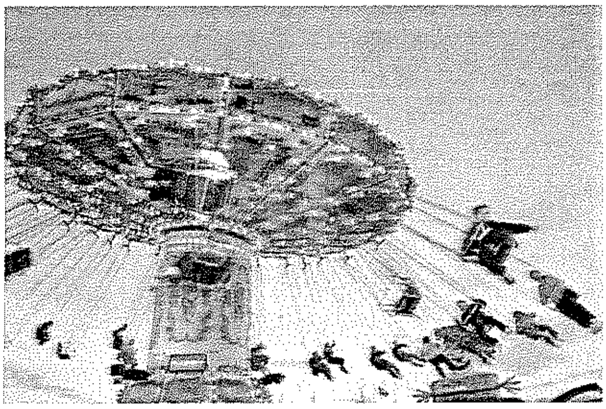
as voltage increases, current should increase proportionately. 1

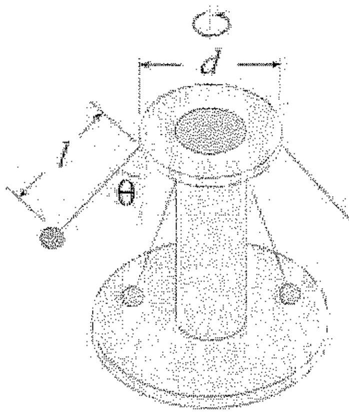
(e) If Saumya was able to increase the speed of her arrow by a factor of 2.00, how would the voltage time graph be different to the previous one? Explain and sketch.

(3 marks)



5. Riddhi and Helen really enjoy amusement park rides. They go to a nearby amusement park. The first ride they try is the hanging carousel chairs (shown in the diagram below). The chairs are suspended by chain from a flat disk at the top. (13 marks)





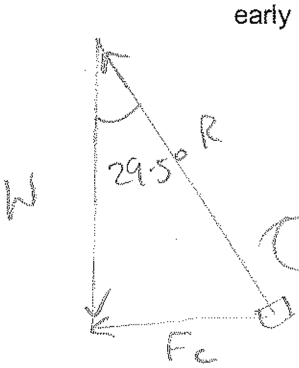
$r = 6.35 + 8.5 \sin 29.5$

$r = 10.54$ m.

l = 8.50m

d = 12.7m

(a) The mass of Helen and the chair is 64.0 kg (52.0 kg without chair). The angle of θ is 29.5° at an early point of the ride. Calculate the speed at which Helen is moving. (4 marks)



$W = mg$ $F_c = 354.85$ if use $r = 6.354$

$v = 5.89\ ms^{-1}$

$\tan\theta = \frac{F_c}{W}$

1 $\tan 29.5° = \frac{mv^2}{r \times mg}$ 1

$v^2 = rg \tan 29.5$

$v = \sqrt{10.54 \times 9.8 \tan 29.5}$

$v = 7.64\ ms^{-1}$ 2

(b) The Mass of Riddhi and the chair is 68.0 kg (56.0 kg without chair). If Riddhi and Helen are on the same ride, would Riddhi be at the same angle as Helen? Explain using some calculation.(2 marks)

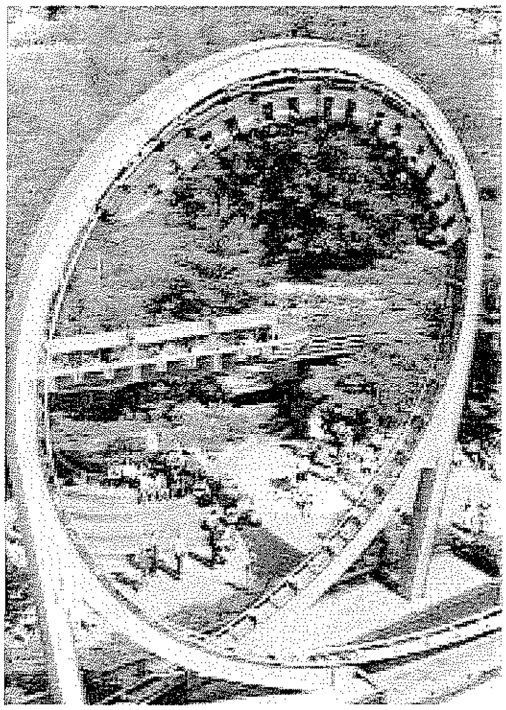
Riddhi and Helen are at the same angle. 1

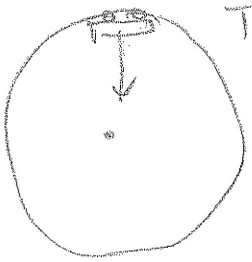
when doing the calculations

$$\tan\theta = \frac{\cancel{m}v^2}{r\cancel{m}g}$$ 1

the mass crosses out ∴ does not effect the angle.

(c) Helen and Riddhi now ride a massive roller coaster. It has a perfectly circular verticle loop of radius 21.5 m. What would be the velocity of the rollercoaster if Helen and Riddhi were to experience 16.5 % of their weight when they were upside down at the top of the loop? (4 marks)





T = 16.5% W 1

$T = F_c - W$

$$0.165\cancel{m}g = \frac{\cancel{m}v^2}{r} - \cancel{m}g$$

$$(0.165g + g)r = v^2$$ 1

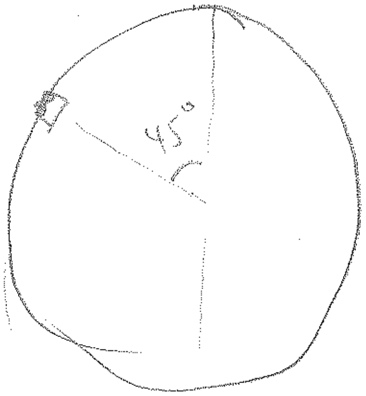
$v^2 = 1.165 \times 9.8 \times 21.5$ m

$v^2 = 245.5$

$v = 15.7\ ms^{-1}$ 2

if we ↑ 16.5% - 1
the v = 13.26ms

(d) When the roller coaster is at 45.0° past the highest point of the loop, they find that their apparent weight has now increased to 0.435 of their weight. Calculate the amount of centripetal force the roller coaster track provided to Riddhi. (3 marks)



$T = F_c - W$

$F_c = T + W$

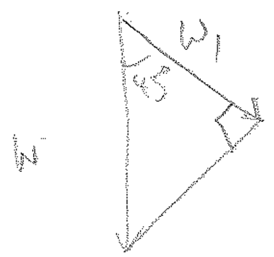
$= 0.435 \times mg + mg \cos 45$ 1

$= 0.435 \times 548.8 + 388.1$ N

$= 238.7$ N $+ 388.1$

$= \cancel{846.8\ N}\ 626.8$ N

$W = mg = 56 \times 9.8$
$= 548.8$ N

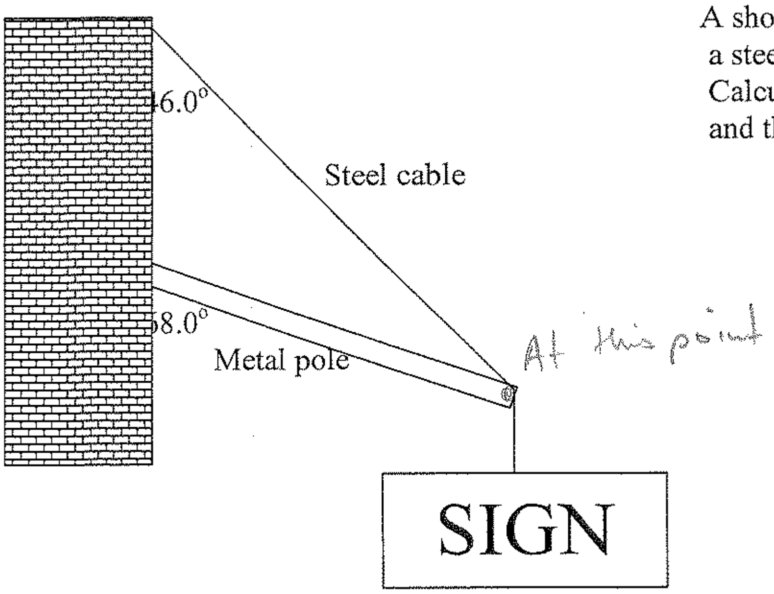


$\cos 45° = \frac{W_1}{W}$ 1

$W_1 = 56 \times 9.8 \times \cos 45$
$W_1 = 388.1$ N.

$\underline{F_c = 627 \text{ N.}}$ 1

6.



Mass of sign is 85.3 kg

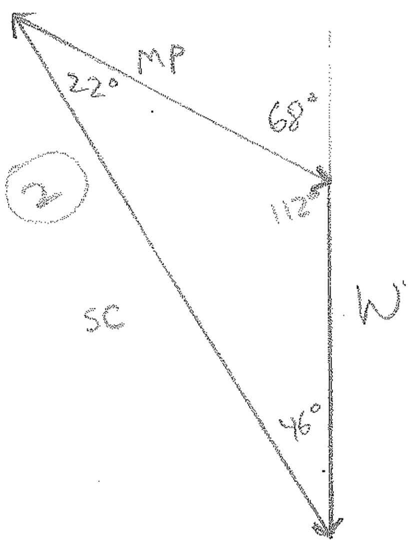
A shop sign is supported by a metal pole and a steel cable as shown in the diagram. Calculate the forces in both the metal pole and the steel cable. (10 marks)

$W = mg$

$= 85.3 \times 9.8$

$= 835.94\ N$

using the method of joints $\Sigma F = 0$ 1



$\frac{W}{\sin W} = \frac{MP}{\sin MP} = \frac{SC}{\sin SC}$ 1

$\frac{835.94}{\sin 22°} = \frac{MP}{\sin 46°} = \frac{SC}{\sin 112°}$

$MP = \frac{835.94 \times \sin 46}{\sin 22}$ 2

$MP = 1605.2\ N$

$SC = \frac{835.94 \times \sin 112}{\sin 22}$ ✓

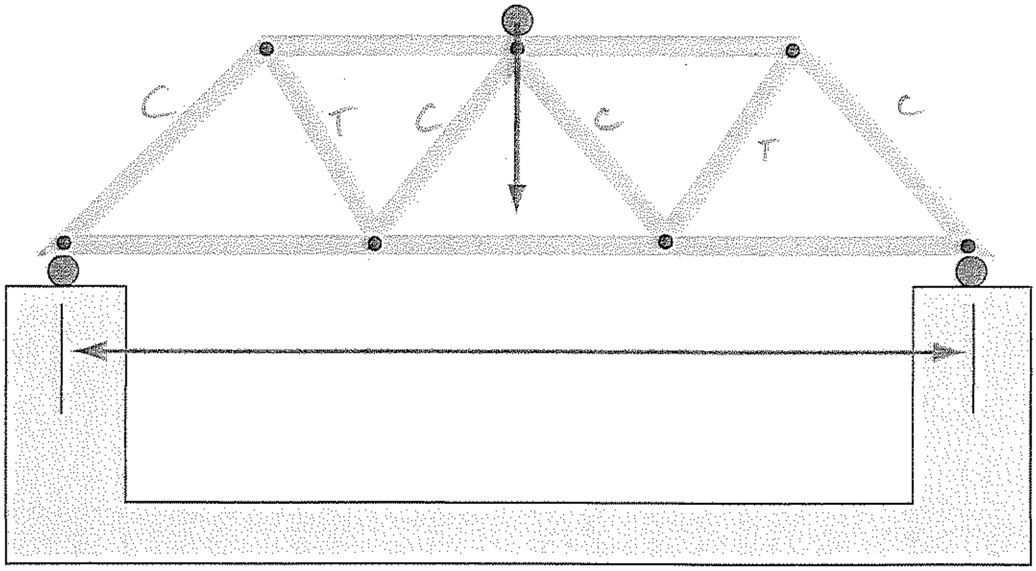
$SC = 2069N$

$\overline{SC} = 2070N$ N 46° W

$\overline{MP} = 1610N$ S 68° E 2

7. For the following diagrams place a C for compression and a T for tension for all the sections of the following diagrams of bridges and the trusses. (8 marks)

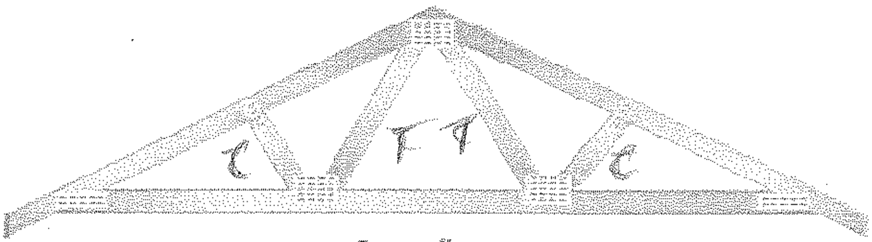
(a)



2

award marks for the main areas shown

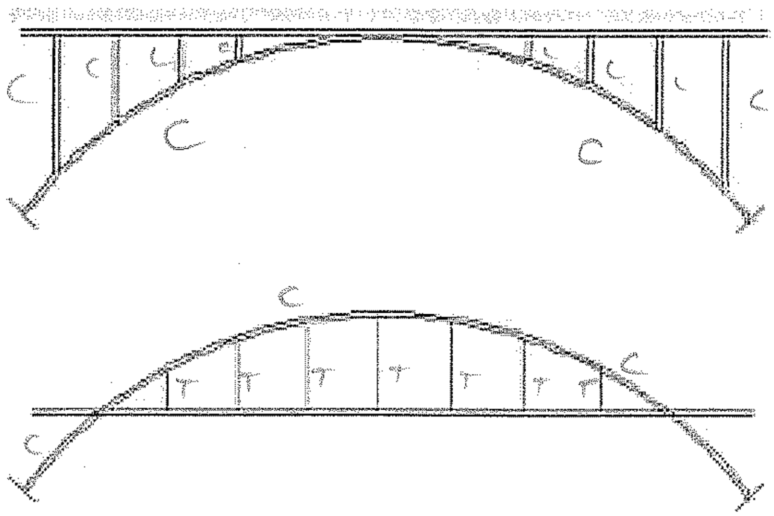
(b)



Gang nail truss

2

(c)



2

2

8. Matthew is an astronaut who has an assignment to work in the International space station. The space station is at an altitude of approximately of 390.0 km above the surface of the Earth. Matt has a mass of 82.5 kg. (10 marks)

(a) What is the weight of Matthew when he is on the space station? (4 marks)

$g = \frac{GM}{r^2}$

$g = \frac{6.67 \times 10^{-11} \times 5.97 \times 10^{24} kg}{(6.38 \times 10^6 + 390 \times 10^3)^2}$

$g = 8.688 ms^{-2}$

$w = mg$

$w = 82.5 kg \times 8.688$

$w = 716.76 N$

SF = 717 N.

(b) By how much would Matthew's mass change travelling from the surface of the Earth to the space station. (2 marks)

Mass would not change.

Mass does not change due to position.

(c) How long would it take the space station to orbit once around the Earth? (4 marks)

$F_c = F_g$

$\frac{\cancel{m}v^2}{\cancel{r}} = \frac{GM\cancel{m}}{r^{\cancel{2}}}$

$v^2 = \frac{6.67 \times 10^{-11} \times 5.97 \times 10^{24}}{(6.38 \times 10^6 + 390 \times 10^3)}$

$v = 7.68 \times 10^3 ms^{-1}$

$v = \frac{s}{t}$

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

$t = \frac{2\pi(6.38 \times 10^6 + 390 \times 10^3)}{7.68 \times 10^3 ms^{-1}}$

$t = 5538.7$ sec.

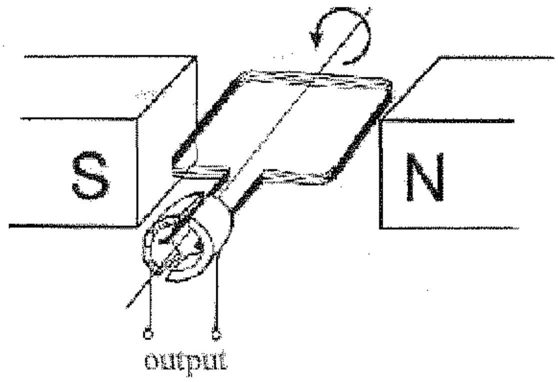
$t = 92.3$ mins

$t = 1.54$ hrs.

exact value = 5546.4 sec.

9. A generator consist of 145 coils of radius 0.850 m , were spun at 155rm in a magnetic field of strength 0.575 T. (10 marks)

rpm



If using square loop
$A = 0.850 \times 0.850 = 0.7225\,m^2$
$\phi = BA = 0.575 \times 0.7225 = 0.415\,Wb$
$emf = -N\frac{\Delta\phi}{\Delta t}$
$= -145 \times \frac{(0 - 0.415)}{0.0968}$
$= 622\,V$

(a) Calculate the effective EMF produced by this generator. (4 marks)

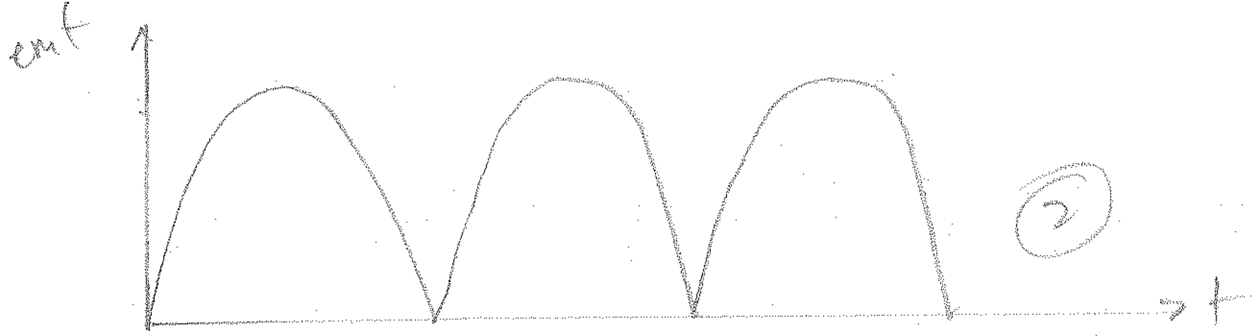
$\phi = BA$
$= 0.575 \times \pi \times 0.850^2$
$= 1.3051\,Wb$

t for $\frac{1}{4}$ turn
$t = \left(\frac{rpm}{60}\right)^{-1} \div 4$
$t = 0.0968\,sec$

$emf = -N\frac{\Delta\phi}{\Delta t}$
$= \frac{-145 \times (0 - 1.3051)}{0.0968}$
$emf = 1955\,V$
$SF = 1960\,V$

(b) What type of EMF output does this generator produce? Sketch a graph of the EMF vs time. (4 marks)

This generator produces DC because of split ring commutator. 2



2

(c) Explain how our mains electricity supply in Australia is provided at 240 V AC. Also explain what the 240 V represents. (2 marks)

In mains, the power is supplied by AC generators.
coal → steam → Ek → generator → AC mains. 1

AC 240V is the effective voltage or the DC equivalent.

End of Section B

Student Name: ______________________

Teacher Name: ________________

Section Three: Comprehension and Data Analysis 20% (40 Marks)

This section has two (2) questions. You must answer all questions. Write your answers in the space provided.
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.
Suggested working time for this section is 36 minutes.

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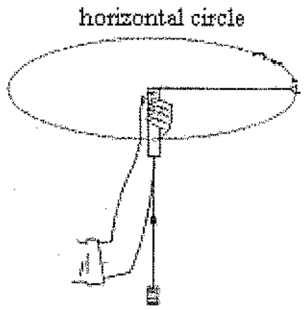
1. Horizontal Circular Pendulums

Three students were investigation circular motion in a similar manner to the investigation you carried out earlier this year. They swung a weight around in a horizontal circle with a known radius and collected the results below: (20 marks)

mass of stopper = 0.0320 kg



The students were trying to find the relationships between the mass, centripetal force, velocity and radius. They repeated their experiment three times. They swung the weight 20 times around their head and recorded that time. These are the results that they obtained:

$C = 2\pi r$
$C = 2.51$ m

Constant radius

Vertical mass (kg)		Radius (cm)	T1 times (s)	T2 time (s)	total time average	T3 time (s)	average velocity (ms^{-1})	v^2
100	0.98	40	50.2	48.8	49.9	50.6	1.01	1.02
200	1.96	40	35.6	36.2	35.8	35.5	1.40	1.96
300	2.94	40	30	29	29.3	28.8	1.71	2.92
400	3.92	40	26	25	25.4	25.2	1.98	3.92
500	4.9	40	22.6	22.4	22.5	22.4	2.23	4.9
600	5.88	40	20	20.4	20.3	20.6	2.47	6.1

F_c

Constant mass

Vertical Mass (kg)		Radius (cm)	$C = 2\pi r$ (m)	T1 time (s)	T2 time (s)	average time	T3 time (s)	velocity ms^{-1}
400	3.92N	120	7.54	43.6	42	43.2	44	3.49
400	3.92N	100	6.28	37	39.8	38.9	40	3.23
400	3.92N	80	5.03	34	35.4	34.8	35	2.89
400	3.92N	60	3.77	30.8	31	30.8	30.6	2.45
400	3.92N	40	2.51	25.2	24.8	25.1	25.4	2.00
400	3.92N	20	1.26	18	17.8	18	18.2	1.40

(a). Calculate the weight of the mass supplying the gravitational force . (2 marks)

$W = mg$

$= 0.032 \text{ kg} \times 9.8$

$= 0.3136 \text{ N}$

SF $= 0.314 \text{ N}$

if they provide similar answers below ok

(b). Calculate the centripetal force on the stopper. (4 marks)

for constant radius

100g – 0.98N

200g – 1.96N

300g – 2.94N

400g – 3.92N

500g – 4.9N

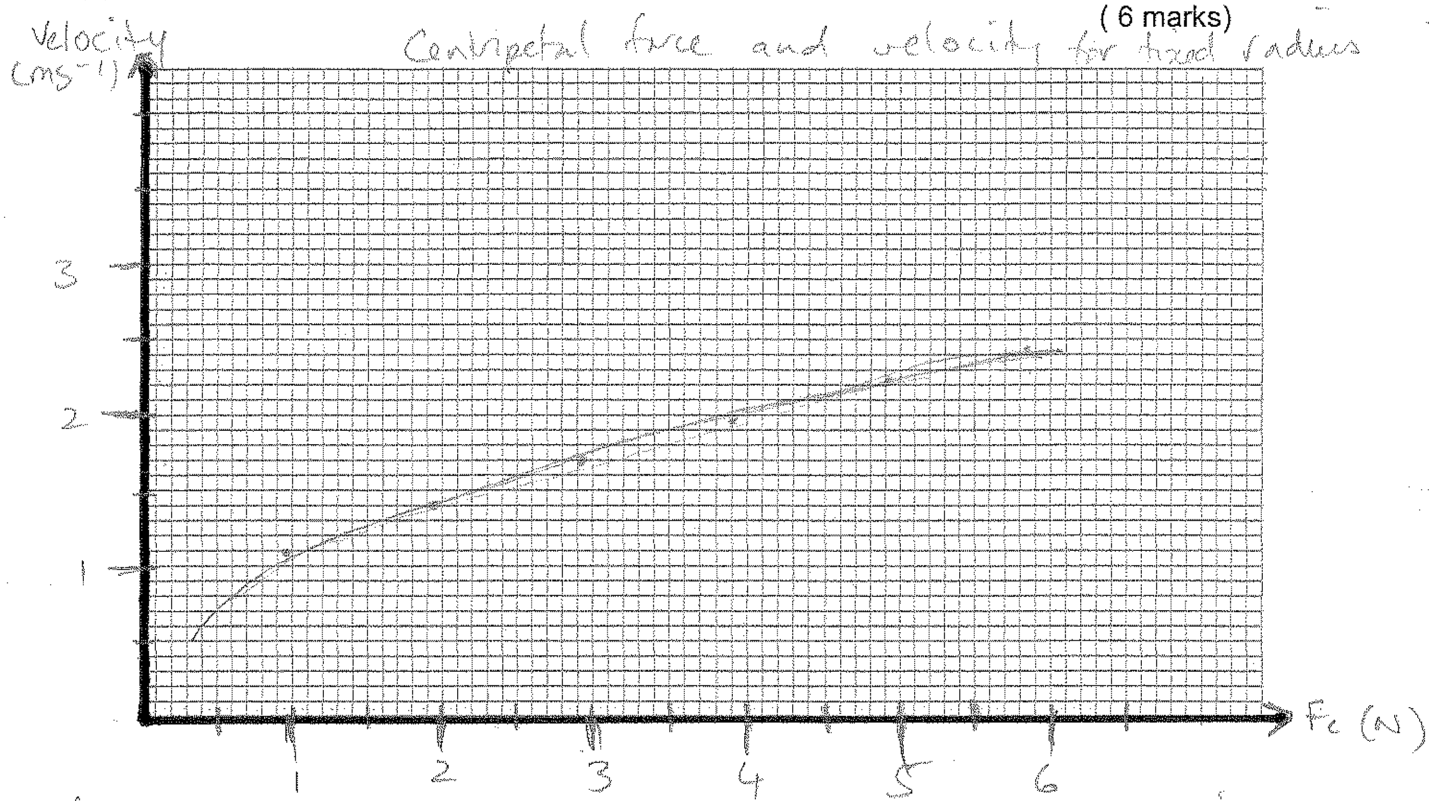
600g – 5.88N

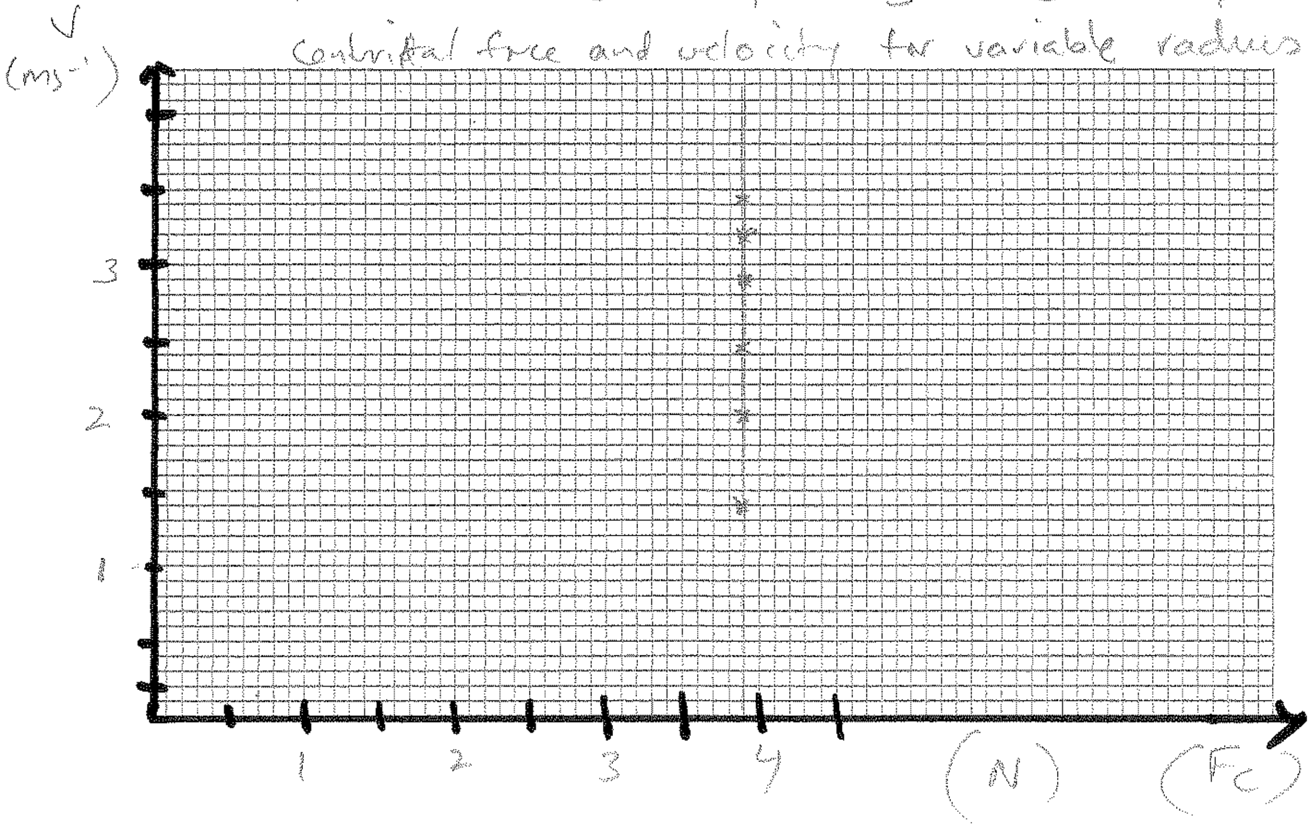
the mass weight supplies the centripetal force.

for constant mass

400g – 3.92N

(c). Draw graphs for both tables, using the relationship of Fc and v and any necessary manipulations.
(6 marks)





(d). From the experimental results determine the value for the mass of the stopper. (3 marks)

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

grad $= m = \frac{F_c r}{v^2}$

grad $= \frac{y_2 - y_1}{x_2 - x_1}$

$= \frac{5.9 - 1.02}{5.7 - 1}$

$= 1.04$.

$m = 1.04 \times 0.4$

$m = 0.415$ kg

$P_1 (1, 1.02)$

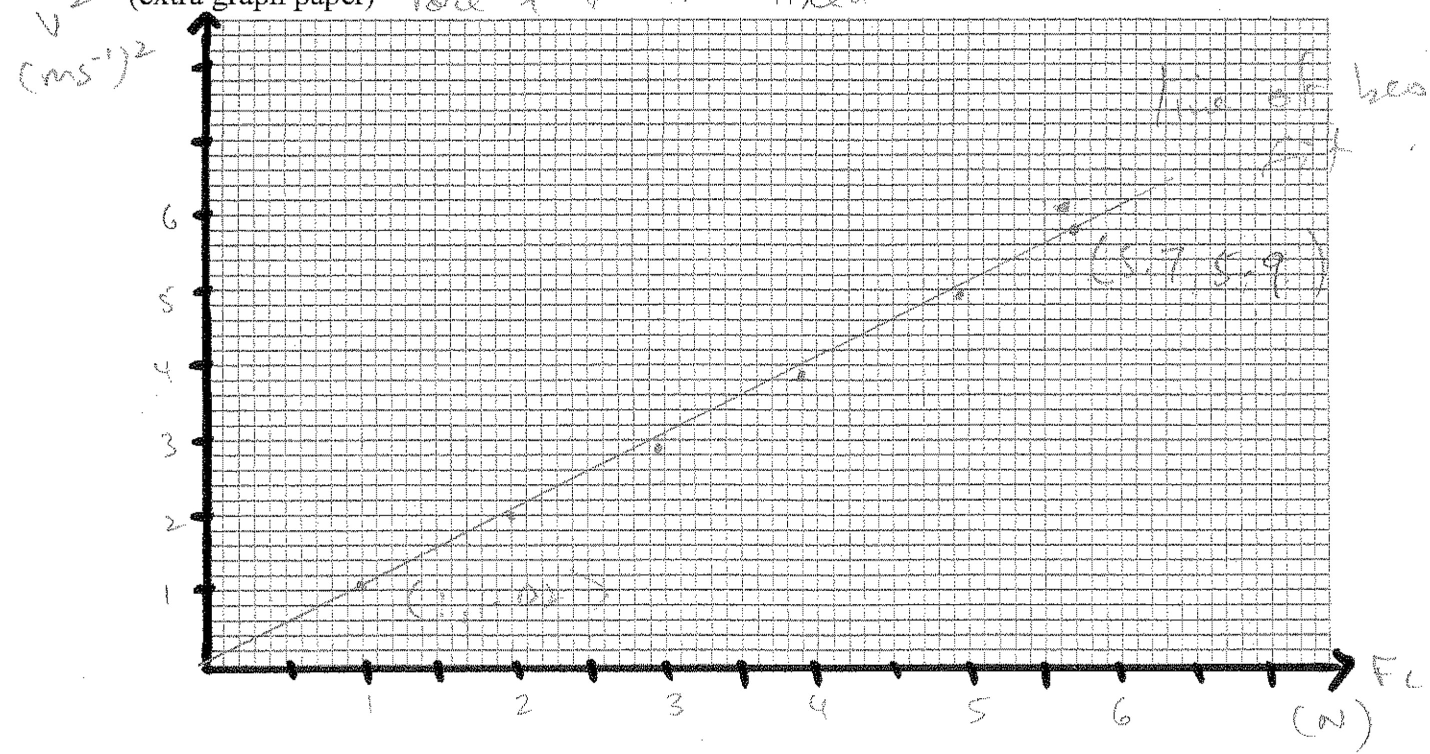
$P_2 (5.7, 5.9)$

(e). Why do you think that there is/isn't any discrepancy between the actual mass of the stopper and the experimental mass of the stopper? (2 marks)

Experimental Error 1

List some errors 1

(extra graph paper) force + v^2 for fixed radius



(f). If the mass of the stopper were to increase by 1.5 times , what would happen to the measured value of the time for the 20 rotations? Please provide some reasoning for your answer. (3 marks)

if the mass of the stopper were to increase by 1.5 times, the stopper would slow down if Fc is fixed. 1

$F = \frac{mv^2}{r}$ then v must reduce

if m & r are fixed 1 $\sqrt{1.5}$

$= 1.22$ times 1

2. Wiring Electric Motors

Motors, generators and transformers all contain coils of wire. When designing these devices, engineers must take into account the electrical properties of the wires, which need to be manufactured from appropriate materials and with the correct dimensions.

One property to take into account is the " conductivity " of the metal from which the wires are made. The conductivity of a material is a measure of how well it conducts electric current. A higher value of conductivity means that the material is a better conductor. Each metal generally has a constant conductivity, provided the temperature does not change.
The resistance of a piece of conducting material is related to the conductivity, length and cross sectional area of the material by the equation

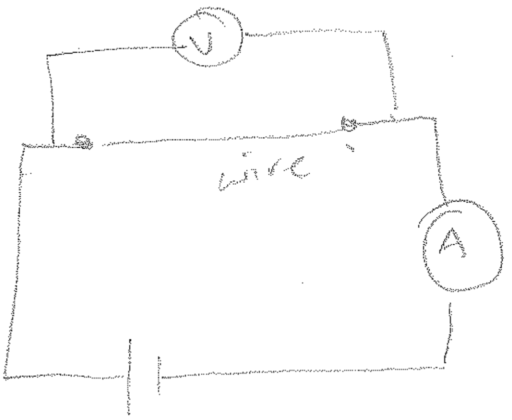
$$R = \frac{\ell}{kA} \quad ....(1)$$

where: R is the resistance of the conductor (Ω)
ℓ is the length of the conductor (m)
A is the area of cross section of the conductor (m^2)
k is the conductivity of the material from which the conductor is made.

Some of the year 12 students were given the task of designing and building a simple motor for their Physics project. They were given a roll of wire with a circular cross section and made from an unidentified metal alloy. They then did a preliminary experiment to find the approximate measure the current through it and the potential difference across it. They also used a micrometer gauge to measure the diameter (d) of the wire, which they measured as 0.400 mm. They obtained the following data:

Length of the wire, $\ell = 50$ cm
Potential difference across the wire, 2.0 V
Current through the wire, 0.33 A

(a).(i). Draw a diagram of the circuit that shows how they would have obtained the above measurements. (3 marks)



-1 for every error.

(ii). Since V = I R, you can replace R in the equation with V / I. The area of cross section, A, can be replaced with πr^2.

Perform these substitutions and then calculate the students' value for the conductivity of the wire. Include the units for conductivity. (3 marks)

$$R = \frac{L}{kA} \rightarrow \frac{V}{I} = \frac{L}{k\pi r^2}$$

$$k = \frac{IL}{V\pi r^2} = \frac{0.33 \times 0.50}{2.0\pi(0.20 \times 10^{-3})^2}$$

$$= 6.6 \times 10^5 \ A\,V^{-1}\,m^{-1}$$

In order to obtain a better experimental value for k, the student decided to collect more data and use graphical techniques to find k. They used different lengths of the same wire, and with a potential difference of 2.0 V across them each time, measured the current through each. They obtained the following data:

Diameter of the wire, d = 0.20 mm.
Potential difference across the wire, V = 2.0 V

Current, I (A)	Wire length, ℓ(m)	1/L (m^{-1})	
1.63	0.1	10	
0.82	0.2	5.0	
0.55	0.3	3.3	
0.40	0.4	2.5	
0.33	0.5	2.0	

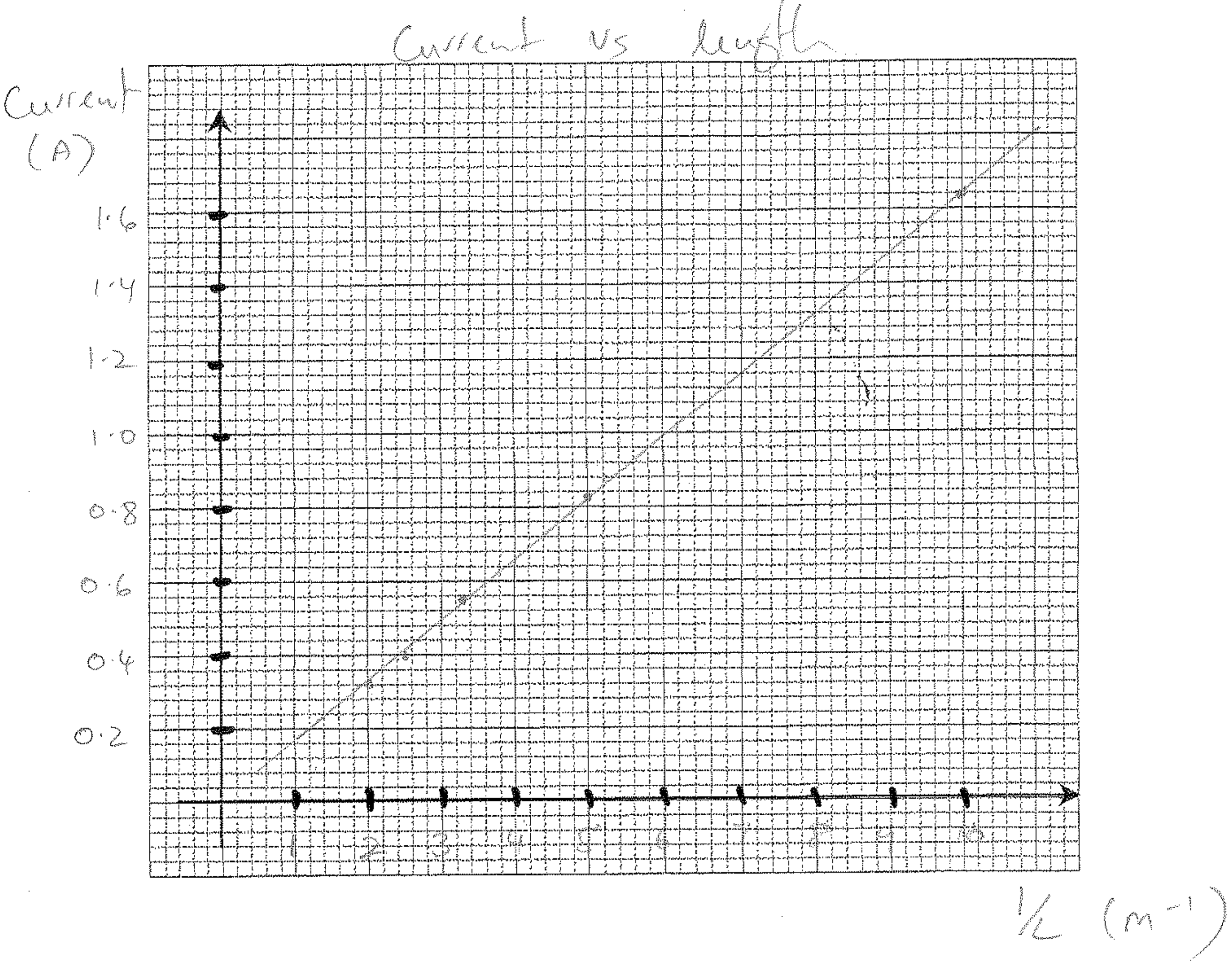
(b).(i). Rearrange the formula you created in part (a) to make current, I, the subject of the equation (i.e. put the equation into the form: I = ...). (1 mark)

$$I = \frac{k V \pi r^2}{L}$$

(ii). If you graph current, I, on the vertical axis, what would you graph on the horizontal axis in order to get a straight line from the data shown in the table above? (1 mark)

$\frac{I}{L}$ or $\frac{V}{L}$

(iii). Process your data as required in order to obtain a straight –line graph. Process your data and graph it in the graph paper below. (4 marks)



What is the equation for the line? (2 marks)

exact answer is $y = 0.163x + 0.0017$.

approximate is fine.

e.g. $y = 0.2x$.

(iv). Use the gradient (slope) of the line of the best fit to find the experimental value of k. (2 marks)

Pt 1 (1.6, 0.25) gradient $= \frac{1.63 - 0.25}{10 - 1.6}$

Pt 2 (10, 1.63)

$= 0.164$ Am

(c). The usual metal used for the coils of the electric motors is copper. Copper has a much higher conductivity than the alloy in this investigation, so the copper wires of the same dimensions (length and cross-sectional area) would have a much less resistance.

(i). How would using this alloy wire instead of copper effect the operation of the students' motor? (2 marks)

Motor would run slower as maximum current is reduced. Less torque generated.

(ii). Will the students' alloy-wired motor be more or less efficient motor than a motor wound with an equal amount of copper wire? Explain briefly. (2 marks)

Less efficient

- because of resistive heating (I^2R), less electrical energy is available for conversion to mechanical energy.

End of Examination
(Yay!)