Semester One Examination, 2011

Question/Answer Booklet

3AB PHYSICS

Please place your student identification label in this box

Student Number: In figures

In words

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.

	Section 1	**Section 2**	**Section 3**	**Total**
Score				
Out of	45	75	30	150
%				

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 response	12	12	54	45	30
Section Two: Problem-solving	7	7	90	75	50
Section Three: Comprehension	2	2	36	30	20
					100

Instructions to candidates

1. The rules for the conduct of Curriculum Council examinations are detailed in the *Student Information Handbook.* 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.

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% (45 marks)**

This section has **12** questions. Answer **all** questions. Write your answers in the space provided.

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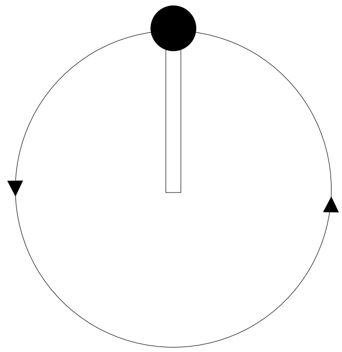
Suggested working time for this section is 54 minutes.

Question 1 **(3 marks)**

A student is flicking peas with a spoon from their table to another table in the school cafeteria. The peas have to travel a distance of 3.00 m horizontally (between tables) and land at the same height from which they took off. They are launched at an angle of $30.0\,^{0}$ to the vertical with a speed of $5.83\ m\ s^{-1}$. What is the time of flight?

Question 2 **(5 marks)**

A 300 g ball is being swung around in a vertical circle on the end of a mass-less stick of length 45.0 cm.



a) If the ball on the end of the stick is travelling at 5.60 m/s at the bottom of the loop, what is the velocity at the top?

(2 marks)

b) What is the magnitude and direction of the force acting on the ball by the stick at the top of the loop?

(3 marks)

Question 3 **(3 marks)**

a) What is the angle of lean on a 75.0 kg runner travelling around a 10.0 m diameter curve at 2.80 m s^{-1}?

(2 marks)

b) If the maximum value of static friction between the shoes of the runner and the road is 100 N, will they be able to successfully round the bend? Explain.

(1 mark)

Question 4 **(3 marks)**

What is the ratio of the strength of gravity on Mars as compared to the strength of gravity on Earth, if the mass of Mars is 0.107 times that of Earth and the radius of Mars is 0.533 times that of Earth?

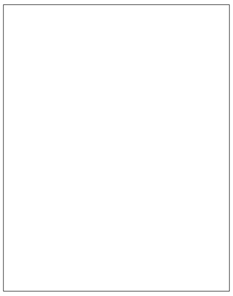
Question 5 **(4 marks)**

If the circumference of the orbit of Mercury is 3.64×10^{11} m, what is the period of Mercury's orbit in Earth years?

Question 6 **(5 marks)**

a) A piece of A4 paper has a length of 297 mm and a width of 210 mm. What is the vertical and horizontal location of the centre of mass of the piece of paper?

(1 mark)



b) The piece of A4 paper is pinned to the wall by its top left corner and set swinging. When the paper comes to rest, what is the angle formed between the shortest edge of the paper and the horizontal. Hint: a diagram may assist your calculation.

(2 marks)

c) Is the paper hanging from the pin in stable, unstable or neutral equilibrium? Explain.

(2 marks)

Stable Equilibrium Unstable Equilibrium Neutral Equilibrium Please Circle One

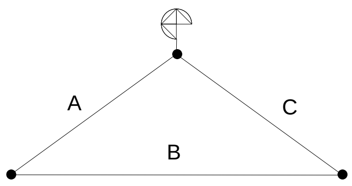
Explanation

Question 7 **(4 marks)**

A triangular coat hanger is hung on a rail. Each of the members (sides) of the triangle is weightless but the bolts that hold the sides together are not.

a) State whether the members that make up the hanger are under tension, compression or both.

(3 marks)



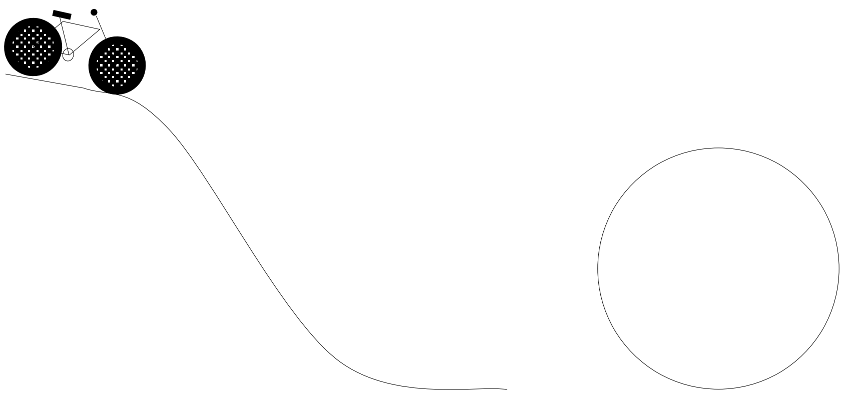
Member	Tension , Compression , Both
A	
B	
C	

b) Which member(s) of the hanger could be replaced with string if it is to retain its shape?

(1 mark)

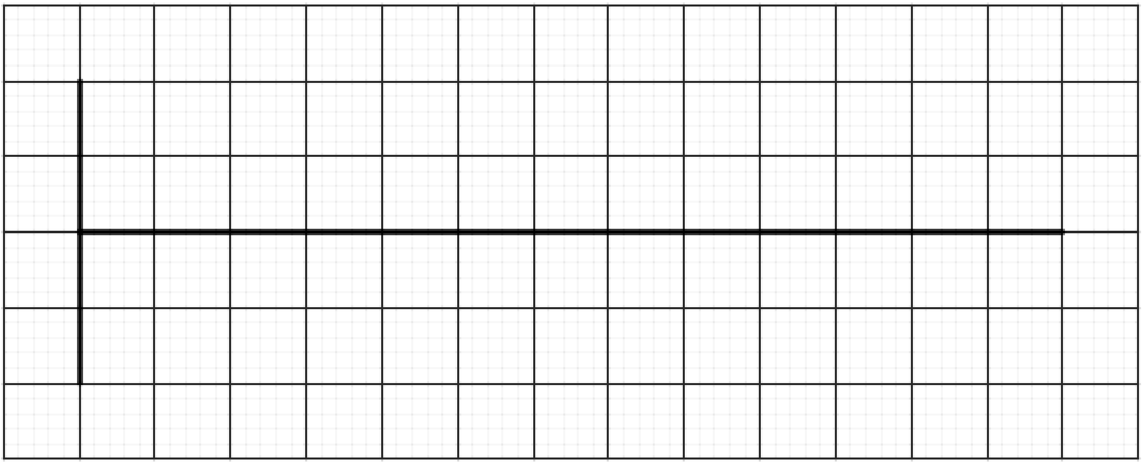
Question 8 **(4 marks)**

A cyclist has offered to do a stunt for charity. She will roll down a ramp on a bike and do a roller coaster loop the loop without falling off the bike. The combined mass of the bike and cyclist is 80.0 kg. The centre of mass of the combined bike and person will execute a loop of radius of 2.00 m. If the rider does not peddle, from what height ramp should the cyclist descend if the top of the loop is to exert a force on the cyclist equal to half the combined weight of the cyclist and bike?



Question 9 **(3 marks)**

Sketch a graph of musical sound that gets louder and lower as time progresses. Be sure to label the axis.



Question 10 **(4 marks)**

a) What is the period of a light wave that has a wavelength of 2.7 nm?

(3 marks)

b) If a sound travelling in air had the same period as the light wave from part a), would it be audible to the human ear?

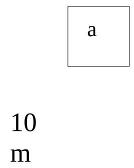
(1 mark)

Yes No Please circle one only

Question 11 **(3 marks)**

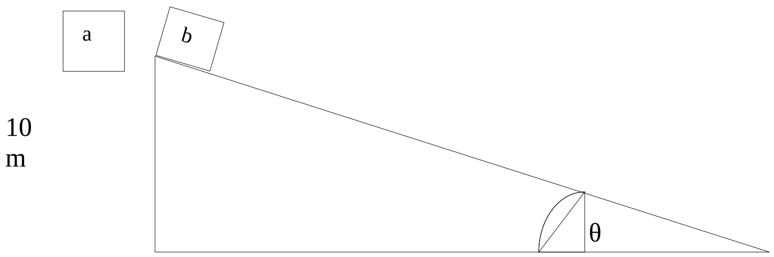
a) Calculate how long will it will take an iceblock to fall 10.0 m vertically downwards from a stationary start?

(1 mark)



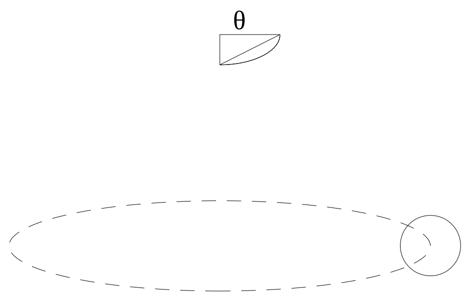
b) An identical iceblock is now put at the top of a uniform frictionless slope of the same height. At what angle relative to the horizontal should the slope be set so the ice block takes twice as long as that calculated in part a) to reach the bottom by sliding down the slope.

(2 marks)

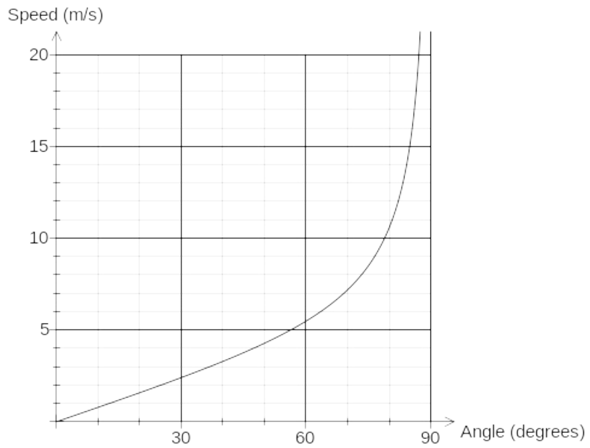


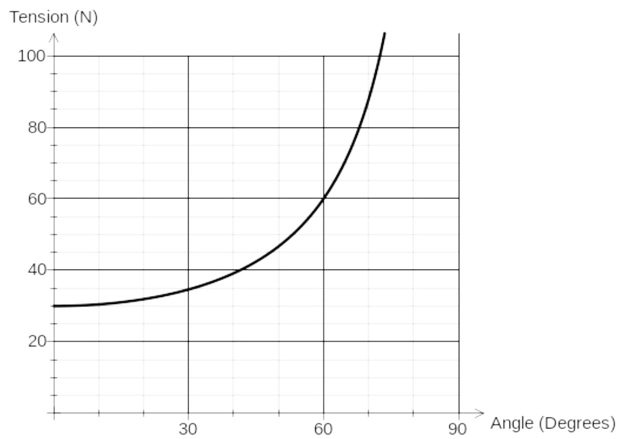
Question 12 **(4 marks)**

A ball is swung in a horizontal circle at different speeds in a gravitational field of 10.0 m s^{-2}. The angle the string forms with the vertical and the tension in the string are recorded.



Graphs of this information are shown below.





a) What is the mass of the ball?

(2 marks)

b) What is the length of the string?

(2 marks)

End of Section One

Section Two : Problem-Solving 50% (75 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 13 (10 marks)

Brushtail possums live in trees and often jump between them. They can jump with an initial velocity of 4.2 m s^{-1}. They are sufficiently streamlined and move with sufficiently low velocities that it is reasonable to ignore air resistance when calculating their motion.

(picture from: www.wildlifetasmania.com)

a) What is the greatest height above its starting point that a brushtail possum can reach when it jumps.

(2 marks)

b) What is the greatest horizontal distance that the brushtail possum can jump assuming it takes off and lands at the same height? State any assumptions made in this calculation.

(3 marks)

c) A brushtail possum was on a branch of a tree 23 m above the forest floor. It decided to jump across to an adjacent tree trunk 0.9 m away measured horizontally. It jumped upwards at an angle to the horizontal of 25° at 4.2 m s^{-1}. Where on the tree trunk would it land?

(2 marks)

d) A sugar glider (illustrated) is also a tree dweller. It has flaps of skin between its limbs that act like a parachute. One followed the brushtail possum, also leaping initially upwards at an angle to the horizontal of 25° from the same starting position with the same original speed as the brushtail possum. It did not land at the same height on the tree trunk. Explain the difference in the two landing heights with the aid of a diagram and without calculations.

(picture from www.petinfo4u.com)

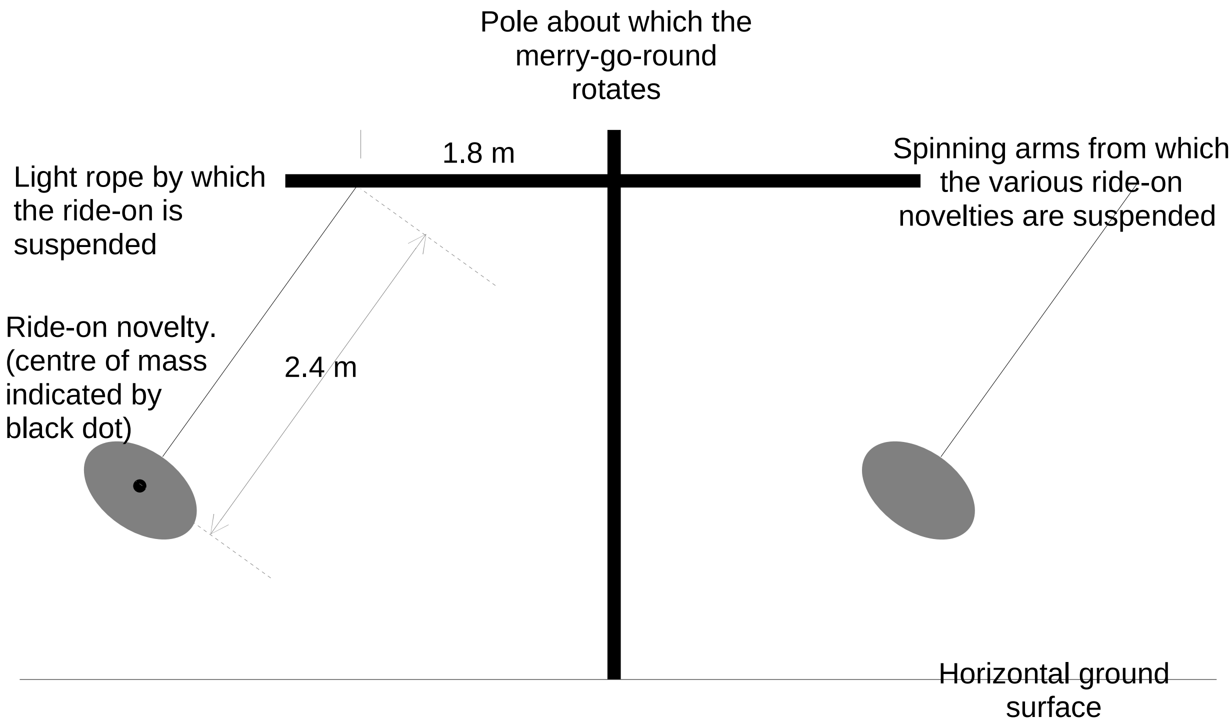
(3 marks)

Question 14 **(10 marks)**

Small merry-go-rounds, such as the one in the picture tend to whirl quite fast and the horses and other ride-on novelties on the which the children sit, tend to be flung outwards at an angle as the merry-go-round spins.

(picture from: http://www.activeattractions.com.au)

The diagram below may make the situation clearer.



a) If the merry-go-round is stationary:

i) What will be value of the angle ϴ?

(1 mark)

ii) What will be the tension in the light rope assuming the ride-on novelty is empty and has a mass of 60 kg?

(1 mark)

b) If the minimum safe value of the angle ϴ is 75°, what is the maximum safe speed of the empty ride-on novelty.

(3 marks)

c) What will be the period of rotation of the merry-go-round when the ride-on novelty is moving at the speed calculated in *part b* above?

(1 mark)

d) What will be the tension in the rope supporting the ride-on novelty when it is moving at the speed calculated in *part b* above?

(1 mark)

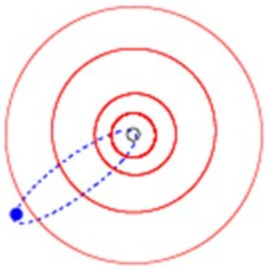
e) Explain without using calculations but making reference to the formulae you have used so far in this question, whether or not the maximum safe speed would be changed if a child sat in the empty novelty ride on.

(3 marks)

Question 15 **(14 marks)**

Halley's Comet is the best known of the comets that orbit the sun. The orbit of Halley's Comet is not a circle but is actually an ellipse. At its closest approach (perihelion) it is only 0.6 AU from the sun. At its greatest distance (aphelion) it is 35 AU from the sun.

Note :- 1 AU is the orbital distance of the earth from the sun (1.50×10^{11} m).



The elliptical orbit of Halley's Comet set against the background of the outer planet orbits.

a) Calculate the difference between the aphelion and perihelion distances in metres?
(3 marks)

b) What is the acceleration on Halley's Comet due to the sun at its perihelion and aphelion?
(4 marks)

c) The average orbital period of Halley's Comet is approximately 76 earth years. If Halley's comet was not a comet, but instead was a mass orbiting the sun in a circular orbit, at what distance from the sun would it need to orbit to have the same orbital period? State your answer in AU.

(4 marks)

d) When the comet in its elliptical orbit passes close by the sun, it heats up causing gases and water vapour to evaporate from its surface. This evaporation causes the comet to lose mass. Why does this have no effect on the period or acceleration of the satellite?

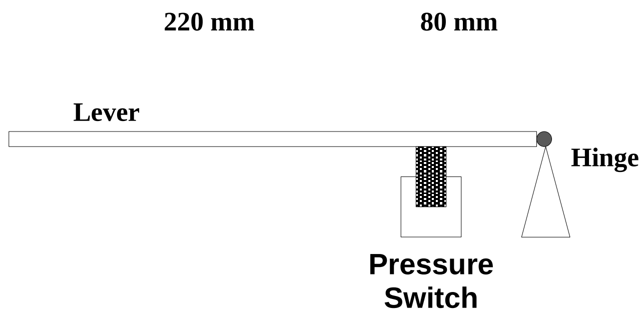
(2 marks)

e) The period of the comet over recorded history can vary between 74 and 79 years. What causes this variation?

(1 mark)

Question 16 **(9 marks)**

An engineer is designing a new water fountain for a park. The fountain has a pressure switch that is activated by a lever (metal bar) being pushed down.



a) The switch requires a downward force of 4.60 N from the bar to activate it. If the uniform bar has a mass of 400 g, will the weight of the bar be so heavy that it activates the switch without a person pushing on it?

(3 marks)

b) The engineer decides to insert a spring at the far end of the lever bar. The spring provides a force of 1.0 N upwards.

With the spring present, what is the force of the bar on the switch, if the bar is in equilibrium?

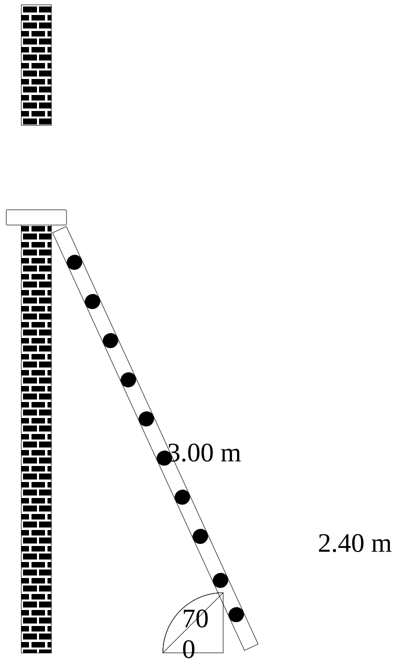
(3 marks)

c) A 300 g one legged bird now flies in and stands on the bar. At what position relative to the hinge should the bird stand to just switch on the fountain?

(3 marks)

Question 17 **(13 marks)**

A fireman is climbing a ladder to rescue someone from the first floor window above the ground floor of a two story house. All distances mentioned are measured along the length of the ladder. The 3.00 m ladder has a mass of 20.0 kg and makes an angle of 70.0^0 with the horizontal. The ladder is leant against the smooth wall near the first floor window The 80.0 kg fireman stands (positions his centre of mass) on a rung 2.40 m from the bottom of the ladder.



a) What is the force of the walll on the ladder?

(4 marks)

b) What is the force of the ground on the ladder?

(4 marks)

c) Because the ground at the bottom of the ladder has become wet (from the fire hose) the maximum value of friction between the base of the ladder and the ground is 500 N. If the fireman now is carrying a 50.0 kg person on their shoulder while standing at the 2.40 m mark, will the bottom of the ladder slip?

(5 marks)

Question 18 **(7 marks)**

A student on an excursion is about to walk down a 1.02 km long railway tunnel. The tunnel is circular and has a radius of 1.7 m. The student has a height of 1.7 m.

1.02 km

a) The student claps once at the start of the tunnel. How long will it take for the sound to reach the other end of the tunnel if the sound travels straight forward and does not bounce off the walls?

(2 marks)

b) If the sound from the clap bounces off the walls of the tunnel at 45.0^0 to the horizontal and is reflected down the tunnel in a zigzag pattern, how long will it take for the sound to reach the other end?

(3 marks)

c) What is the difference in time between the direct sound arriving and the zigzag sound arriving?

(1 mark)

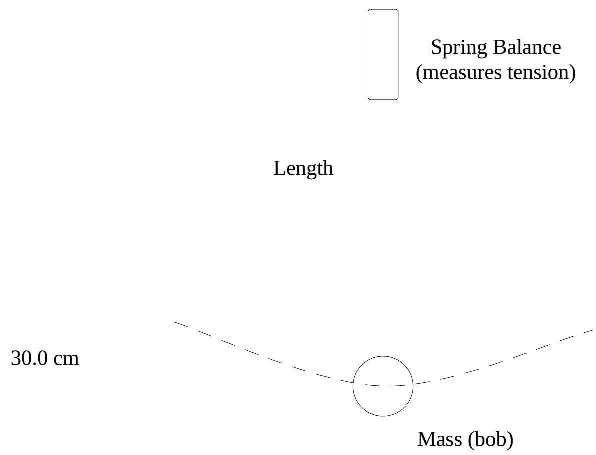
d) Will the sound as heard by a listener at the other end appear louder, softer or the same loudness as the original clap? Explain why.

(1 mark)

Question 19 **(12 marks)**

A physics student is investigating how altering the string length on a pendulum effects the tension in the pendulum string. The tension in the pendulum string is measured when the mass at the end of the string is at its lowest point in the swing. Regardless of the string length the mass is always swung from a height that is 30.0 cm above its lowest point. A diagram of the investigation setup is shown below.

Note - the mass at the bottom of the string is called a bob.



a) Using your knowledge of physics, write an equation that relates the tension in the string as the mass swings past its **lowest point** to the length of the string.

(1 mark)

b) What is the independent and dependent variable?

(1 mark)

Independent ______________________ Dependent ______________________

c) The data collected for different string lengths and tensions are in the table below. Manipulate the data in preparation for graphing a straight line. Complete all parts of the table.

(2 marks)

Trial	**Units**	**1**	**2**	**3**	**4**	**5**
String Length	**m**	**1.0**	**0.9**	**0.7**	**0.5**	**0.3**
Tension	**N**	**3.92**	**4.083**	**4.55**	**5.39**	**7.35**

d) Graph the manipulated data on the graph paper below.

(4 marks)

e) Calculate the slope of the line of best fit from the graph.

(3 marks)

g) What is the speed of the pendulum at the bottom of the string if the mass always falls through a distance of 30.0 cm?

(1 mark)

Section Three: Comprehension **20% (30 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 36 minutes.

Question 20 **(15 marks)**

Kessler Syndrome

(Paragraph 1)
The **Kessler syndrome** (also called the **Kessler effect**, **collisional cascading** or **ablation cascade**), proposed by NASA scientist Donald J Kessler in 1978, is a scenario in which the number of objects (satellites) in low earth orbit (LEO) is high enough that, if a collision between two satellites were to happen, the pieces of satellite debris would create a cascade or domino effect. In this cascade the debris would collide with other satellites creating more debris and increasing the likelihood of further collisions. The implications of this are that the distribution of debris in orbit could stop space exploration and make the use of satellites impossible until the debris eventually returned to earth or escapes orbit into space.

Debris generation and destruction

(Paragraph 2)
Every satellite, space probe, and manned mission has the potential to create space debris. As the number of satellites in orbit grows and old satellites become obsolete, the risk of a cascading Kessler syndrome becomes greater.

(Paragraph 3)
Fortunately, at the most commonly-used Low Earth Orbits, residual air drag helps keep the zones clear. Collisions that occur in low earth orbit are less of a problem. This it because the kinetic energy lost and change in direction would create an elliptical orbit. Elliptical orbits have radii of nearest approach (perigee) and furthest distance from (apogee) from earth. If the perigee is inside the outer edge of the earth's atmosphere, the debris will return to earth.

(Paragraph 4)
At altitudes above the levels where atmospheric drag is significant, the time required for orbital decay is much longer. Slight atmospheric drag, lunar perturbation, and solar wind drag can gradually bring debris down to lower altitudes where fragments finally re-enter, but at very high altitudes this can take 1000's of years.

Seriousness

(Paragraph 5)
The Kessler syndrome is especially insidious because of the "domino effect" and "feedback runaway". Any impact between two objects of sizable mass breaks off shrapnel debris from the force of collision. Each piece of shrapnel now has the potential to cause further damage, creating even more space debris. With a large enough collision or explosion (such as one between a space station and a defunct satellite, or the result of hostile actions in space), the amount of cascading debris could be enough to render low Earth orbit essentially impassable.

(Paragraph 6)
This process is similar to the critical mass phenomena of a neutron induced chain reaction with the exception that once a neutron clears the area containing fissionable atoms, the neutron does not return. In the Kessler scenario the space debris does return periodically.

Avoidance and reduction

(Paragraph 7)
To minimize the chances of damage to other vehicles, designers of a new vehicle or satellite are frequently required to demonstrate that it can be safely disposed of at the end of its life, for example by use of a controlled atmospheric re-entry system or a boost into a graveyard orbit.

(Paragraph 8)
One technology proposed to help deal with fragments from 1 cm to 10 cm in size is the laser broom, a proposed multi-megawatt land-based laser that could be used to target fragments. When the laser light hits a fragment, one side of the fragment would ablate (super heat and vaporise / boil), creating a thrust that would change the eccentricity (shape of orbit) of the remains of the fragment until it would re-enter harmlessly.

End of Article

Reference
http://en.wikipedia.org/wiki/Kessler_syndrome

Questions

1. As the result of a collision between two orbiting objects in space, the resulting debris will have a range of directions and speeds. Name the three types of orbits that the resulting pieces of debris could produce and draw the shapes of these orbits.

(3 marks)

2. Will any outward spirals be produced? Explain why or why not.

(2 marks)

3. Will all the debris entering the earth's atmosphere reach the ground? Explain.

(2 marks)

4. In the comparison between the neutron induced chain reaction and the Kessler syndrome (paragraph 8), why does the space debris return periodically when the neutrons do not.

(2 marks)

5. What factors other than collisions mentioned in the article can alter the shape of the orbit of a satellite / piece of space debris.

(3 marks)

6. Explain an advantage and disadvantage of letting an obsolete satellite re-enter the earth's atmosphere as compared to moving it to a graveyard orbit?

(3 marks)

	Advantage	Disadvantage
Re-enter		
Graveyard orbit		

Question 21 **(15 marks)**

Who Hits Harder: The Nordic Skier or Aerial Jumper?

(Paragraph 1)

Using physics you can calculate that the force (shocks) acting on a Freestyle Aerialist Jumper on landing is equivalent to a vertical drop of 6.1 m (20 feet) to a flat surface. This is over twice the landing force (shock) of a Nordic Jumper even though the Nordic Jumpers travel at twice the velocity and fall twice as far.

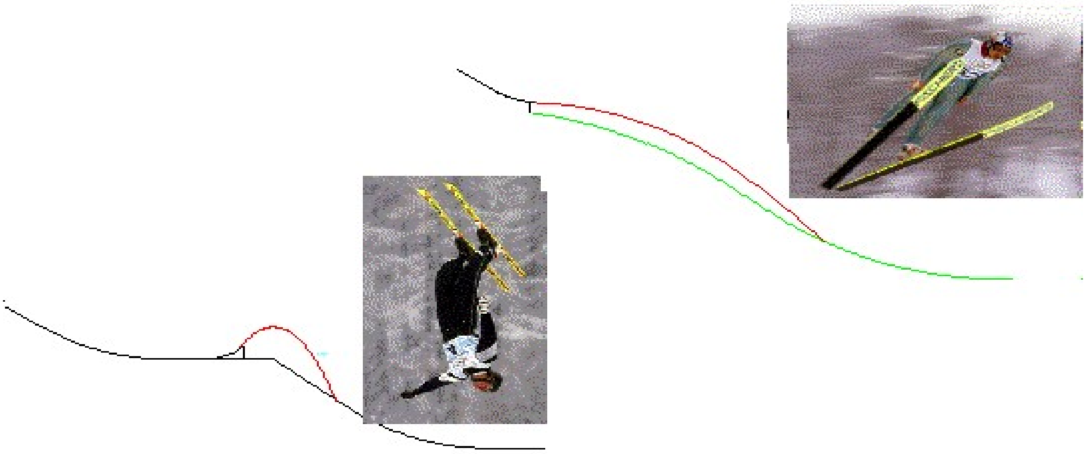


Figure 1: Freestyle Aerial jumper Eric Bergous (left) and Nordic jumper Masahiko Harada (right).

(Paragraph 2)

Introduction

In the winter Olympics, two types of skiers, Nordic Jumpers and Freestyle Aerialists, are known for their dazzling displays of aerial manoeuvres that most spectators find incredible and possibly dangerous. The Aerial Jumpers in the Freestyle Skiing competition perform very high leaps with twists and somersaults. The 1998 Olympic winner, Eric Bergous (Figure 1), executed three complete rotations with four twists. This required extensive time in the air, will have consequences on landing when gravity pulls him back to earth. At the Nordic Ski Jumps, Masahiko Harada (Figure 1), and Takanobu Okabe both flew 137 m (449 ft) in distance.

(Paragraph 3)

Competition drives the skiers to fly higher and farther to win the competition. The athletes risk falling upon impact. Fortunately, the Federation of International Skiing (FIS) has imposed rules on the designs of ski jumps to insure safety and minimize injuries. The FIS specifications for Freestyle Aerial jumps is shown in Figure 2.

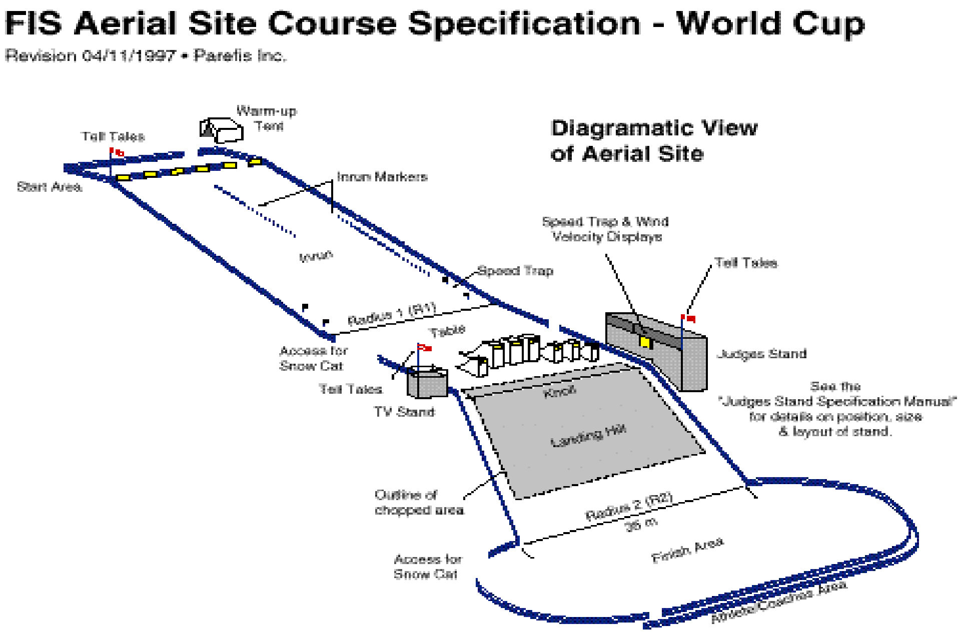


Figure 2: Federation of International Skiing specifications for Freestyle Aerial hills. Full details are available at http://www.zip.com.au/~birdman/FTP.html under “1997/98 Freestyle Course Standards”.

(Paragraph 4)
Computer Model of Skier’s Flight
Nordic ski jumping has been modelled by Muller et al. (1995 and 1996). They found that most jumpers have a very small impact on the landing hill equivalent to a vertical drop of < 1 m, even though they fly distances over 100 m (328 ft.) with vertical drops over 30 m (98 ft.). The Nordic skiers experience light landings because they are flying close to the hill which is shaped for their flight trajectory (Figure 1).

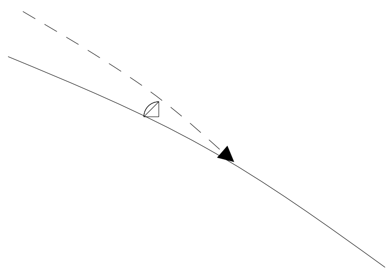


Figure 3: Diagram showing small angle of landing for Nordic ski jumping

(Paragraph 5)
The Freestyle Aerial Jumpers take off with a much higher trajectory to perform rotations and twists. Judges award points for the heights of the jumps along with the difficulty of the rotations and twists. Distance is not a factor in Aerial Jumping as it is in Nordic Jumping. They experience harder landing because the angle at which they strike the ground is larger as measured with the line of the hill.

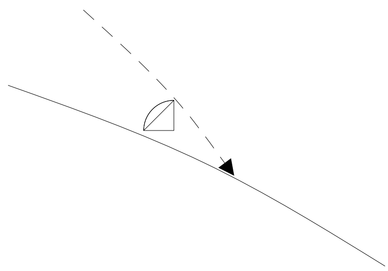


Figure 4: Diagram showing larger angle of landing for the Freestyle Aerial Jumper.

(Paragraph 6)
To answer the question, "How hard do the Freestyle Aerialists land?" a smaller version of the Muller model was used. The impact of a skier on the landing hill is not simply the vertical distance he/she drops because they land on a steep slope (~37°). The skier also does not stop on the hill. The impact the skier feels is the force it takes to change the skier's direction from their flight path to that of the slope of the hill. This is illustrated in Figure 5.

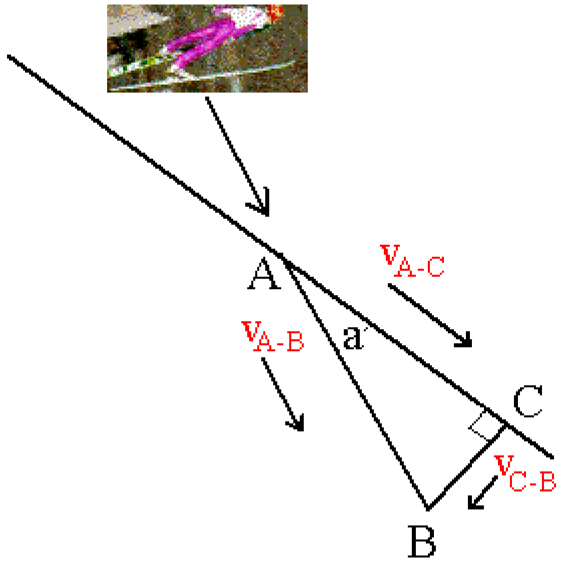


Figure 5: The skier approaches a landing at A, ravelling with an initial velocity toward B, but will abruptly change direction toward C on landing.

(Paragraph 7)
The skier's direction of motion just before landing is shown by the vector A-B. The hill has a slope from A-C. The skier's velocity (V_{A-B}) can be expressed as two orthogonal (right angle) components. The component along the hill is V_{A-C} whereas the other component is V_{C-B}. Upon impact, the skier's velocity will change from V_{A-B} to V_{A-C}. The change in direction is angle (a) and the velocity component V_{C-B} will be absorbed in the landing impact. The impact the skier feels is the dissipation of V_{C-B}.

(Paragraph 8)
Using the triangle in Figure 5, the skier's velocity component perpendicular to the face of the hill, V_{C-B}, can be calculated from the skier's velocity, V_{A-B}, and the change in direction (a).

$$V_{C-B} = V_{A-B}.\text{Sin (a)} \qquad (1)$$

(Paragraph 9)
The velocity of the skier is changed by the accelerations of the forces on the skier. Since the speed of the Aerial Jumper is relatively slow, aerodynamic lift and drag are not considered. However, Muller had to consider aerodynamic forces for the Nordic jumper because of the greater velocities (23-27 m/s or 51-57 mph).

(Paragraph 10)
For the Aerial jumper we know the location of the takeoff point and the inclination angle, but not the velocity. Aerial jumpers can choose their velocity by selecting any starting position on the take off ramp. They vary their velocity for the air time needed for their manoeuvres.

(Paragraph 11)
The largest takeoff kicker (ramp) for aerial skiing in Figure 6 has an inclination of 55° to the horizontal and is positioned 8.1 m back from the start of the landing slope, which has a constant pitch of 37° and is 25 m long.

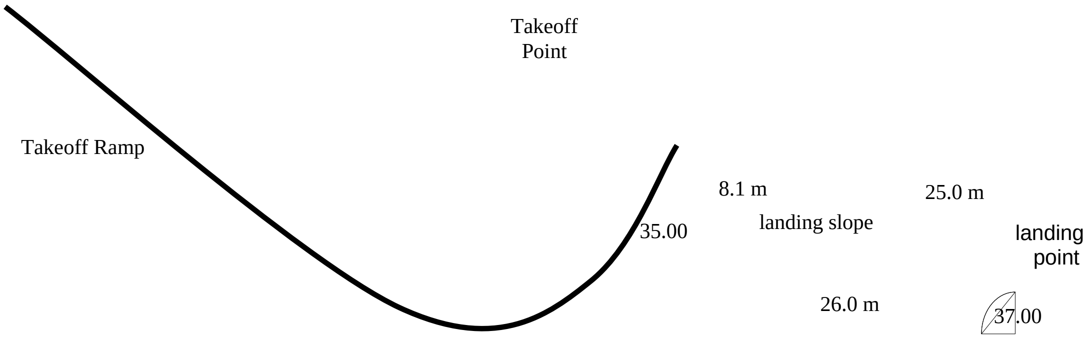


Figure 6: An aerial jump ramp

(Paragraph 12)
Muller converted the vector $V_{C\text{-}B}$ to an equivalent drop from a fictitious height to a flat surface so that comparisons could be made to other sports. The conversion takes the velocity of impact perpendicular to the slope and converts it to height using the law of conservation of energy.

(Paragraph 13)
Discussion
The Aerial jumper model shows landing impacts of 3.2-6.1 m (10-20 ft) in vertical drop whereas Nordic jumpers experience much smaller impacts of 0.6-2.4 m. A 20-foot fall could cause serious injury. It's about the height of the roof on a two-story house. However, Freestyle Aerial jumping has an exceptional record in that they have never had a debilitating injury in 22 years[1].

This article has been heavily edited but is closely based on the article …

By: Donald P Wylie, Space Science and Engineering Centre, University of Wisconsin-Madison, 1225 W. Dayton Street, Madison WI 53717 e-mail: don.wylie@ssec.wisc.edu

From: The PUMAS Collection http://pumas.jpl.nasa.gov

End of Article

1

Questions

1. Explain why Nordic skiers experience smaller landing forces than Aerial jumpers. Use diagrams to assist your explanation.

(2 marks)

2. In which type of jump is air resistance more significant? Explain why.

(2 marks)

3. An aerial jumper takes off from the top of a ramp with a velocity of 12.5 m/s. What is the minimum height from which the aerial jumper must start on the takeoff ramp to reach this takeoff velocity?

(3 marks)

4. If an aerial ski jumper leaves the top of the kicker (ramp) at an angle of 55.0^0 degrees to the horizontal with a speed of 12.5 m/s and lands at a horizontal distance of 26.0 m from the takeoff point, what is the time of flight of the jumper?

(2 marks)

5. What is the maximum height of the jumper above the kicker (ramp)?

(3 marks)

6. What is the landing height of the skier relative to the take off point?

(3 marks)

End of Exam

Additional working space

Additional working space

Additional working space

Additional working space

Semester One Examination, 2011

Question/Answer Booklet

3AB PHYSICS

Answers

Student Number: In figures

In words

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.

	Section 1	**Section 2**	**Section 3**	**Total**
Score				
Out of	45	75	30	150
%				

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 response	12	12	54	45	30
Section Two: Problem-solving	7	7	90	75	50
Section Three: Comprehension	2	2	36	30	20
					100

Instructions to candidates

1. The rules for the conduct of Curriculum Council examinations are detailed in the *Student Information Handbook.* 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.

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% (45 marks)

This section has **12** 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.
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.

Suggested working time for this section is 54 minutes.

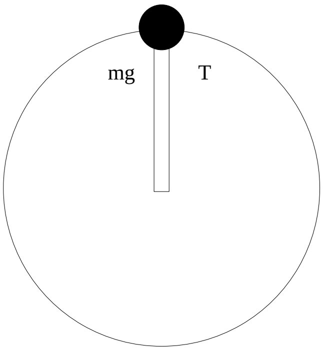
Question 1 (3 marks)

A student is flicking peas with a spoon from their table to another table in the school cafeteria. The peas have to travel a distance of 3.00 m horizontally (between tables) and land at the same height from which they took off. They are launched at an angle of 30.0 ^{0} to the vertical with a speed of 5.83 m s^{-1}. What is the time of flight?

Vertical	Horizontal
u_v = 5.83 Cos 30 = 5.0515 m/s v = u + at -5.0515 = 5.0515 + (-9.8) t -10.1031 / -9.8 = t **t = 1.03 s**	

Question 2 **(5 marks)**

A 300 g ball is being swung around in a vertical circle on the end of a mass-less stick of length 45.0 cm.



a) If the ball on the end of the stick is travelling at 5.60 m/s at the bottom of the loop, what is the velocity at the top?

(2 marks)

$\frac{1}{2}$ m u^2 = mgh + $\frac{1}{2}$ m v^2
$\frac{1}{2}$ u^2 = gh + $\frac{1}{2}$ v^2
0.5 x 5.6^2 = 9.8 x 0.9 + 0.5 x v^2
15.68 = 8.82 + 0.5 x v^2
6.86 = 0.5 x v^2

v = 3.70 m/s

b) What is the magnitude and direction of the force acting on the ball by the stick at the top of the loop?

(3 marks)

Draw forces on ball

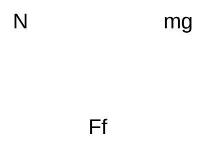
- mg + - T = - mv^2 / r
(0.3 x 9.8) + T = 0.3 x 3.7^2 /0.45
2.94 + T = 9.1266666

T = 6.186 N

Question 3 **(3 marks)**

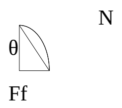
a) What is the angle of lean on a 75.0 kg runner travelling around a 10.0 m diameter curve at 2.80 m s^{-1}?

(2 marks)



Vertical	Horizontal
-mg + N = 0 mg = N 75 x 9.8 = N **N = 735 N**	$F_f = mv^2/r$ $F_f = 75 \times 2.8^2/5$ **F_f = 117.6 N**

Form triangle and find angle



Tan θ = N / F_f
θ = ArcTan (735/117.5)

θ = 80.9^0

b) If the maximum value of static friction between the shoes of the runner and the road is 100 N, will they be able to successfully round the bend? Explain.

(1 mark)

The reaction required is 117.6 N.

The friction available is only 100 N.

The runner will not be able to round the bend.

Question 4 **(3 marks)**

What is the ratio of the strength of gravity on Mars as compared to the strength of gravity on Earth, if the mass of Mars is 0.107 times that of Earth and the radius of Mars is 0.533 times that of Earth?

$g_{mars} = G\ m_m / r^2$

$g_{mars} = 6.67 \times 10^{11} \times 5.98 \times 10^{24} \times 0.107 / (6.37 \times 10^6 \times 0.533)^2$

$g_{mars} = 3.70\ m/s^2$

$g_{mars} : g_{earth}$

3.70 : 9.8 **or** **0.377 : 1**

Question 5 **(4 marks)**

If the circumference of the orbit of Mercury is 3.64×10^{11} m, what is the period of Mercury's orbit in Earth years?

Kepler's Law

Circumference = $2\pi r$
$3.64 \times 10^{11} = 2 \times 3.142 \times r$
$r = 5.79 \times 10^{10}$ m

$r^3 / T^2 = Gm/4\pi^2$

$(5.79 \times 10^{10})^3 / T^2 = 6.67 \times 10^{-11} \times 1.99 \times 10^{30} / 4\pi^2$

$1.94 \times 10^{32} / T^2 = 3.361 \times 10^{40}$

$1.94 \times 10^{32} / 3.361 \times 10^{18} = T^2$

$T^2 = 5.772 \times 10^{13}$

$T = 7.60 \times 10^6$ s

1 earth year = 60x60x24x365 = 31536000 s

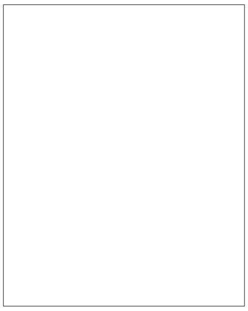
$7.60 \times 10^6 / 31536000$

T = 0.241 earth years

Question 6 **(5 marks)**

a) A piece of A4 paper has a length of 297 mm and a width of 210 mm. What is the vertical and horizontal location of the centre of mass of the piece of paper?

(1 mark)

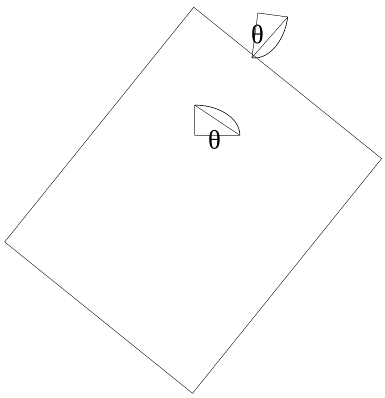


Vertical = 0.297 / 2
Vertical = 0.149 m

Horizontal = 0.210 / 2
Horizontal = 0.105 m

b) The piece of A4 paper is pinned to the wall by its top left corner and set swinging. When the paper comes to rest, what is the angle formed between the shortest edge of the paper and the horizontal. Hint: a diagram may assist your calculation.

(2 marks)



Tan θ = 0.105 / 0.149

θ = ArcTan (0.105 / 0.149)

θ = 35.2^0

c) Is the paper hanging from the pin in stable, unstable or neutral equilibrium? Explain.

(2 marks)

Stable Equilibrium   Unstable Equilibrium   Neutral Equilibrium   Please Circle One

Explanation

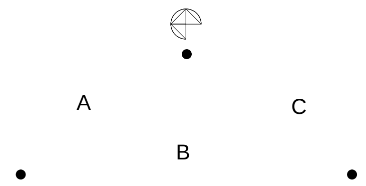
When nudged centre of mass rises.
After being nudged, the object returns to its original position.

Question 7 **(4 marks)**

A triangular coat hanger is hung on a rail. Each of the members (sides) of the triangle is weightless but the bolts that hold the sides together are not.

a) State whether the members that make up the hanger are under tension, compression or both.

(3 marks)



Member	Tension , Compression , Both
A	Tension
B	Compression (allow both)
C	Tension

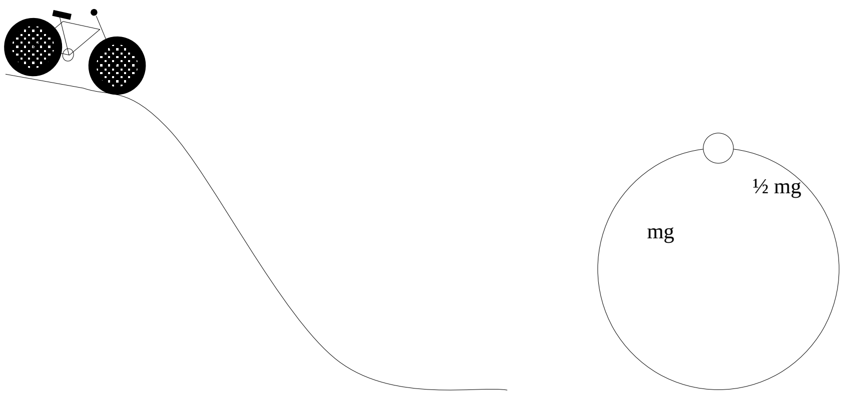
b) Which member(s) of the hanger could be replaced with string if it is to retain its shape?

(1 mark)

A and C

Question 8 **(4 marks)**

A cyclist has offered to do a stunt for charity. She will roll down a ramp on a bike and do a roller coaster loop the loop without falling off the bike. The combined mass of the bike and cyclist is 80.0 kg. The centre of mass of the combined bike and person will execute a loop of radius of 2.00 m. If the rider does not peddle, from what height ramp should the cyclist descend if the top of the loop is to exert a force on the cyclist equal to half the combined weight of the cyclist and bike?



$\Sigma F = mv^2 / r$

$- mg + - ½ mg = -mv^2 / r$
$- 1.5mg = -mv^2 / r$
$1.5g = v^2 / r$
$v = (1.5 \times 9.8 \times 2)^{1/2}$

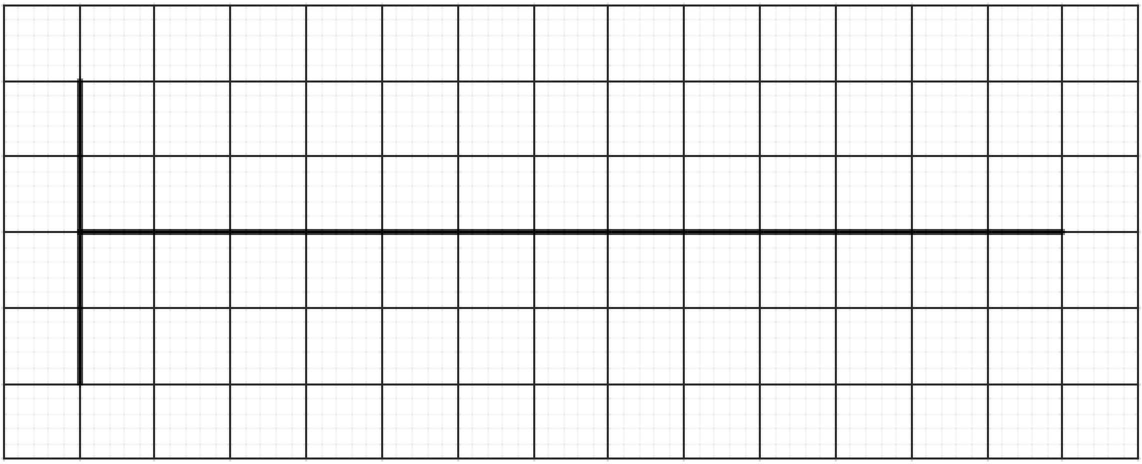
$v = 5.42$ m/s

$½ mv^2 + mgh = mgh$
$½ v^2 + gh = gh$
$0.5x5.42^2 + 9.8x4 = 9.8xh$
$14.6882 + 39.2 = 9.8h$
$53.8882 / 9.8 = h$

$h = 5.50$ m

Question 9 **(3 marks)**

Sketch a graph of musical sound that gets louder and lower as time progresses. Be sure to label the axis.



Question 10 **(4 marks)**

a) What is the period of a light wave that has a wavelength of 2.7 nm?

(3 marks)

$c = \lambda \times f$

$3 \times 10^{8} = 2.7 \times 10^{-9} \times f$

$\mathbf{f = 1.11111 \times 10^{17}}$

$T = 1/f$

$\mathbf{T = 9 \times 10^{-18}\ s}$

b) If a sound travelling in air had the same period as the light wave from part a), would it be audible to the human ear?

(1 mark)

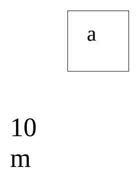
Yes No Please circle one only

$1.111 \times 10^{17} > 2.0 \times 10^{4}$ Hz which is the upper limit of human hearing.

Question 11 **(3 marks)**

a) Calculate how long will it will take an iceblock to fall 10.0 m vertically downwards from a stationary start?

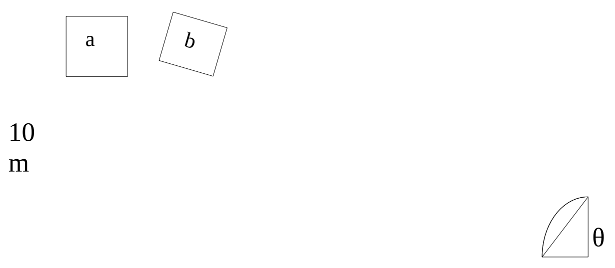
(1 mark)



$s = ut + ½ at^2$
$-10 = ½ -9.8 \times t^2$
$t = 1.43$ s

b) An identical iceblock is now put at the top of a uniform frictionless slope of the same height. At what angle relative to the horizontal should the slope be set so the ice block takes twice as long as that calculated in part a) to reach the bottom by sliding down the slope.

(2 marks)

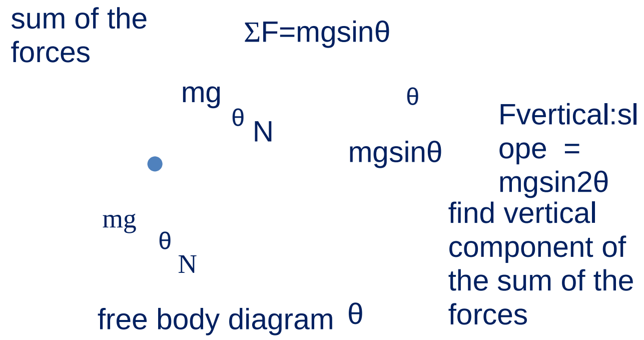


$t_{slope} = 2 \times t_v$

=> $a_{vertical:slope} = ¼ \times a_v$ where $a_{vertical:slope}$ is the vertical acceleration of the block as it slides down the slope and a_v is the acceleration of the ice block falling vertically.
(because $s = ½at^2 \Rightarrow a \propto 1/t^2$ for constant s and the time taken for the block sliding down the slope is also the time it takes for the vertical component of that slide)

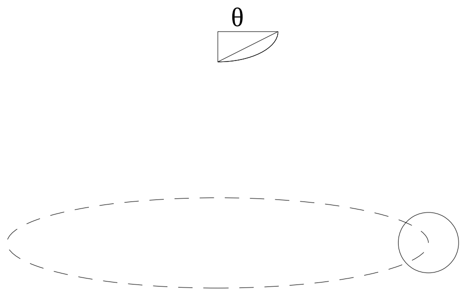
=> $F_{vertical:slope} = ¼ \times F_v$ where the forces are those corresponding to the accelerations above

=> $F_{vertical:slope} = ¼ \times mg$
=> $mg\sin^2\theta = ¼ \times mg$
=> $\sin^2\theta = ¼$
=> $\sin\theta = ½$
=> $\theta = \sin^{-1}0.5 = 30°$

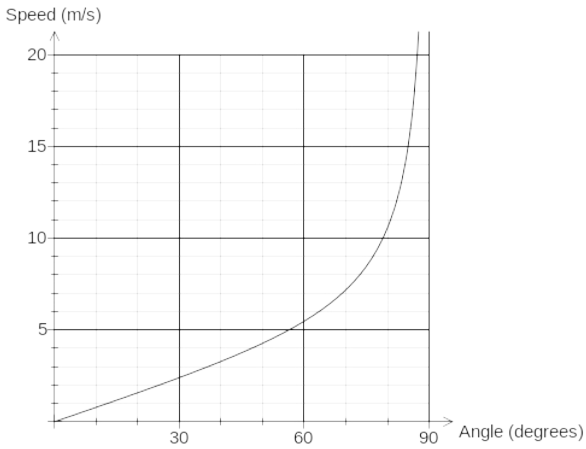


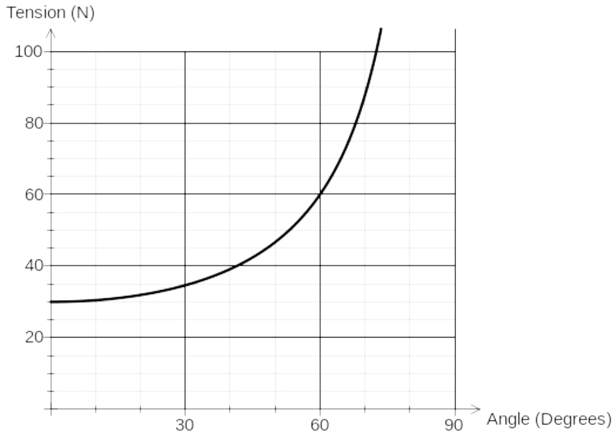
Question 12 **(4 marks)**

A ball is swung in a horizontal circle at different speeds in a gravitational field of 10.0 m s^{-2}. The angle the string forms with the vertical and the tension in the string are recorded.



Graphs of this information are shown below.





a) What is the mass of the ball?

(2 marks)

In Graph 2 when the angle is zero the tension is just the weight of the ball.

mg = 30
m x 10 = 30
m = 3 kg

b) What is the length of the string?

(2 marks)

T_h = 60 Sin 60 = 52 N

T_h = mv^2/l Sin 60
52 = $3x5.5^2$/l Sin 60
l = 3 x 5.5^2 / 52 Sin 60
2.02 m

60 30

Th

End of Section One

Section Two : Problem-Solving **50% (75 Marks)**

This section has **seven (7)** 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.
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.

Suggested working time for this section is 90 minutes.

Question 13 (10 marks)

Brushtail possums live in trees and often jump between them. They can jump with an initial velocity of 4.2 m s^{-1}. They are sufficiently streamlined and move with sufficiently low velocities that it is reasonable to ignore air resistance when calculating their motion.

(picture from: www.wildlifetasmania.com)

a) What is the greatest height above its starting point that a brushtail possum can reach when it jumps.

(2 marks)

$v^2 = u^2 + 2as$
$0 = 4.2^2 + 2x\text{-}9.8 \times s$
$-17.64 = -19.6\ s$

s = 0.9 m up

b) What is the greatest horizontal distance that the brushtail possum can jump assuming it takes off and lands at the same height? State any assumptions made in this calculation.

(3 marks)

The greatest distance will be achieved based on an angle of 45.0^0 assuming no air resistance.

Vertical	Horizontal
$u_v = 4.2 \text{ Sin } 45^0 = 2.97$ m/s $v = u + at$ $-2.97 = 2.97 + -9.8t$ $-5.94 / -9.8 = t$ **t = 0.606 s**	$u_h = 4.2 \text{ Cos } 45^0 = 2.97$ m/s $u = s/t$ $2.97 = s / 0.606$ **s = 1.80 m horizontally**

c) A brushtail possum was on a branch of a tree 23 m above the forest floor. It decided to jump across to an adjacent tree trunk 0.9 m away measured horizontally. It jumped upwards at an angle to the horizontal of 25° at 4.2 m s^{-1}. Where on the tree trunk would it land?

(2 marks)

Vertical	**Horizontal**
$u_v = 4.2 \sin 25^0 = 1.775$ m/s $s = ut + \frac{1}{2} at^2$ $s = (1.775 \times 0.2365) + (0.5 \times -9.8 \times 0.2365^2)$ **s = 0.146 m** **s = 23.146 m**	$u_h = 4.2 \cos 25^0 = 3.806$ m/s $u = s/t$ $3.806 = 0.9 / t$ **t = 0.2365 s**

d) A sugar glider (illustrated) is also a tree dweller. It has flaps of skin between its limbs that act like a parachute. One followed the brushtail possum, also leaping initially upwards at an angle to the horizontal of 25° from the same starting position with the same original speed as the brushtail possum. It did not land at the same height on the tree trunk. Explain the difference in the two landing heights with the aid of a diagram and without calculations.

(picture from www.petinfo4u.com)

(3 marks)

The Brush Tail Possum will have a parabolic symmetrical pathway

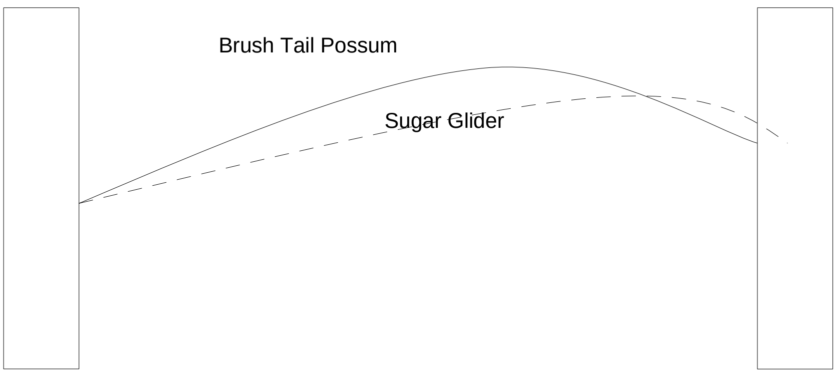
The Sugar Glider will have an asymmetrical pathway because of air resistance.

Both diagrams superimposed and correct = 1 mark

Not superimposed but both present = ½ marks

Cross sectional area has an effect = 1 mark

The cross sectional area has a stronger effect in the vertical than the horizontal because areas is different viewed horizontally as compared to vertically. = 1 mark

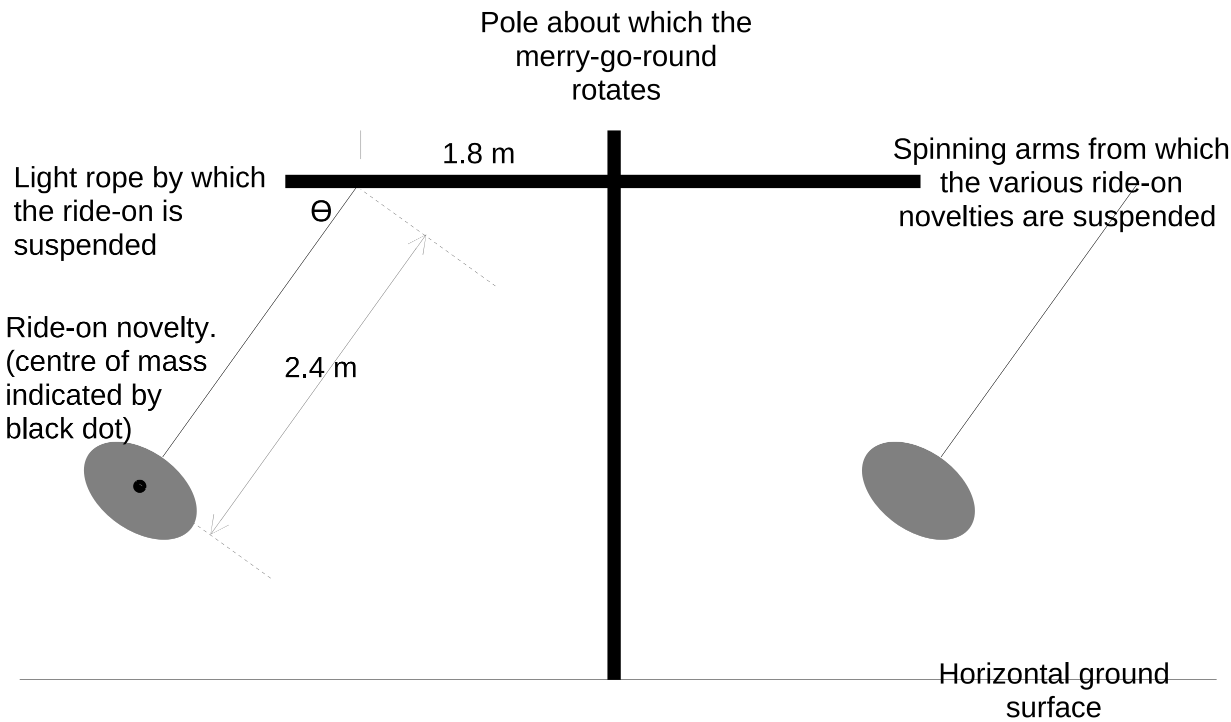


Question 14 **(10 marks)**

Small merry-go-rounds, such as the one in the picture tend to whirl quite fast and the horses and other ride-on novelties on which the children sit, tend to be flung outwards at an angle as the merry-go-round spins.

(picture from: http://www.activeattractions.com.au)

The diagram below may make the situation clearer.



a) If the merry-go-round is stationary:

i) What will be value of the angle ϴ?

(1 mark)

90.0 degrees

ii) What will be the tension in the light rope assuming the ride-on novelty is empty and has a mass of 60 kg?

(1 mark)

T = mg
T = 60 x 9.8
T = 588 N

b) If the minimum safe value of the angle ϴ is 75°, what is the maximum safe speed of the empty ride-on novelty.

(3 marks)

Vertical	Horizontal
$-mg + T_v = 0$ $T_v = 588$	$T_h = mv^2 / r$ From force triangle below $T_h = 157.55 = mv^2 / r$ From the distance triangle below $157.55 = mv^2 / 2.421$ $157.55 = 60\ v^2 / 2.421$ **v = 2.52 m/s**

Tv = 588N

2.4 m

750

750

Th

x

Tan 75 = 588 / T_h **T_h = 157.55 N**	Cos 75 = x / 2.4 m 2.4 x Cos 75 = x x = 0.621 m Distance to centre of circle = 0.621 + 1.8 **= 2.421 m**

c) What will be the period of rotation of the merry-go-round when the ride-on novelty is moving at the speed calculated in *part b* above?

(1 mark)

$v = 2\pi r / T$
$2.52 = 2 \times \pi \times 2.421 / T$
T = 6.037 s

d) What will be the tension in the rope supporting the ride-on novelty when it is moving at the speed calculated in *part b* above?

(1 mark)

By Trig …
Sin 75 = 588 / T

T = 609 N along the string

e) Explain without using calculations but making reference to the formulae you have used so far in this question, whether or not the maximum safe speed would be changed if a child sat in the empty novelty ride on.

(3 marks)

The child's mass will have no effect if the centre of mass of the ride is not altered this is because the angle is determined by …

Tan $\theta = r\ g / v^2$ and mass is not a term.

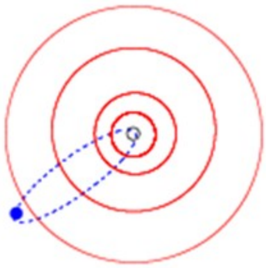
Tan $\theta = (2.4 \cos 75 + 1.8) \times g / v^2$

If the height of the centre of mass alters then r will alter and so yes it could have an effect.

Question 15 (14 marks)

Halley's Comet is the best known of the comets that orbit the sun. The orbit of Halley's Comet is not a circle but is actually an ellipse. At its closest approach (perihelion) it is only 0.6 AU from the sun. At its greatest distance (aphelion) it is 35 AU from the sun.

Note :- 1 AU is the orbital distance of the earth from the sun (1.50×10^{11} m).



The elliptical orbit of Halley's Comet set against the background of the outer planet orbits.

a) Calculate the difference between the aphelion and perihelion distances in metres?

(3 marks)

Method 1	Method 2
difference = 35 – 0.6 difference = 34.4 AU difference in metres = $34.4 \times 1.5 \times 10^{11}$ m **Difference = 5.16×10^{12} m**	$35 \times 1.5 \times 10^{11} = 5.25 \times 10^{12}$ m $0.6 \times 1.5 \times 10^{11} = 9.00 \times 10^{10}$ m $5.25 \times 10^{12} - 9.00 \times 10^{10}$ = difference **Difference = 5.16×10^{12} m**

b) What is the acceleration on Halley's Comet due to the sun at its perihelion and aphelion?

(4 marks)

Perihelion = 0.6 AU	**Aphelion = 35 AU**
$a = G\ m / r^2$ $a = 6.67 \times 10^{11} \times 1.99 \times 10^{30} / (0.6 \times 1.5 \times 10^{11})^2$ **$a = 1.63 \times 10^{-2}$ m s^{-2} (towards the sun)**	$a = G\ m / r^2$ $a = 6.67 \times 10^{11} \times 1.99 \times 10^{30} / (35 \times 1.5 \times 10^{11})^2$ **$a = 4.81 \times 10^{-6}$ m s^{-2} (towards the sun)**

c) The average orbital period of Halley's Comet is approximately 76 earth years. If Halley's comet was not a comet, but instead was a mass orbiting the sun in a circular orbit, at what distance from the sun would it need to orbit to have the same orbital period? State your answer in AU.

(4 marks)

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

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

$$r^3 = \frac{6.67 \times 10^{-11} \times 1.99 \times 10^{30} \times (76 \times 365 \times 24 \times 3600)^2}{4\pi^2}$$

$$r^3 = \frac{6.67 \times 10^{-11} \times 1.99 \times 10^{30} \times (2.396736000 \times 10^9)^2}{4\pi^2}$$

$$r^3 = \frac{1.327 \times 10^{20} \times 5.7443 \times 10^{18}}{4\pi^2}$$

$$r^3 = 1.930 \times 10^{37}$$

$r = 2.683 \times 10^{12}$ m

$r = 2.683 \times 10^{12} / 1.5 \times 10^{11}$

r (AU) = 17.88 AU

d) When the comet in its elliptical orbit passes close by the sun, it heats up causing gases and water vapour to evaporate from its surface. This evaporation causes the comet to lose mass. Why does this have no effect on the period or acceleration of the satellite?

(2 marks)

The mass of the satellite does not appear in Kepler's Law.

Kepler's is only dependent on the mass of the sun, the orbital radius and the orbital period.

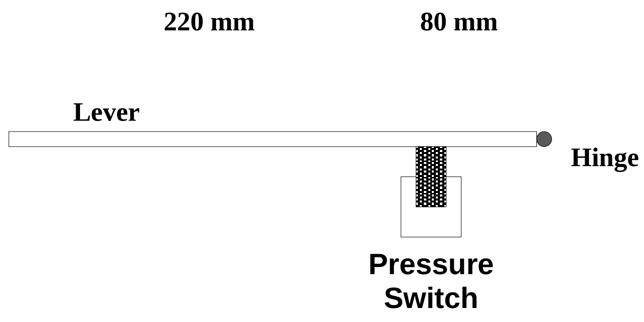
e) The period of the comet over recorded history can vary between 74 and 79 years. What causes this variation?

(1 mark)

The gravitational pull of other planets alter the period of the comet.

Question 16 **(9 marks)**

An engineer is designing a new water fountain for a park. The fountain has a pressure switch that is activated by a lever (metal bar) being pushed down.



a) The switch requires a downward force of 4.60 N from the bar to activate it. If the uniform bar has a mass of 400 g, will the weight of the bar be so heavy that it activates the switch without a person pushing on it?

(3 marks)

Compare clock an anti moments
Σ Mc = 0.08 x 4.6 = 0.368 Nm Clockwise or more is required to activate the switch.

Σ Ma = 0.4 x 9.8 x 0.3/2 = 0.588 Nm is created by the mass of the bar.

The Torque of the bar is greater than that required for activation, hence the fountain switches on.

b) The engineer decides to insert a spring at the far end of the lever bar. The spring provides a force of 1.0 N upwards.

With the spring present, what is the force of the bar on the switch, if the bar is in equilibrium?

(3 marks)

Σ Mc = Σ Ma
(0.08 x F) + (1 x 0.3) = (0.4 x 9.8 x 0.3/2)
0.08F + 0.3 = 0.588
0.08F = 0.588 - 0.3
0.08F = 0.288
F = 3.6 N

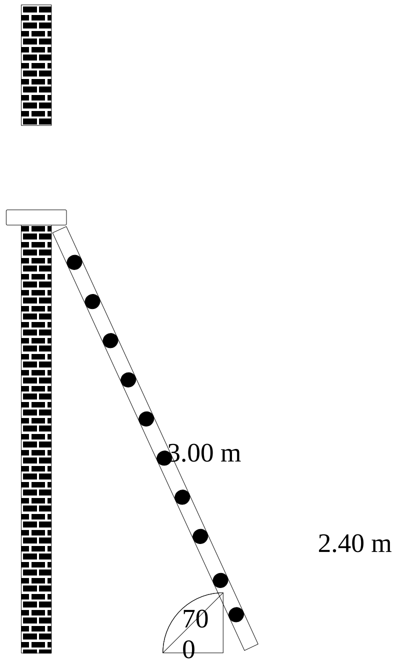
c) A 300 g one legged bird now flies in and stands on the bar. At what position relative to the hinge should the bird stand to just switch on the fountain?

(3 marks)

Σ Mc = Σ Ma
(0.08 x 4.6) + (1 x 0.3) = (0.4 x 9.8 x 0.3/2) + (X x 0.3 x 9.8)
0.368 + 0.3 = 0.588 + 2.94X
0.08 = 2.94X
X = 0.0272 m

Question 17 **(13 marks)**

A fireman is climbing a ladder to rescue someone from the first floor window above the ground floor of a two story house. All distances mentioned are measured along the length of the ladder. The 3.00 m ladder has a mass of 20.0 kg and makes an angle of 70.0^0 with the horizontal. The ladder is leant against the smooth wall near the first floor window The 80.0 kg fireman stands (positions his centre of mass) on a rung 2.40 m from the bottom of the ladder.



a) What is the force of the wall on the ladder?

(4 marks)

Σ Mc = Σ Ma

Using Method 2
3 Sin 70 x W = (20 x 9.8 x ½ x 3 Cos 70) + (80 x 9.8 x 2.4 Cos 70)

2.819 x W = (196 x 0.513) + (784 x 0.821)

2.819 x W = (100.548) + (643.664)

W = (744.21) / 2.819

W = 264 N

b) What is the force of the ground on the ladder?

(4 marks)

Σ F up = Σ F down

(20 x 9.8) + (80 x 9.8) = N
N = 980 N

Σ F left = Σ F right

Friction = W
Friction = 264 N

264 N

980 N

θ

Resultant = square root of ($980^2 + 264^2$)
Resultant = 1015 N

Angle
Tan θ = 264 / 980
θ = 15.1 ^{0}

Answer = 1015 up 15.1 Right.

c) Because the ground at the bottom of the ladder has become wet (from the fire hose) the maximum value of friction between the base of the ladder and the ground is 500 N. If the fireman now is carrying a 50.0 kg person on their shoulder while standing at the 2.40 m mark, will the bottom of the ladder slip?

(5 marks)

Take moment about base of ladder

Σ Mc = Σ Ma

Using Method 2
3 Sin 70 x W = (20 x 9.8 x ½ x 3 Cos 70) + (80 x 9.8 x 2.4 Cos 70)

W = (20 x 9.8 x ½ x 3 Cos 70) + ([80 + 50] x 9.8 x 2.4 Cos 70) / (3 Sin 70)
W = (100.55 + 1045.76) / 2.819

W = 406.63 N

406.63 is less than 500 and so will not slip. They are ok

Question 18 **(7 marks)**

A student on an excursion is about to walk down a 1.02 km long railway tunnel. The tunnel is circular and has a radius of 1.7 m. The student has a height of 1.7 m.

1.02 km

a) The student claps once at the start of the tunnel. How long will it take for the sound to reach the other end of the tunnel if the sound travels straight forward and does not bounce off the walls?

(2 marks)

v = s / t
346 = 1020 / t
t = 1020 / 346
t = 2.95 s

b) If the sound from the clap bounces off the walls of the tunnel at 45.0^0 to the horizontal and is reflected down the tunnel in a zigzag pattern, how long will it take for the sound to reach the other end?

(3 marks)

New distance travelled is 1020 / sin 45 or cos 45 = 1442.497

v = s / t
346 = 1442.497 / t
t = 1442.497 / 346
t = 4.17 s

c) What is the difference in time between the direct sound arriving and the zigzag sound arriving?

(1 mark)

4.17 – 2.95 = **1.22 s**

d) Will the sound as heard by a listener at the other end appear louder, softer or the same loudness as the original clap? Explain why.

(1 mark)

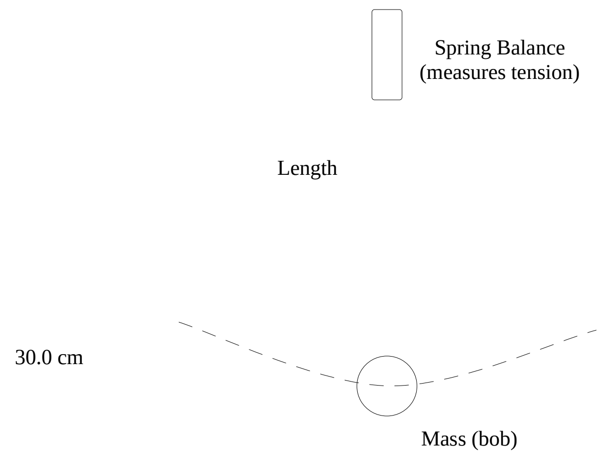
Softer

The same amount of energy is being delivered over a longer time, so the volume has been reduced.

Question 19 **(12 marks)**

A physics student is investigating how altering the string length on a pendulum effects the tension in the pendulum string. The tension in the pendulum string is measured when the mass at the end of the string is at its lowest point in the swing. Regardless of the string length the mass is always swung from a height that is 30.0 cm above its lowest point. A diagram of the investigation setup is shown below.

Note - the mass at the bottom of the string is called a bob.



a) Using your knowledge of physics, write an equation that relates the tension in the string as the mass swings past its **lowest point** to the length of the string.

(1 mark)

$(+T) + (-mg) = +mv^2 / R$

$T = mv^2 / R + mg$

b) What is the independent and dependent variable?

(1 mark)

Independent Length Dependent Tension

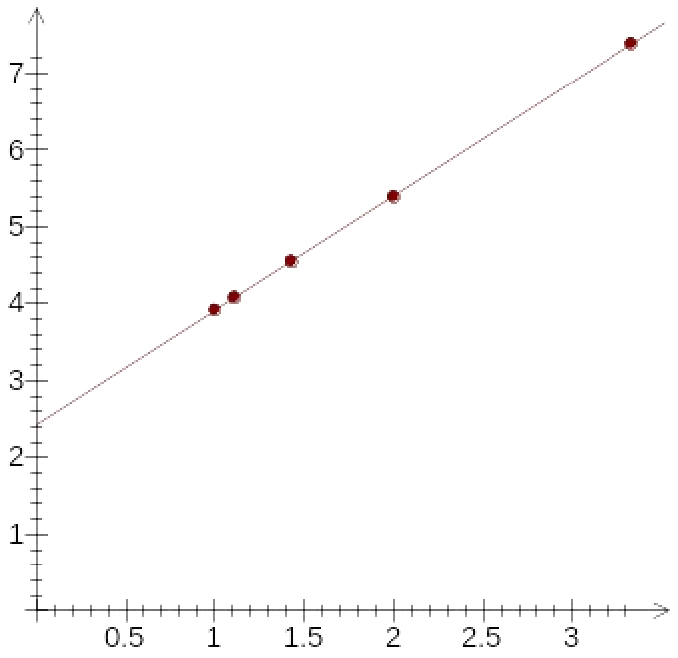
c) The data collected for different string lengths and tensions are in the table below. Manipulate the data in preparation for graphing a straight line. Complete all parts of the table.

(2 marks)

Trial	**Units**	**1**	**2**	**3**	**4**	**5**
String Length	**m**	**1.0**	**0.9**	**0.7**	**0.5**	**0.3**
Tension	**N**	**3.92**	**4.083**	**4.55**	**5.39**	**7.35**
1 / R	**m^{-1}**	**1.00**	**1.111**	**1.429**	**2.00**	**3.333**

d) Graph the manipulated data on the graph paper below.

(4 marks)



e) Calculate the slope of the line of best fit from the graph.

(3 marks)

Slope = Rise / Run

M = 1.48742958 (slope) based on computer calculation.

g) What is the speed of the pendulum at the bottom of the string if the mass always falls through a distance of 30.0 cm?

(1 mark)

$mgh = ½ m v^2$
$gh = ½ v^2$
$9.8 \times 0.3 = 0.5 \times v^2$
$2.94 \times 2 = v^2$
$v = 2.42$ m/s

Section Three: Comprehension **20% (30 Marks)**

This section contains **two (2)** questions. You must answer both 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.
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.

Suggested working time for this section is 36 minutes.

Question 20 **(15 marks)**

Kessler Syndrome

(Paragraph 1)
The **Kessler syndrome** (also called the **Kessler effect**, **collisional cascading** or **ablation cascade**), proposed by NASA scientist Donald J Kessler in 1978, is a scenario in which the number of objects (satellites) in low earth orbit (LEO) is high enough that, if a collision between two satellites were to happen, the pieces of satellite debris would create a cascade or domino effect. In this cascade the debris would collide with other satellites creating more debris and increasing the likelihood of further collisions. The implications of this are that the distribution of debris in orbit could stop space exploration and make the use of satellites impossible until the debris eventually returned to earth or escapes orbit into space.

Debris generation and destruction

(Paragraph 2)
Every satellite, space probe, and manned mission has the potential to create space debris. As the number of satellites in orbit grows and old satellites become obsolete, the risk of a cascading Kessler syndrome becomes greater.

(Paragraph 3)
Fortunately, at the most commonly-used Low Earth Orbits, residual air drag helps keep the zones clear. Collisions that occur in low earth orbit are less of a problem. This it because the kinetic energy lost and change in direction would create an elliptical orbit. Elliptical orbits have radii of nearest approach (perigee) and furthest distance from (apogee) from earth. If the perigee is inside the outer edge of the earth's atmosphere, the debris will return to earth.

(Paragraph 4)
At altitudes above the levels where atmospheric drag is significant, the time required for orbital decay is much longer. Slight atmospheric drag, lunar perturbation, and solar wind drag can gradually bring debris down to lower altitudes where fragments finally re-enter, but at very high altitudes this can take 1000's of years.

Seriousness

(Paragraph 5)
The Kessler syndrome is especially insidious because of the "domino effect" and "feedback runaway". Any impact between two objects of sizable mass breaks off shrapnel debris from the force of collision. Each piece of shrapnel now has the potential to cause further damage, creating even more space debris. With a large enough collision or explosion (such as one between a space station and a defunct satellite, or the result of hostile actions in space), the amount of cascading debris could be enough to render low Earth orbit essentially impassable.

(Paragraph 6)
This process is similar to the critical mass phenomena of a neutron induced chain reaction with the exception that once a neutron clears the area containing fissionable atoms, the neutron does not return. In the Kessler scenario the space debris does return periodically.

Avoidance and reduction

(Paragraph 7)
To minimize the chances of damage to other vehicles, designers of a new vehicle or satellite are frequently required to demonstrate that it can be safely disposed of at the end of its life, for example by use of a controlled atmospheric re-entry system or a boost into a graveyard orbit.

(Paragraph 8)
One technology proposed to help deal with fragments from 1 cm to 10 cm in size is the laser broom, a proposed multi-megawatt land-based laser that could be used to target fragments. When the laser light hits a fragment, one side of the fragment would ablate (super heat and vaporise / boil), creating a thrust that would change the eccentricity (shape of orbit) of the remains of the fragment until it would re-enter harmlessly.

End of Article

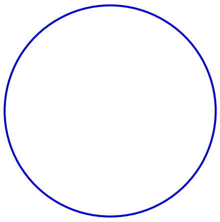
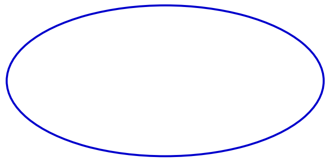
Reference

http://en.wikipedia.org/wiki/Kessler_syndrome

Questions

1. As the result of a collision between two orbiting objects in space, the resulting debris will have a range of directions and speeds. Name the three types of orbits that the resulting pieces of debris could produce and draw the shapes of these orbits.

(3 marks)

Circular	Elliptical	Spiral
		my computer skills need improving sorry. 

2. Will any outward spirals be produced? Explain why or why not.

(2 marks)

No.

Outward spirals require an injection of additional energy from some other source such as a rocket engine. Space debris do not have this additional force available.

3. Will all the debris entering the earth's atmosphere reach the ground? Explain.

(2 marks)

No.

Some will vaporise in the atmosphere as they plummet towards the ground.

4. In the comparison between the neutron induced chain reaction and the Kessler syndrome (paragraph 8), why does the space debris return periodically when the neutrons do not.

(2 marks)

The neutrons are not attracted back by a force (field). While they do have mass the gravitational strength is not significant.

The space debris is attracted back by the gravitational field resulting in orbits of various shapes.

5. What factors other than collisions mentioned in the article can alter the shape of the orbit of a satellite / piece of space debris.

(3 marks)

Slight atmospheric drag
Lunar perturbation
Solar wind / drag

6. Explain an advantage and disadvantage of letting an obsolete satellite re-enter the earth's atmosphere as compared to moving it to a graveyard orbit?

(3 marks)

	Advantage	Disadvantage
Re-enter	No longer clutter up space an so cannot contribute to the Kessler syndrome were it to occur	Re-entering satellites can fall on people and introduce toxins / radioactive material to the air.
Graveyard orbit	No toxins put in atmosphere. No falling on people's heads.	Can contribute to the Kessler syndrome if it were to eventuate.

Question 21 **(15 marks)**

Who Hits Harder: The Nordic Skier or Aerial Jumper?

(Paragraph 1)
Using physics you can calculate that the force (shocks) acting on a Freestyle Aerialist Jumper on landing is equivalent to a vertical drop of 6.1 m (20 feet) to a flat surface. This is over twice the landing force (shock) of a Nordic Jumper even though the Nordic Jumpers travel at twice the velocity and fall twice as far.

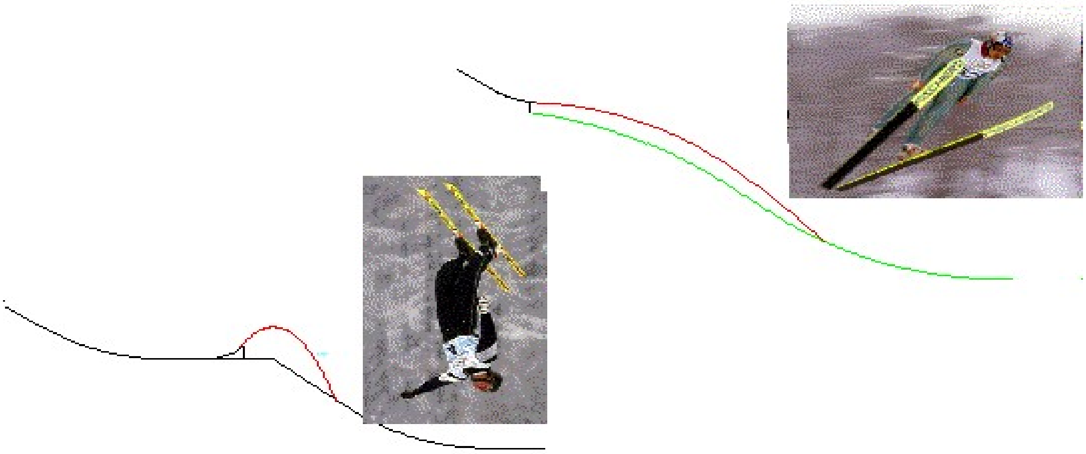


Figure 1: Freestyle Aerial jumper Eric Bergous (left) and Nordic jumper Masahiko Harada (right).

(Paragraph 2)
Introduction
In the winter Olympics, two types of skiers, Nordic Jumpers and Freestyle Aerialists, are known for their dazzling displays of aerial manoeuvres that most spectators find incredible and possibly dangerous. The Aerial Jumpers in the Freestyle Skiing competition perform very high leaps with twists and somersaults. The 1998 Olympic winner, Eric Bergous (Figure 1), executed three complete rotations with four twists. This required extensive time in the air, will have consequences on landing when gravity pulls him back to earth. At the Nordic Ski Jumps, Masahiko Harada (Figure 1), and Takanobu Okabe both flew 137 m (449 ft) in distance.

(Paragraph 3)
Competition drives the skiers to fly higher and farther to win the competition. The athletes risk falling upon impact. Fortunately, the Federation of International Skiing (FIS) has imposed rules on the designs of ski jumps to insure safety and minimize injuries. The FIS specifications for Freestyle Aerial jumps is shown in Figure 2.

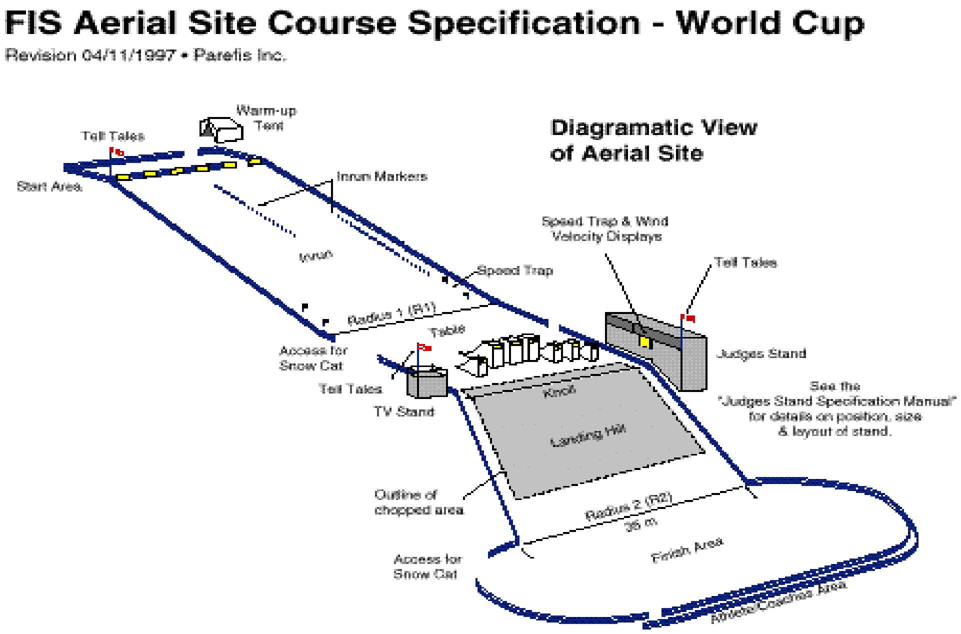


Figure 2: Federation of International Skiing specifications for Freestyle Aerial hills. Full details are available at http://www.zip.com.au/~birdman/FTP.html under “1997/98 Freestyle Course Standards”.

(Paragraph 4)
Computer Model of Skier’s Flight
Nordic ski jumping has been modelled by Muller et al. (1995 and 1996). They found that most jumpers have a very small impact on the landing hill equivalent to a vertical drop of < 1 m, even though they fly distances over 100 m (328 ft.) with vertical drops over 30 m (98 ft.). The Nordic skiers experience light landings because they are flying close to the hill which is shaped for their flight trajectory (Figure 1).

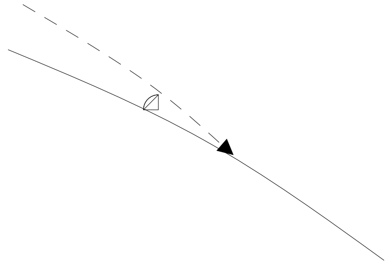


Figure 3: Diagram showing small angle of landing for Nordic ski jumping

(Paragraph 5)
The Freestyle Aerial Jumpers take off with a much higher trajectory to perform rotations and twists. Judges award points for the heights of the jumps along with the difficulty of the rotations and twists. Distance is not a factor in Aerial Jumping as it is in Nordic Jumping. They experience harder landing because the angle at which they strike the ground is larger as measured with the line of the hill.

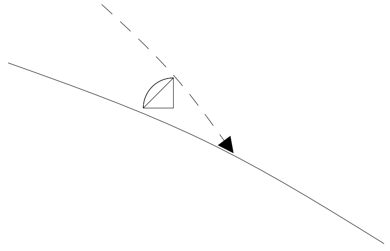


Figure 4: Diagram showing larger angle of landing for the Freestyle Aerial Jumper.

(Paragraph 6)
To answer the question, “How hard do the Freestyle Aerialists land?” a smaller version of the Muller model was used. The impact of a skier on the landing hill is not simply the vertical distance he/she drops because they land on a steep slope (~37°). The skier also does not stop on the hill. The impact the skier feels is the force it takes to change the skier’s direction from their flight path to that of the slope of the hill. This is illustrated in Figure 5.

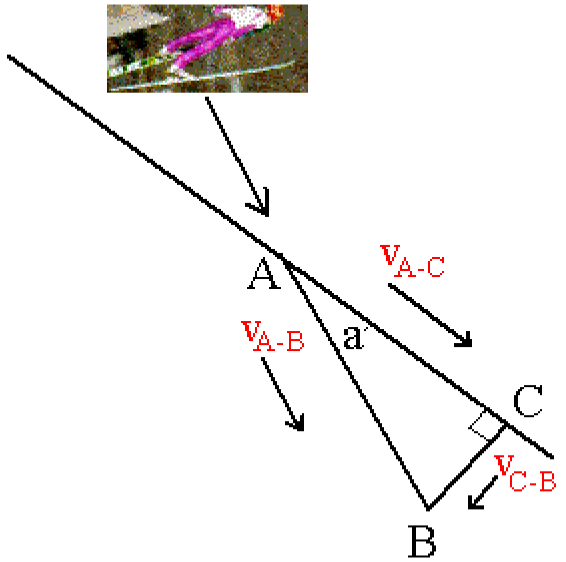


Figure 5: The skier approaches a landing at A, ravelling with an initial velocity toward B, but will abruptly change direction toward C on landing.

(Paragraph 7)
The skier’s direction of motion just before landing is shown by the vector A-B. The hill has a slope from A-C. The skier’s velocity (V_{A-B}) can be expressed as two orthogonal (right angle) components. The component along the hill is V_{A-C} whereas the other component is V_{C-B}. Upon impact, the skier’s velocity will change from V_{A-B} to V_{A-C}. The change in direction is angle (a) and the velocity component V_{C-B} will be absorbed in the landing impact. The impact the skier feels is the dissipation of V_{C-B}.

(Paragraph 8)
Using the triangle in Figure 5, the skier’s velocity component perpendicular to the face of the hill, V_{C-B}, can be calculated from the skier’s velocity, V_{A-B}, and the change in direction (a).

$$V_{C-B} = V_{A-B}.\text{Sin (a)} \qquad (1)$$

(Paragraph 9)
The velocity of the skier is changed by the accelerations of the forces on the skier. Since the speed of the Aerial Jumper is relatively slow, aerodynamic lift and drag are not considered. However, Muller had to consider aerodynamic forces for the Nordic jumper because of the greater velocities (23-27 m/s or 51-57 mph).

(Paragraph 10)
For the Aerial jumper we know the location of the takeoff point and the inclination angle, but not the velocity. Aerial jumpers can choose their velocity by selecting any starting position on the take off ramp. They vary their velocity for the air time needed for their manoeuvres.

(Paragraph 11)
The largest takeoff kicker (ramp) for aerial skiing in Figure 6 has an inclination of 55° to the horizontal and is positioned 8.1 m back from the start of the landing slope, which has a constant pitch of 37° and is 25 m long.

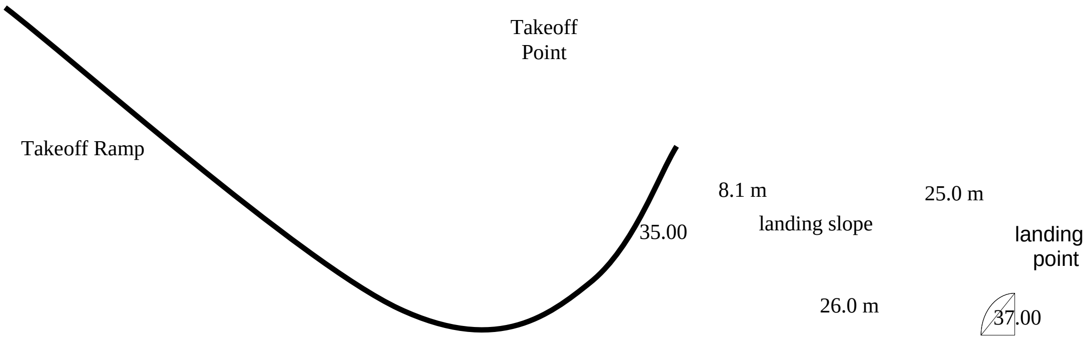


Figure 6: An aerial jump ramp

(Paragraph 12)
Muller converted the vector V_{C-B} to an equivalent drop from a fictitious height to a flat surface so that comparisons could be made to other sports. The conversion takes the velocity of impact perpendicular to the slope and converts it to height using the law of conservation of energy.

(Paragraph 13)
Discussion
The Aerial jumper model shows landing impacts of 3.2-6.1 m (10-20 ft) in vertical drop whereas Nordic jumpers experience much smaller impacts of 0.6-2.4 m. A 20-foot fall could cause serious injury. It's about the height of the roof on a two-story house. However, Freestyle Aerial jumping has an exceptional record in that they have never had a debilitating injury in 22 years[2].

This article has been heavily edited but is closely based on the article …

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End of Article

2

Questions

1. Explain why Nordic skiers experience smaller landing forces than Aerial jumpers. Use diagrams to assist your explanation.

(2 marks)

The change in direction of the Nordic jumper is less than the Aerial skier. The smaller the change in direction, the smaller the force acting on the skier. Increased velocity increases the force but the angle variable ha a larger effect.

Nordic Skier

Aerial Skier

Diagrams required …

2. In which type of jump is air resistance more significant? Explain why.

(2 marks)

Air resistance is more significant in the Nordic jump because the velocities are larger.

Air resistance forces are given by the formula. $F_{air} = kAv^2$

3. An aerial jumper takes off from the top of a ramp with a velocity of 12.5 m/s. What is the minimum height from which the aerial jumper must start on the takeoff ramp to reach this takeoff velocity?

(3 marks)

$mgh = ½ m v^2$
$gh = ½ v^2$
$h = ½ 12.5^2 / 9.8$
h = 7.97 m above the takeoff point (ignoring friction)

4. If an aerial ski jumper leaves the top of the kicker (ramp) at an angle of 55.0^0 degrees to the horizontal with a speed of 12.5 m/s and lands at a horizontal distance of 26.0 m from the takeoff point, what is the time of flight of the jumper?

(2 marks)

12.5m/s

55.00

$u_h = s_h / t$
12.5 Cos 55 = 26 / t
t = 26 / 12.5 Cos 55
t = 3.63 s

5. What is the maximum height of the jumper above the kicker (ramp)?

(3 marks)

$v^2 = u^2 + 2as$
$0 = (12.5 \sin 55)^2 + 2 \times -9.8 \times s$
-104.84 = -19.6 s
s = 5.35 m above kicker ramp

6. What is the landing height of the skier relative to the take off point?

(3 marks)

$s_v = ut + ½ at^2$
$s = 12.5 \text{ Sin } 55 \times 3.63 + ½ \times -9.8 \times 3.63^2$
$s = 27.17 + -64.56$
$s = -27.4$ m
s = 27.4 m below the takeoff point (kicker ramp) End of Article

End of Exam