St. Mary's Anglican Girls' School

Semester I Exam

2008 Question/Answer Booklet

PHYSICS 12

TIME ALLOWED FOR THIS PAPER

Reading time before commencing work: 10 minutes
Working time for paper: 2 ½ hours

MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER

TO BE PROVIDED BY THE SUPERVISOR
This Question/Answer Booklet.
Physical Formulae and Constants sheet.

TO BE PROVIDED BY THE CANDIDATE
Standard Items
Pens, pencils, eraser or correction fluid, ruler.
Special Items
Physical formulae and constants sheet, drawing implements, templates and calculators satisfying the conditions set by the Curriculum Council.

IMPORTANT NOTE TO CANDIDATES

No other items may be taken into the examination room.

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

NAME: _____

	Short Answer	**Problem Solving**	**Comprehension**	**%**
Out of	/52	/82	/33	/167

% Weights	/30	/50	/20	/100

STRUCTURE OF THE PAPER

Section	No of questions	No of marks out of 167	Proportion of exam total
A: Short Answers	13	52	30%
B: Problem Solving	7	82	50%
C: Comprehension and Interpretation	1	33	20%

INSTRUCTIONS TO CANDIDATES

Write your answers in the spaces provided beneath each question in sections A and B
The value of each question in section A is four marks.

Note that (where appropriate) answers should be given numerically and they should be evaluated **and not left in fractional or radical form**. Give all numerical **answers to three significant figures** except in the cases for which estimates are required.

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

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

Candidates should remember that when descriptive answers are required, they should be used to display understanding of the aims and objectives of the physics 12 course. A descriptive answer, which addresses the context of a question without displaying an understanding of physics principles, will not attract marks.

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

SECTION A : Shorts Answers - 52 Marks (30%)

Attempt ALL 13 questions in this section.
Show all working out. (4 marks each)

A1. A girl is throwing a soccer ball over her head. She wants the ball to land at the feet of another member of her team. The ball is released from a height of 1.2 m above the ground at an angle of 35.0 ^{o} above the horizontal. The initial velocity of the ball is 4.46 m s^{-1}. What is the range of the team member from the girl if she throws the ball accurately.

A2.a) A large beach ball and a tennis ball have the same mass but very different volumes and surface areas. In the space provided below qualitatively show the pathway (trajectory) taken by each ball. Assume that both balls are launched at identical angles and identical speeds from ground level.

(1 mark)

Beach Ball	Tennis Ball

b) Show the approximate size and direction of the individual forces acting on the balls on your diagrams drawn above…

i) just <u>after</u> launch.

ii) at their maximum height.

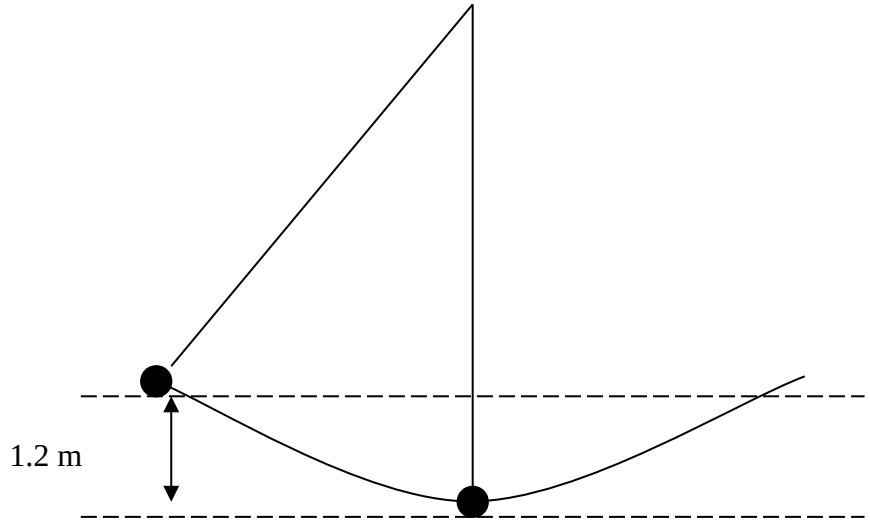
(2 marks)

c) Explain why the different balls have different ranges.

(1 mark)

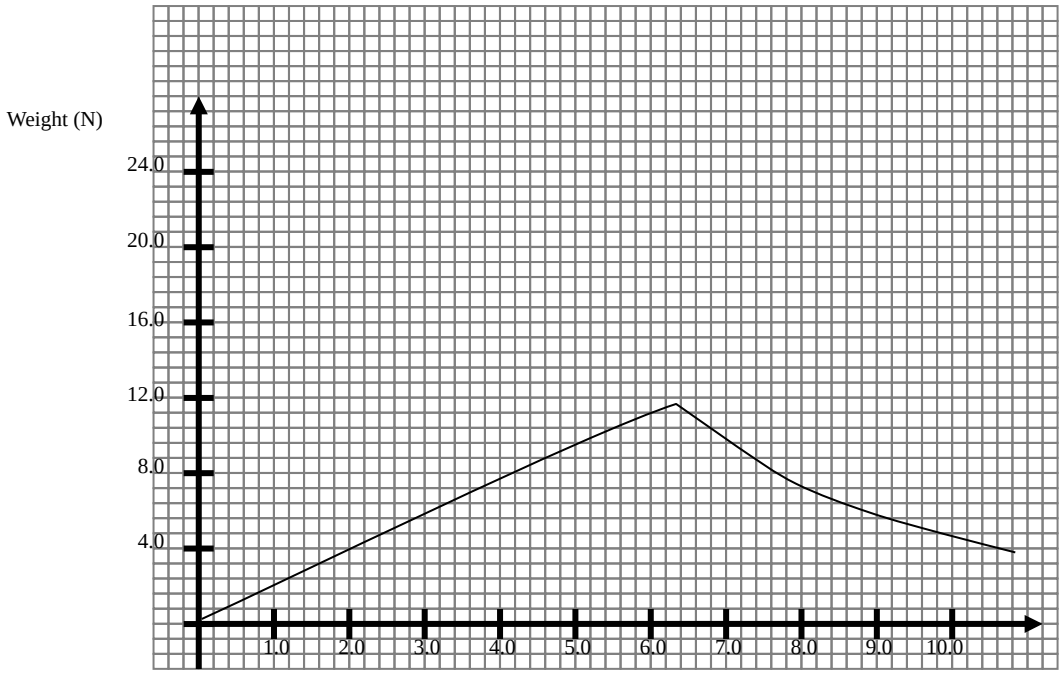
A3. A push bike and rider have a combined mass of 90.0 kg. They are travelling around a corner by leaning over so they form an angle with the horizontal. The road on which the bike is travelling is flat. The maximum value of friction between the tyres and the road is 2000 N. Will the bike round the corner of radius 5.00 m if they are traveling at 40.0 km/h?

***A4.** A pendulum falls through a height of 1.2 m. The bob on the pendulum has a mass of 3.00 kg and the string is 4.00 m long. What is the tension in the string at the bottom of the swing?



A5. A graph of the weight of a 1.00 kg mass at various distances from the centre of the earth is shown below.

Weight of a 1.00 kg mass as a function of distance from the centre of the earth.



a) Mark with an X on the graph the weight of the object at the centre of the earth and with a Y the weight at the surface of the earth.

(2 marks)

b) What does the area under the curve of the graph represent? Explain how you came to this conclusion.

(2 mark)

A6.a) At what distance from the centre of Venus should a 3.00 kg communications satellite be placed so that it is geostationary?

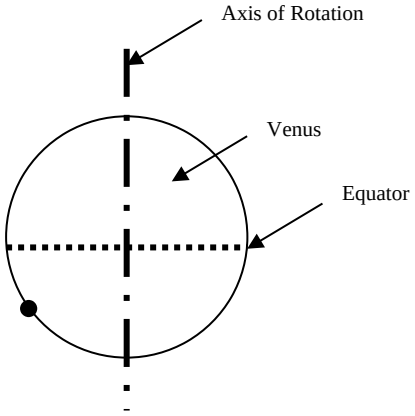
Note:- m_{venus} = 4.82×10^{24} kg
r_{venus} = 6.31×10^{6} m
Period of rotation = 243 earth days (yes - Venus does spin very slowly).

(3 marks)

b) The position with which you wish to communicate on the surface of Venus is shown as a ●. Place an X in the space surrounding the diagram of Venus below to indicate where the communications satellite should be placed.

(1 mark)

Note the diagram is not to scale.

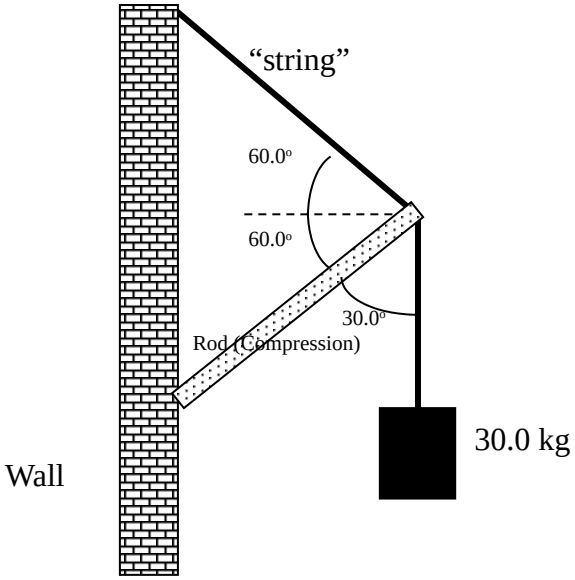


A7. You have a weight of 784 N on the surface of the planet Earth. What is the ratio of your weight on the surface of the earth to your weight on the surface of Jupiter? The mass of Jupiter is 314 times the mass of the earth and the radius of Jupiter is 11.25 times the radius of the earth?

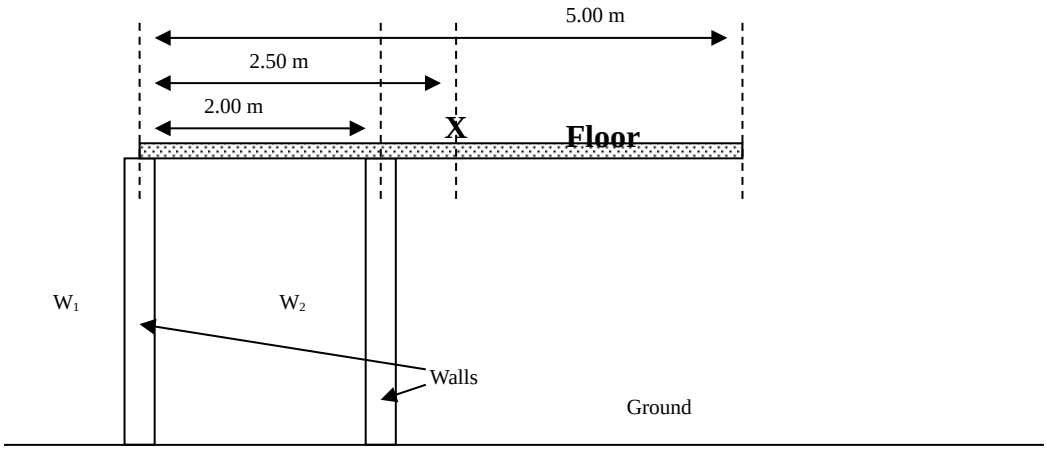
A8.

You should be able to manage this

Calculate the tension in the “string” below. The rod is experiencing compression parallel with its length. The rod is mass less.

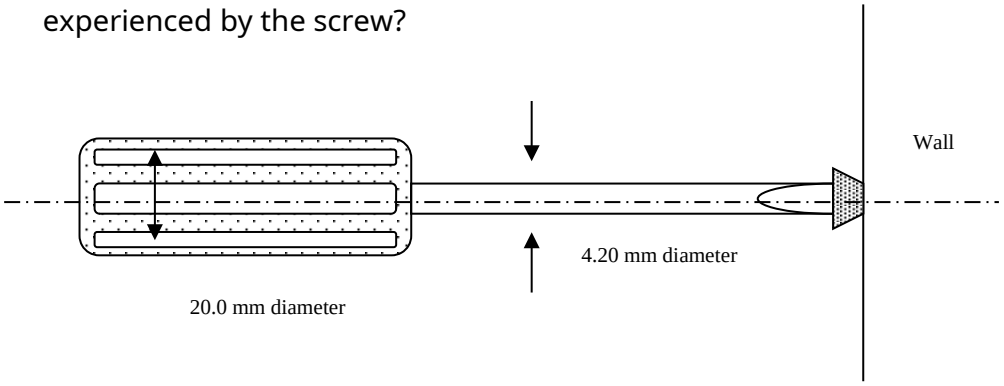


A9. A house is being renovated and the owners have decided to put on a second storey. A floor has been placed onto some existing concrete walls. The floor extends over the edge of these walls to make a balcony as shown in the diagram below.

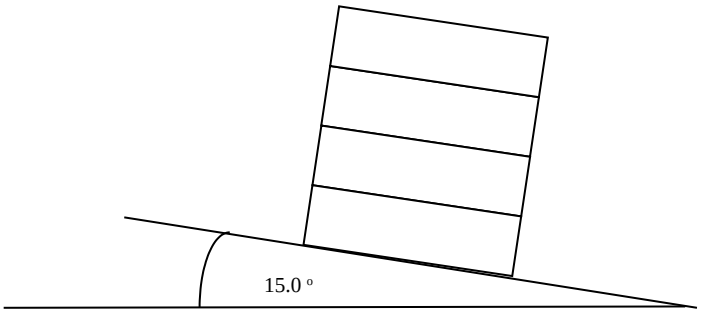


What is the magnitude and direction of the force on the wall (W_1) if the floor has a mass of 30 000 kg acting through its centre of mass marked X.

A10. A student is using a screw driver to tighten a screw into some wood. The dimensions of the screw driver are as shown in the diagram below. If the student is applying a force of 100 N to the handle of the screw driver to produce a turning effect, what will be the turning force experienced by the screw?



A11. A student is playing with some wooden blocks. The student stacks the blocks on a surface that is inclined at an angle of 15.0 °. The blocks are 8.00 cm long and 2.00 cm high. The student initially constructs a tower that is 4 blocks high. Each block is uniform



a) Is the tower in...

mechanical equilibrium static equilibrium not in equilibrium?

(please circle 1 only)
(1 mark)

b) Is the tower in...

stable equilibrium unstable equilibrium

neutral equilibrium not in equilibrium

(please circle 1 only)
(1 mark)

c) The student now adds more blocks to the tower. Assuming that the blocks do not slide off each other; will the tower still be stable if 16 blocks in total are in the pile? Show calculations to support your answer.

(2 marks)

***A12.** A spring changes its length by 3.00 cm when a 500 g mass is hung from it. Assuming that the spring is still operating in its proportional region, how much energy is stored in the spring when 500 g is hung from it?

A13 A 30.0 m length of steel cable has a Hooke's Law constant of 2.20×10^6 N m^{-1}. The diameter of the cable is 2.00 cm. A 10.0 m section of cable is cut from the original 30.0 m. 2000 kg is hung from the 10.0 m cable.

a) What is the Young's Modulus for the 30 m cable?

(2 marks)

b) By how much will 10.0 m cable stretch?

(2 marks)

You are up to here

SECTION B : Problem Solving - 82 Marks (50%)

Attempt ALL 7 questions.

B1. (Total = 12 marks)

Sam has joined the circus and has been loaded into an air cannon. She is a human cannon ball! The cannon is pointed at an angle of 35.0 ^{o} above the horizontal. The open end of the cannon is positioned 4.00 m above the ground and the net which will catch Sam is positioned 2.00 m above the ground. Sam's initial speed on leaving the end of the cannon is 13.0 m s^{-1}.

a) At what range from the cannon should the centre of the net be placed?

(4 marks)

b) What is the greatest height that Sam will achieve relative to the ground?

(4 marks)

c) The barrel (tube) inside the cannon is 3.5 m long. If Sam has a mass of 90 kg while wearing safety equipment, what is the average force exerted on Sam as she accelerates continuously along the barrel of the cannon?

(2 marks)

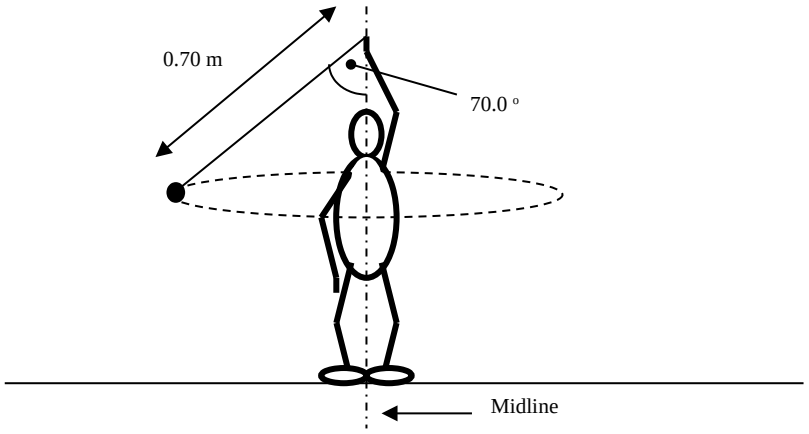
d) Unfortunately the performance circle in the centre of the circus tent is only

15.0 m in diameter. At what new angle must the cannon be pointed above the horizontal in order for Sam to make a safe landing in the net 15.0 m away from the open end of the cannon? Assume the speed at which Sam leaves the cannon is still 13.0 m s^{-1} and the open end of the cannon is still 4.00 m above the ground.

(2 marks)

B2. (Total = 12 marks)

Alecia is playing the part of "David" in a biblical play called "David and Goliath". Alecia's character will swing a stone in a horizontal circle around her head on the end of a piece of string, and at just the right moment release the string to throw the stone at Goliath and kill him. Alecia does not know what the mass of the stone is.



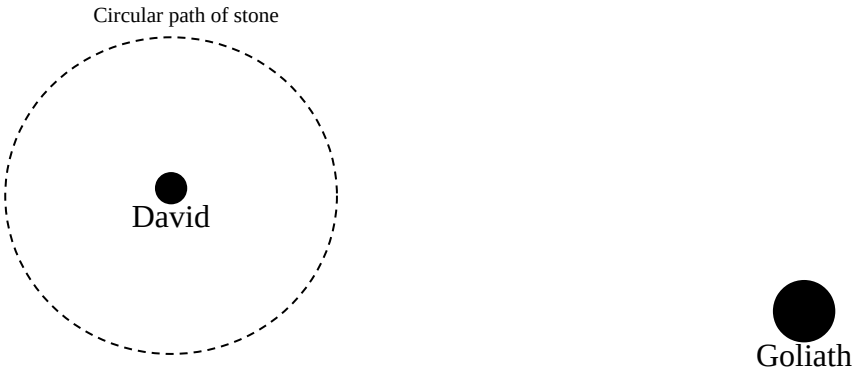
a) The string attached to the centre of the stone is 0.70 m long. The string forms an angle of 70.0 ° with the vertical. What is the speed at which Alecia is swinging the stone?

(4 marks)

b) The stone is being swung in a clockwise direction when viewed from above. Mark onto the diagram the position of the stone when the string is released, if the stone is to successfully hit Goliath? Explain the reasoning behind your choice.

(2 marks)

Top View diagram of "David and Goliath" situation



c) Alecia decides to change her swinging technique and now swings the stone in a vertical circle. Draw a free body diagram of all the forces acting on the stone at the top of the vertical circle.

(2 marks)

d) At what speed should the stone be swung if the tension in the string is to be twice the weight of the stone, when the stone is at the top of the circle?

(2 marks)

e) The string will break when the tension in the string is equal to or greater than 7mg. Will the string break at the top of the circle or at the bottom of the circle? Explain?

(2 marks

B3. (Total = 11 marks)

While looking though a telescope Eloise discovers a solar system in which two stars are orbiting around each other. The first star has a mass equal to the earth's sun. The second star has a mass 4 times the mass of the earth's sun.

a) What is the average gravitational field strength at a distance of 10.0 astronomical units created by the combined mass of these stars? Note that 1 astronomical unit is equal to the distance from the earth to the sun.

(3 marks)

b) The small star takes 1 minute to orbit the larger star. What is the distance at which the centre of the smaller star is orbiting the centre of the larger star?

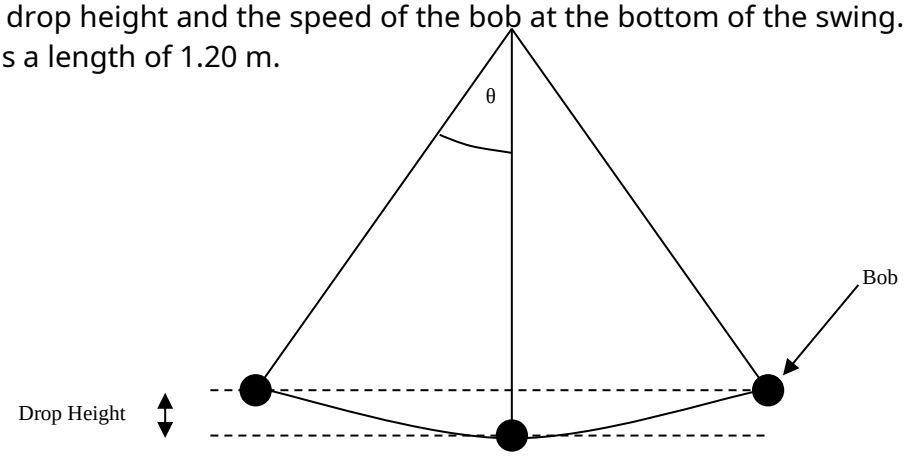
(4 marks)

c) What is the force of attraction between the two stars?

(4 marks)

***B4. (Total = 10 marks)**

A pendulum is being tested. The student changes the angle that the pendulum makes with the vertical and then measures the maximum speed of the bob which occurs at the bottom of the swing. Changing the angle alters the height through which the bob falls. The student wishes to determine the relationship between drop height and the speed of the bob at the bottom of the swing. The string has a length of 1.20 m.



a) Predict, using the law of conservation of energy, the speed of the bob when the pendulum is dropped through a height of 16.0 cm.

(2 mark)

b) Rearrange the law of conservation of energy to form a relationship between the independent variable "h" and the dependant variable "v"

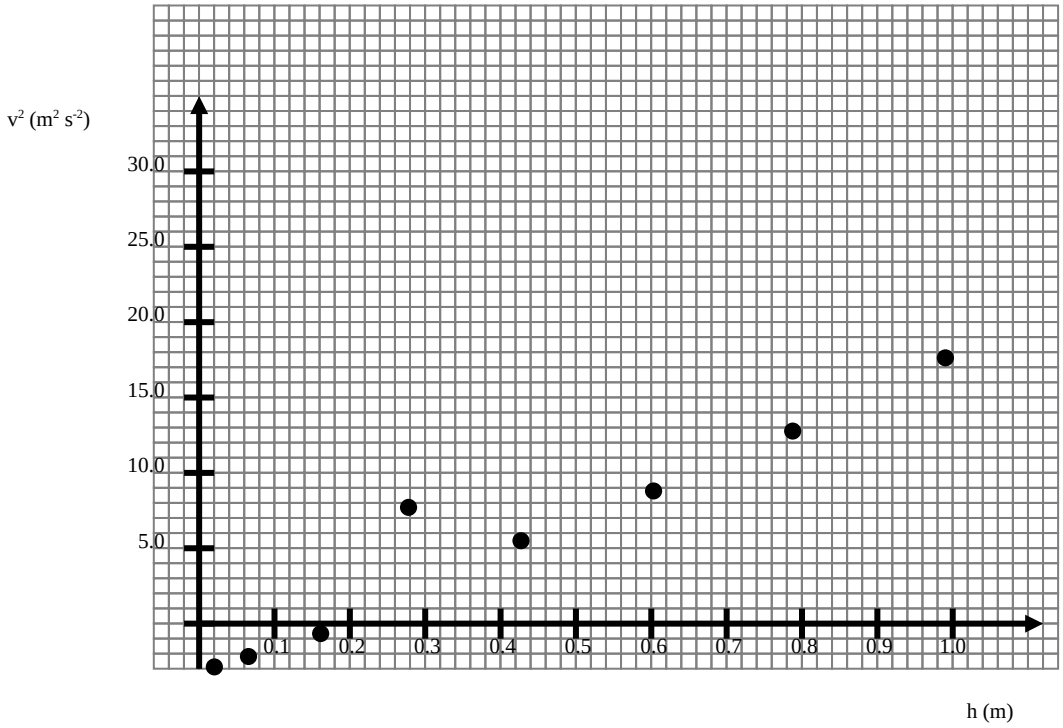
(2 mark)

The data is as shown in the data table below and then graphed on the next page.

Angle	Degrees	10	20	30	40	50	60	70	80
Drop Height	(m)	0.018	0.072	0.161	0.281	0.429	0.6000	0.790	0.992
Speed	(m/s)	0.60	1.19	1.78	3.25	2.90	3.43	3.93	4.41

Speed^2	$(m/s)^2$	0.36	1.41	3.17	10.56	8.41	11.76	15.44	19.45

Graph of the relationship between v^2 and h.



c) From the graph mathematically determine the slope of the line

(2 marks)

d) Algebraically what does your answer from part c) represent in the formula stated in part b)?

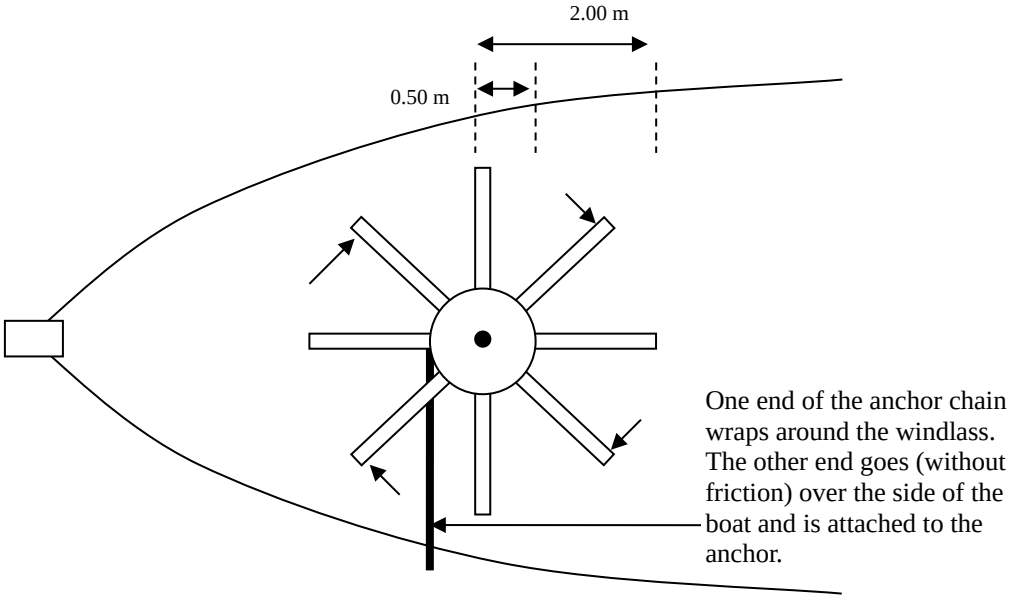
(2 mark)

e) What are the units of the slope of the line?

(2 mark)

B5. (Total = 10 marks)

A group of students have taken a trip on a replica of an old fashioned tall ship (sailing ship). The ship contains a windlass which is used to pull up the anchor. A top view of the windlass is shown below.



The students are all equally strong and push on the ends of the bars in a clockwise direction to hoist (lift) the anchor. The anchor is initially stationary.

a) The anchor has an apparent mass of 600 kg when immersed in water. Four (4) students each applying a force of 200N to the ends of the handles will not be enough to raise the anchor? Explain with the support of calculations why.

(3 marks)

b) How many students each pushing with a force of 200N on the ends of the handles at right angles to the handle will be required to lift the anchor. Please state your answer as a whole number.

(2 marks)

c) With the students in part b) applying their forces at the ends of the handles, and ignoring friction, at what rate of acceleration does the anchor rise from the sea floor? Explain with the support of calculations.

(3 marks)

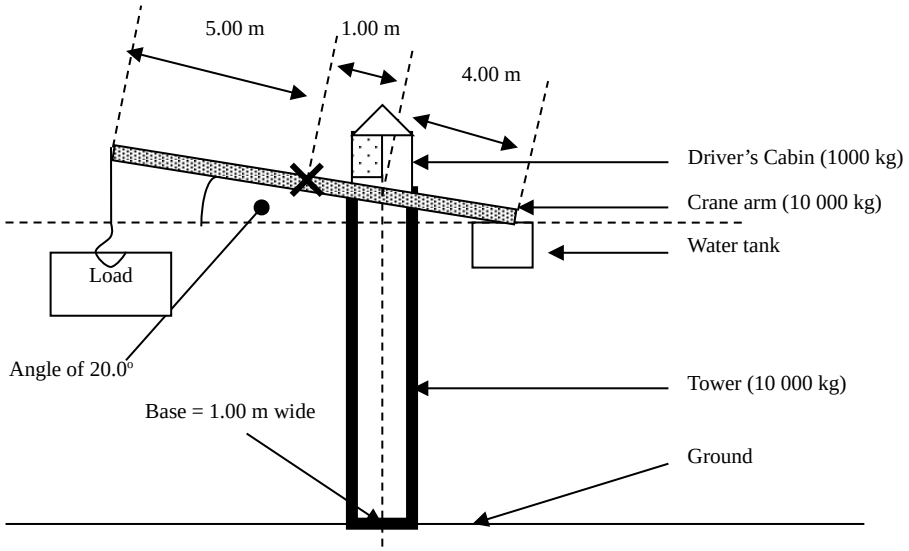
d) The anchor is to be raised at a constant velocity. To achieve this, the students need to reduce their torque. They decide to change the position at which they exert their force on the handles. How far along each handle from the centre of the windlass should the students push? Assume that each student continues to push with a force of 200 N.

(2 marks)

***B6. (Total = 15 marks)**

You should be able to manage this

An engineering student has designed a new crane which uses the weight of water to counterbalance the torque of heavy loads. The design is shown below.



Water is pumped from the water supply to the water tank at the right hand end of the crane arm to balance the load placed onto the hook of the crane. The driver's cabin exerts no force on the crane arm. The crane arm is uniform and has a mass of 10 000 kg acting at its centre at point X. The crane arm makes an angle of 20.0° with the horizontal.

a) Draw all forces acting **on** the crane arm in the diagram above. (assume all forces are purely vertical)

(1 mark)

b) What type of static equilibrium is the crane in? Explain.

(2 marks)

c) When the crane is not carrying a load, the weight of the crane arm is balanced by the weight of the empty water tank. What is the weight of the empty water tank? Assume that the crane hook and cables are weightless.

(3 marks)

d) The crane now lifts and holds a 2000 kg elephant a short distance above the ground. What weight of water must be **added** to the water tank to counterbalance the load?

(4 marks)

e) If each litre of water has a mass of 1 kg. How many litres of water does this represent?

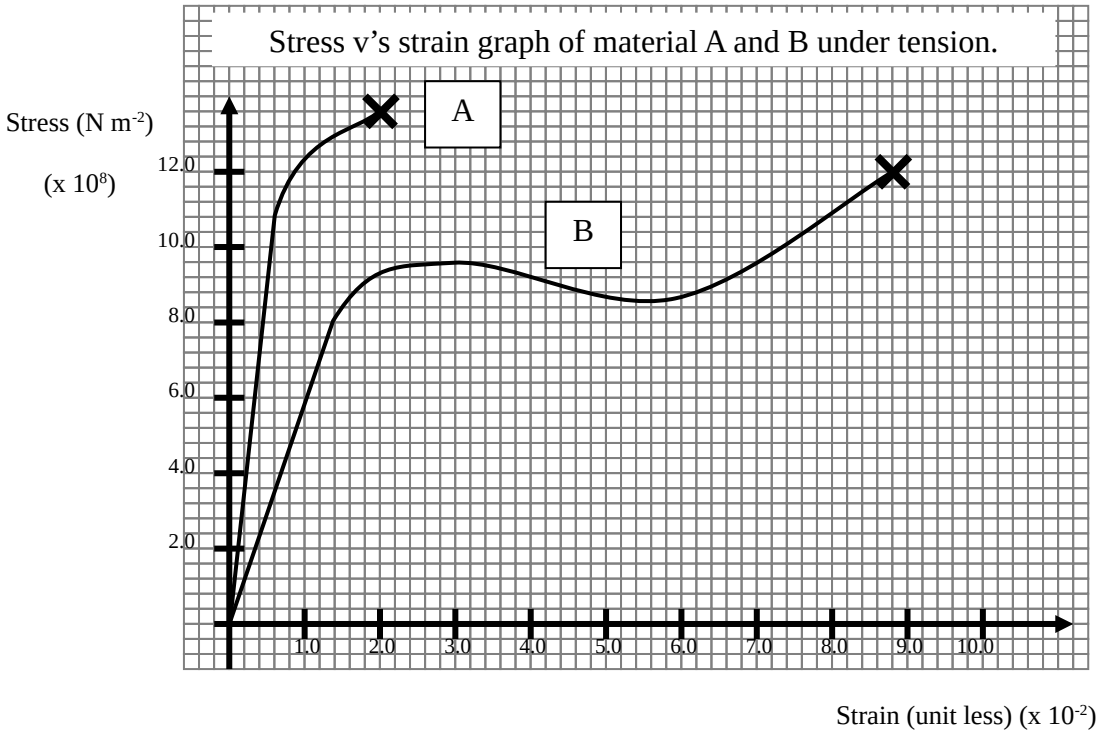
(2 marks)

f) What is the force that the crane arm exerts on the tower when the crane is holding the elephant and water as described in part d)?

(3 marks)

***B7. (Total = 12 marks)**

Below is a stress strain graph for two materials. Both materials are cylindrical in shape, with a length of 30.0 cm and a cross sectional area of 78.5 mm^2.



a) Which material, A or B has the greater ultimate strength? Explain

(2 marks)

b) Which material, A or B is tougher? Explain.

(2 marks)

c) Name a material that will produce a similarly shaped graph to A and B above

(2 marks)

A _____ B _____

d) For what range of strain values is material B behaving plastically?

(1 mark)

e) What is the Young's Modulus of the brittle material?

(2 marks)

f) Mark the proportional limit on both graphs with a star (*). Which graph, A or B, stores more energy in its proportional region. Support your answer with calculations for both graphs.

(3 marks)

SECTION C : Comprehension and Interpretation - 33 Marks (20%)
Read the passage below carefully and answer all of the questions at the end of the passage. Candidates are reminded of the need for correct English and clear and precise presentation of answers.
Show all working out for questions requiring numerical answers.

Spanning a gap in a wall to create a doorway

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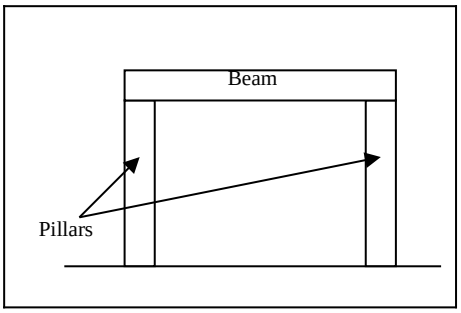
an age old problem.

A building is of little use if you can not get in or out. Unfortunately if you make a doorway or hole in a wall, the building materials above the door tend to fall in on your head shortly after followed by the roof collapsing. Consequently the wall and roof above a doorway need to be supported by some "strong structure" or device to transfer the weight of the building material above the doorway to the walls on either side.

Beam and Pillars
A stone beam and two pillars was the first attempt at solving this problem. The stone pillars on the sides worked well, but the stone beam above the doorway tended to crack in the middle and fall in. It is for this reason that so many ancient structures using this method of construction have the beam missing and only the pillars remaining.



Beam and Pillars

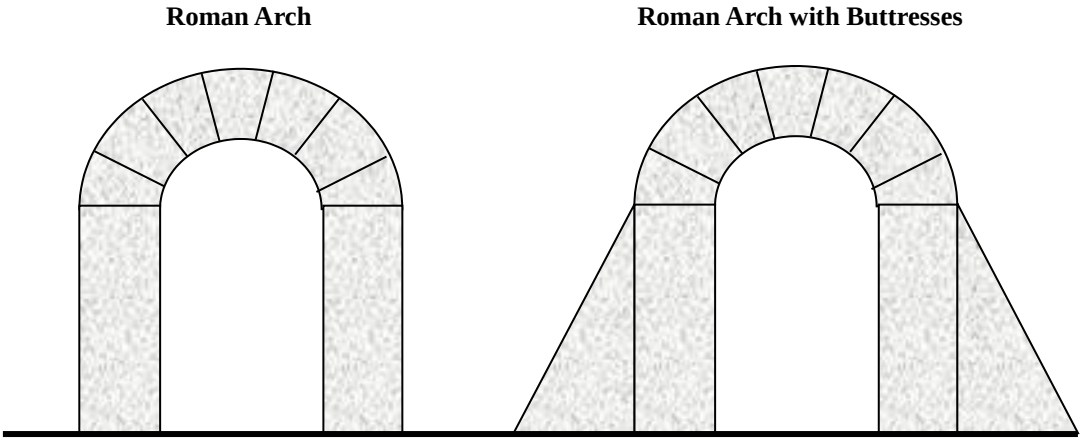
Pillars near Acropolis
acropropylaia/index.html 2/5/2008

Wood was tried as an alternative material for the beam to stone. The wood was harder to crack but suffered from rot and pestilence not to mention combustion. It also tended to expand and contract as the season changed, resulting in lateral, cracking forces on the pillars.

Arches

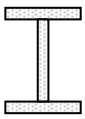
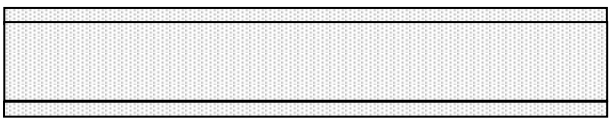
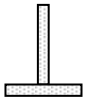
Next, in a stroke of genius, the archway was invented. The stones of the arch were capable of withstanding the weight of the wall and roofing materials above the gap without cracking. Unfortunately, the weight forces had to be borne by some part of the structure. The pillars or walls took the load, tending to topple if too slender. Buttresses were used to reinforce the pillars or walls to transfer the weight force to ground with a minimum of toppling effect.

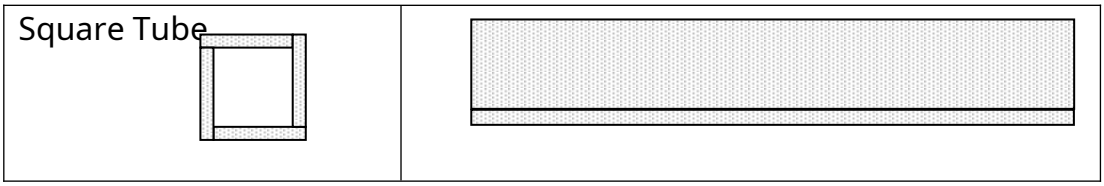
The arch had cracked the problem. Many arches still stand today from the ancient world. They were expensive and slow to build, requiring skill and carefully designed scaffolding. The stone from which they were made (like the rest of the building) was heavy and difficult to transport and shape.



Steel Beams or Girders

As peoples ability to extract and refine metals progressed, steel (iron) became an expensive possibility as a building material. Steel beams or girders as they are called are capable of withstanding large bending forces. Moisture and precipitation slowly converts steel to rust unfortunately, weakening metal structures. Rusting can be reduced by painting and chemical means but requires expensive ongoing maintenance.

End View	Side View
I Beam 	
T Beam 	

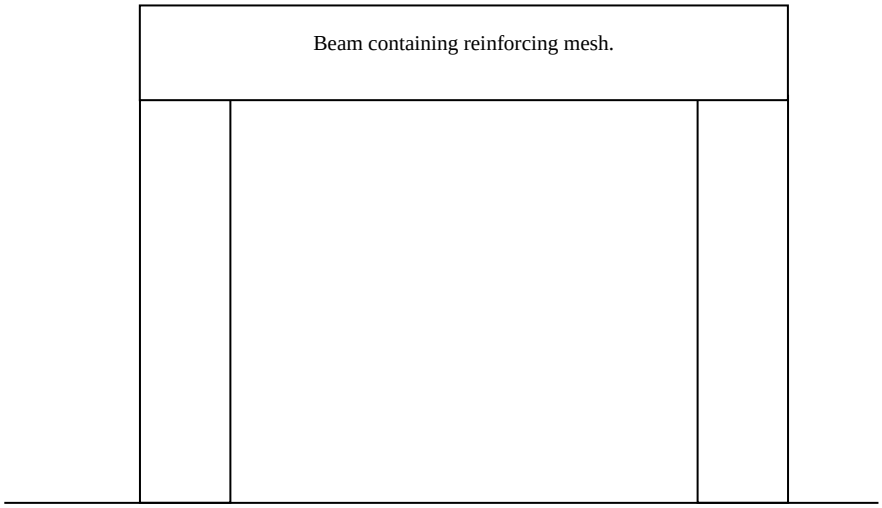


Pictures of Steel Beams

If only stone beams were not so prone to cracking…

Reinforced Concrete

Concrete (artificial stone) whose ingredients can be transported more easily in bags, mixed and molded into shape in its final resting place, developed in parallel with advancements in steel refining. Like natural stone however, pure concrete still suffered from cracking when spanning a gap. Steel mesh or cables were added to reinforce / strengthen the concrete to reduce its tendency to crack, so creating a hybrid material that could withstand tension and compression. Reinforced concrete is now the favoured building material of many but not all architects.



So, the next time you walk in a door, look up and consider what structure stops the roof falling in on you.

Questions

1. Draw a pillar and beam model. Show and label all of the forces acting on the beam.

(3 marks)

2. In a pillar and beam model made from natural stone, why is it that over time the beam cracks but the posts do not? Use diagrams to assist your explanation.

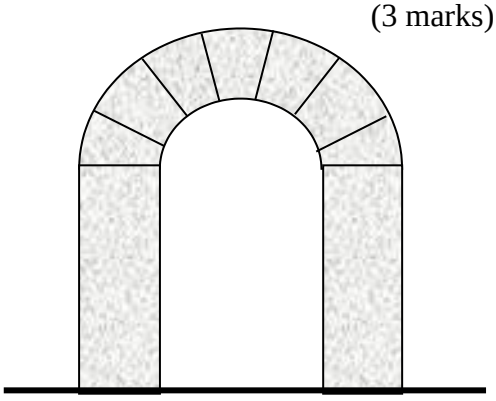
(4 marks)

3. If a builder has to use a beam made from natural stone, what 2 things can the builder do to reduce the bending and cracking. Support your explanation with diagrams.

(4 marks)

4. Why does the stone in an arch not crack? Explain by analyzing any **one** stone in the diagram provided.

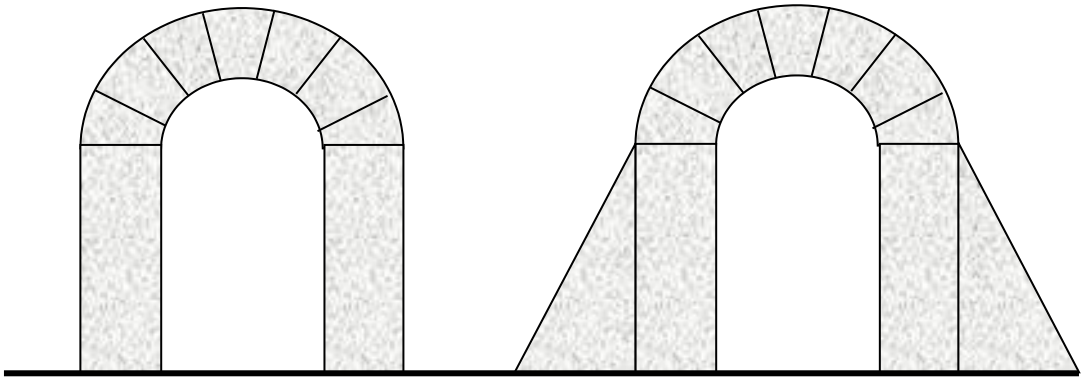
(3 marks)



5. Why do the pillars of an arch tend to topple unless buttresses support them? Explain using the diagrams provided.

(4 marks)

Roman Arch **Roman Arch with Buttresses**



6. Name one advantage and one disadvantage for each of the following materials when it is used as a building material.

(6 marks)

Material	Advantage	Disadvantage
Natural Rock or Concrete		
Metal		
Reinforced Concrete		

7. Draw a reinforced concrete beam. Explain the purpose and reason for the location of the reinforcing.

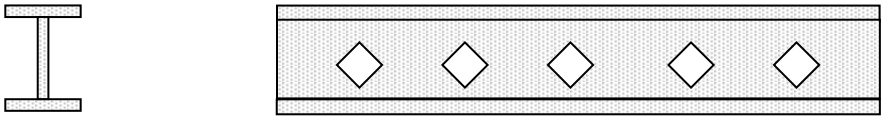
(4 marks)

8. A free standing concrete beam and pillars is to be used at the entrance to a school car park frequented by many learner drivers. Would you put reinforcing in the pillars as well as the beam? Explain why or why not?

(2 marks)

9. A builder wishes to use an "I" beam with diamond shapes cut out of the middle section (web). Will the beam still be safe to use? Explain.

(3 marks)



END OF EXAM

St. Mary's Anglican Girls' School

Semester I Exam

2008 Question/Answer Booklet

PHYSICS 12

Answers

TIME ALLOWED FOR THIS PAPER

Reading time before commencing work: 10 minutes
Working time for paper: 2 ½ hours

MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER

TO BE PROVIDED BY THE SUPERVISOR
This Question/Answer Booklet.
Physical Formulae and Constants sheet.

TO BE PROVIDED BY THE CANDIDATE
Standard Items
Pens, pencils, eraser or correction fluid, ruler.
Special Items
Physical formulae and constants sheet, drawing implements, templates and calculators satisfying the conditions set by the Curriculum Council.

IMPORTANT NOTE TO CANDIDATES

No other items may be taken into the examination room.

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

NAME: _____

	Short Answer	Problem Solving	Comprehension	%

Out of	/52	/82	/33	/167
% Weights	/30	/50	/20	/100

STRUCTURE OF THE PAPER

Section	No of questions	No of marks out of 167	Proportion of exam total
A: Short Answers	13	52	30%
B: Problem Solving	7	82	50%
C: Comprehension and Interpretation	1	33	20%

INSTRUCTIONS TO CANDIDATES

Write your answers in the spaces provided beneath each question in sections A and B
The value of each question in section A is four marks.

Note that (where appropriate) answers should be given numerically and they should be evaluated **and not left in fractional or radical form**. Give all numerical **answers to three significant figures** except in the cases for which estimates are required.

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

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

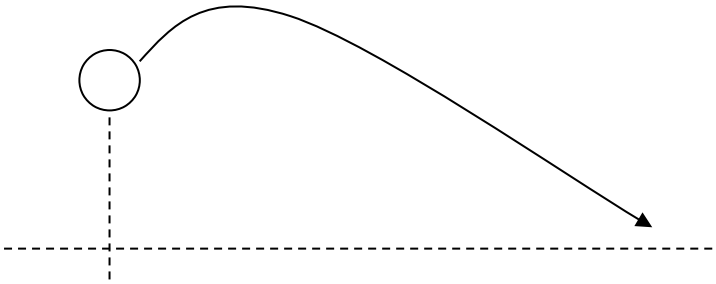
Candidates should remember that when descriptive answers are required, they should be used to display understanding of the aims and objectives of the physics 12 course. A descriptive answer, which addresses the context of a question without displaying an understanding of physics principles, will not attract marks.

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

SECTION A : Shorts Answers - 52 Marks (30%)

Attempt ALL 13 questions in this section.
Show all working out. (4 marks each)

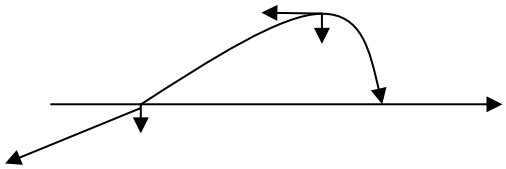
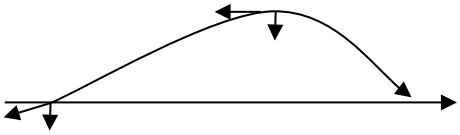
A1. A girl is throwing a soccer ball over her head. She wants the ball to land at the feet of another member of her team. The ball is released from a height of 1.2 m above the ground at an angle of 35.0 ^{o} above the horizontal. The initial velocity of the ball is 4.46 m s^{-1}. What is the range of the team member from the girl if she throws the ball accurately.



Vertical	***Horizontal***
$v^2 = u^2 + 2as$	$u_h = s / t$
$s = ut + ½\ at^2$	
$v = u + at$	
$s = ut + ½\ at^2$ (1)	
$-1.2 = 4.46 \sin(35)\ t + ½\ -9.8\ t^2$	
Solve mode	
	$s = u\ t$
$t = 0.8205$ s (1)	$s = 4.46 \cos(35)\ 0.8205$ (1)
	$s = 3.00$ m (1)

A2.a) A large beach ball and a tennis ball have the same mass but very different volumes and surface areas. In the space provided below qualitatively show the pathway (trajectory) taken by each ball. Assume that both balls are launched at identical angles and identical speeds from ground level.

(1 mark)

Beach Ball	***Tennis Ball***
Non symmetrical *Range short* *Must look correct* 	*Non symmetrical* *Range Long* *Must look correct* 

b) Show the approximate size and direction of the individual forces acting on the balls on your diagrams drawn above…

i) just <u>after</u> launch.

ii) at their maximum height.

mg is same size in all diagrams (1)

friction is larger in beach ball than tennis ball and drops as height increases (1)

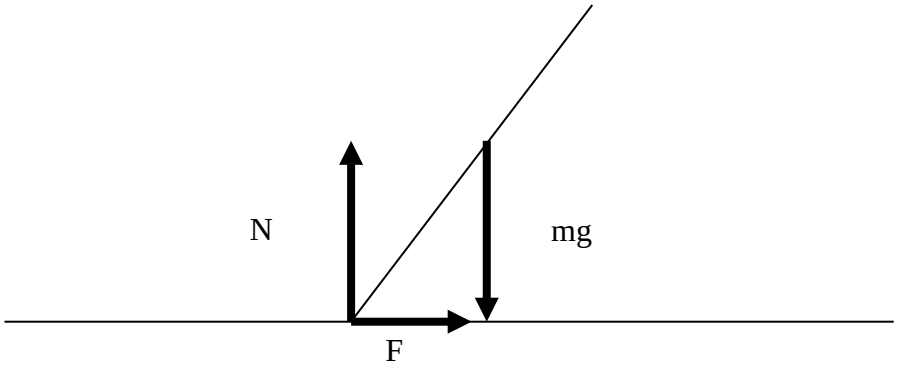
(2 marks)

c) Explain why the different balls have different ranges.

(1 mark)

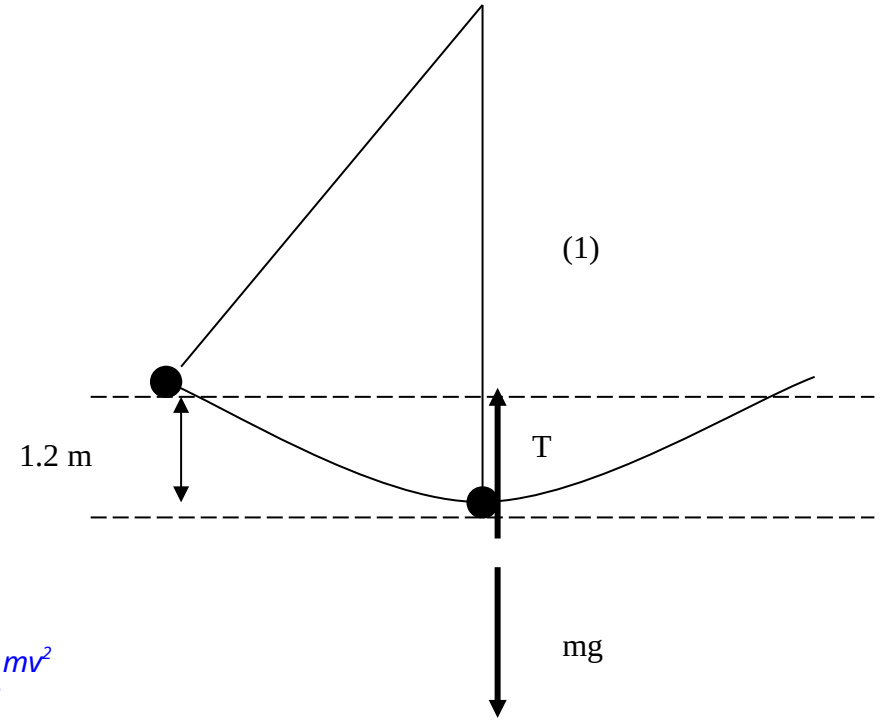
Beach Ball	***Tennis Ball***
Large surface area but constant mass *F = ma* *Large F means large a* *Shortens range*	*Small surface area but constant mass* *F = ma* *Small F means small a* *Increases range.*

A3. A push bike and rider have a combined mass of 90.0 kg. They are travelling around a corner by leaning over so they form an angle with the horizontal. The road on which the bike is travelling is flat. The maximum value of friction between the tyres and the road is 2000 N. Will the bike round the corner of radius 5.00 m if they are traveling at 40.0 km/h?



Vertical	*Horizontal*
(+N) + (-mg) = 0	(1) *(+F) = mv^2 / r* *(+F) = mv^2 / r* *F = 90 x (40/3.6)^2 / 5 (1)* *F = 2.22 x 10^3 N (1)* *2.22 x10^3 > 2000* *Bike does not round bend. (1)*

A4. A pendulum falls through a height of 1.2 m. The bob on the pendulum has a mass of 3.00 kg and the string is 4.00 m long. What is the tension in the string at the bottom of the swing?



mgh = ½ mv²
gh = ½ v²

9.8 x 1.2 = 0.5 x v²

v = 4.8497 m/s ***(1)***

sum of the forces (vertical) = 0

(-mg) + (+T) = mv² / r *(1)*

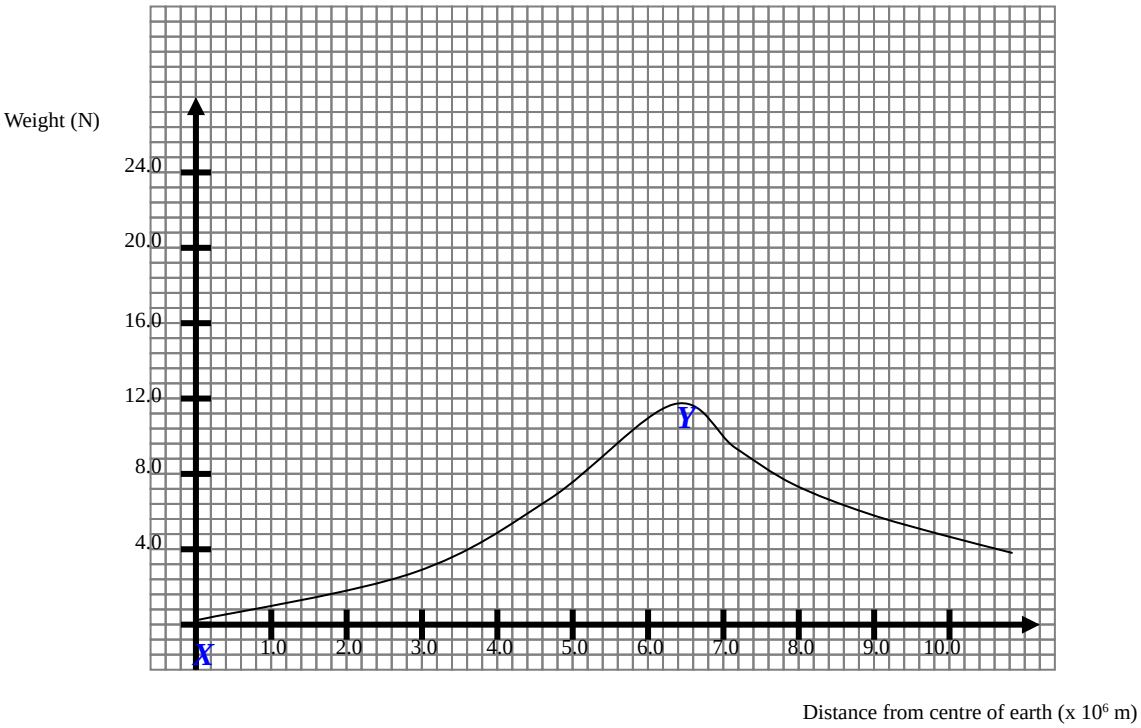
T = (+mg) + (+mv² / r)

T = (3 x 9.8) + (3 x 4.8497² / 4)

T = 47.0 N up (towards the center of the circle) *(1)*

A5. A graph of the weight of a 1.00 kg mass at various distances from the centre of the earth is shown below.

Weight of a 1.00 kg mass as a function of distance from the centre of the earth.



a) Mark with an X on the graph the weight of the object at the centre of the earth and with a Y the weight at the surface of the earth.

(2 marks)

b) What does the area under the curve of the graph represent? Explain how you came to this conclusion.

(2 mark)

The area under the curve represents the **potential energy** (1) of the object due to its weight and its position.

Ep = mgh

But mg = weight

Ep = weight x h *(1)*

A6.a) At what distance from the centre of Venus should a 3.00 kg communications satellite be placed so that it is geostationary?

Note:- m_{venus} = 4.82×10^{24} kg
r_{venus} = 6.31×10^{6} m
Period of rotation = 243 earth days (yes - Venus does spin very slowly).

(3 marks)

$r^3 / T^2 = G\,m / 4\,\pi^2$ *(1)*

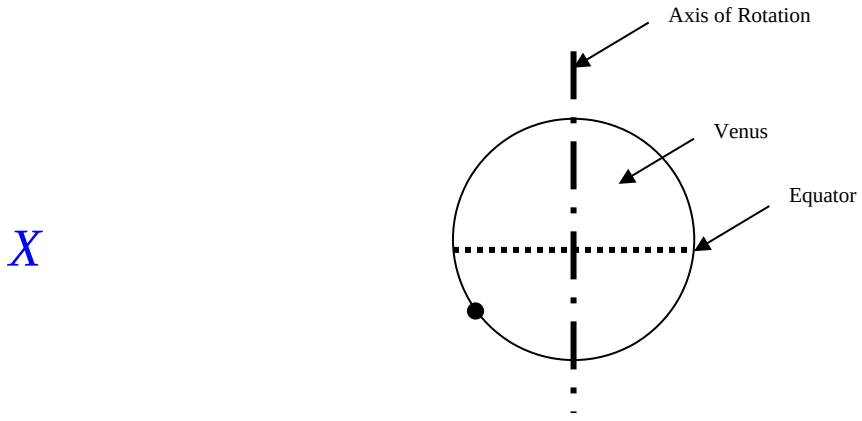
$r^3 / (243 \times 24 \times 3600)^2 = 6.67 \times 10^{-11} \times 4.82 \times 10^{24} / (4 \times \pi^2)$ *(1)*

$r = 1.53 \times 10^9$ m ***(1)***

b) The position with which you wish to communicate on the surface of Venus is shown as a ●. Place an X in the space surrounding the diagram of Venus below to indicate where the communications satellite should be placed.

(1 mark)

Note the diagram is not to scale.



A7. You have a weight of 784 N on the surface of the planet Earth. What is the ratio of your weight on the surface of the earth to your weight on the surface of Jupiter? The mass of Jupiter is 314 times the mass of the earth and the radius of Jupiter is 11.25 times the radius of the earth?

2 methods

Method 1 – use actual numbers

Find your mass. *(1)*

State law of universal gravitation *(1)*

Sub in numbers from constants sheet *(1)*

Get answer and find ratio *(1)*

Method 2 – divide page and take ratio early (algebraic)

Write universal grav. formula for you on earth. *(1)*

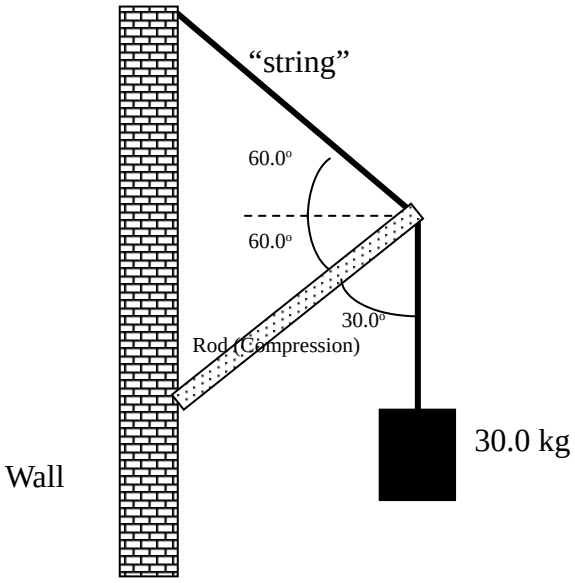
Write universal grav. formula for you on Jupiter. *(1)*

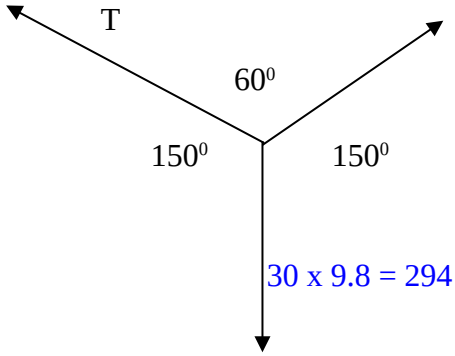
Take ratio of formulas and cancel common terms. *(1)*

Take remaining terms and solve. *(1)*

Ans = 1 : 2.48 or 1 : 0.403

A8. Calculate the tension in the "string" below. The rod is experiencing compression parallel with its length.





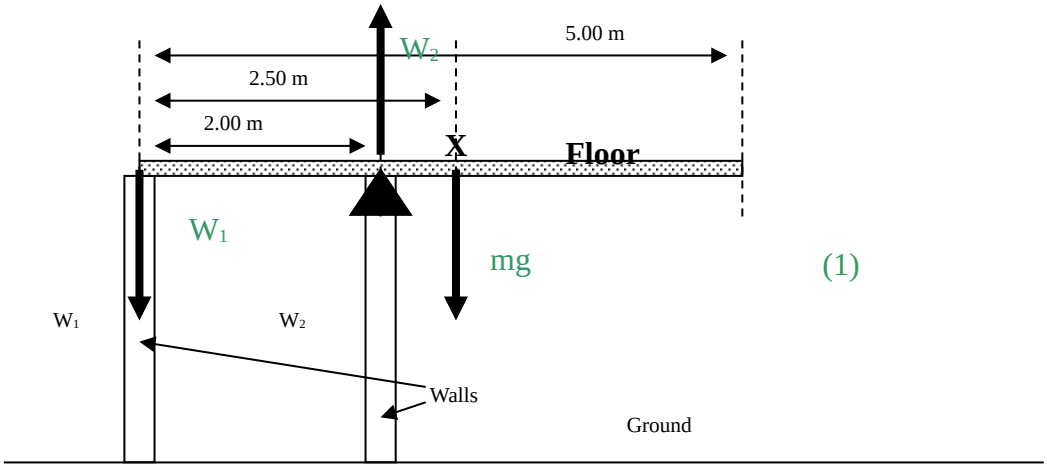
Angles (1)

30 x 9.8 = 294 N (1)

T / Sin (150) = 30 x 9.8 / Sin (60) *(1)*

T = 170 N *(1)*

A9. A house is being renovated and the owners have decided to put on a second storey. A floor has been placed onto some existing concrete walls. The floor extends over the edge of these walls to make a balcony as shown in the diagram below.



What is the magnitude and direction of the force on the wall (W_1) if the floor has a mass of 30 000 kg acting through its centre of mass marked X.

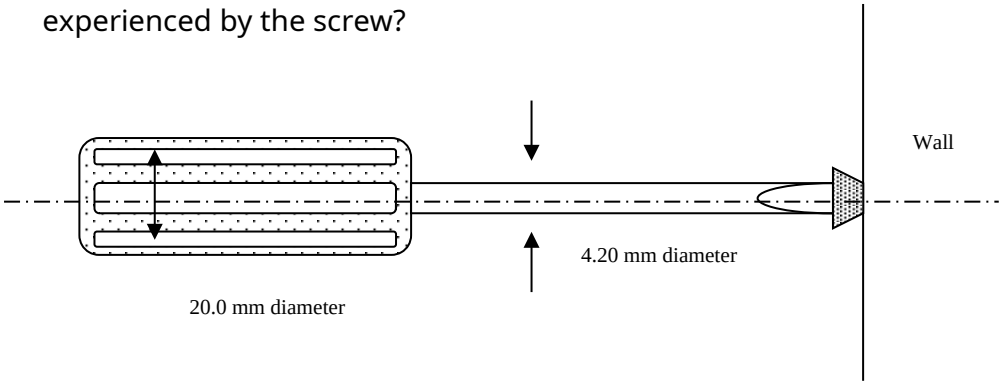
Take moments about pivot marked on diagram.

W1 x 2 = 30 000 x 9.8 x 0.5 (1)

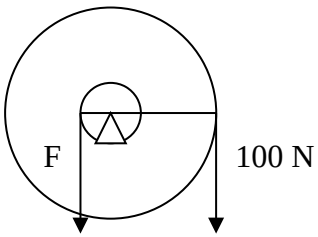
W1 = 7.35 x 10^4 down on the cantilever (1)

W1 = 7.35 x 10^4 up on the wall (1)

A10. A student is using a screw driver to tighten a screw into some wood. The dimensions of the screw driver are as shown in the diagram below. If the student is applying a force of 100 N to the handle of the screw driver to produce a turning effect, what will be the turning force experienced by the screw?



Redraw diagram



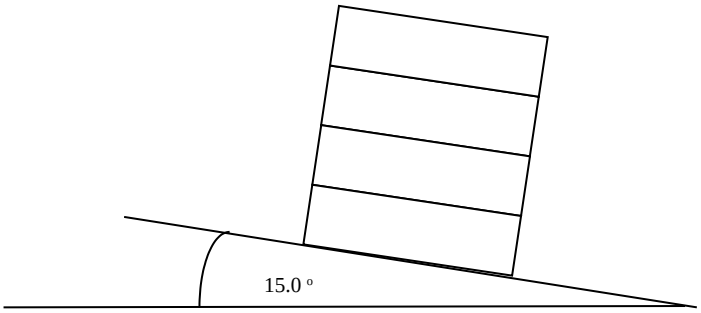
(1)

Moments clock = moments anti

$100 \times 10 \times 10^{-3} = F \times 2.1 \times 10^{-3}$ *distances (1)* *Equation (1)*

$F = 4.76 \times 10^{2}$ N *(1)*

A11. A student is playing with some wooden blocks. The student stacks the blocks on a surface that is inclined at an angle of 15.0 °. The blocks are 8.00 cm long and 2.00 cm high. The student initially constructs a tower that is 4 blocks high. Each block is uniform



a) Is the tower in...

mechanical equilibrium static equilibrium not in equilibrium?

(please circle 1 only)
(1 mark)

b) Is the tower in...

stable equilibrium unstable equilibrium

neutral equilibrium not in equilibrium

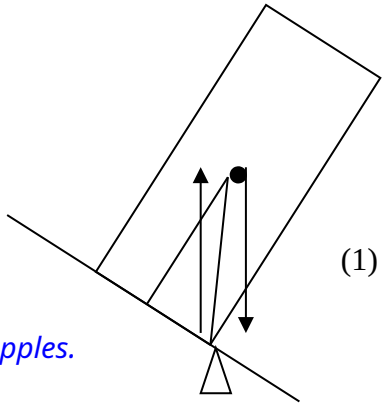
(please circle 1 only)
(1 mark)

c) The student now adds more blocks to the tower. Assuming that the blocks do not slide off each other; will the tower still be stable if 16 blocks in total are in the pile? Show calculations to support your answer.

(2 marks)

Triangle normal height to com = 16 cm

Half base = 4 cm *Form triangle (1)*
(or)
Toppling angle = 14.0^0 *(1)*



(1)

15 degrees is greater than 14 degrees so tower topples.
(1)

A12. A spring changes its length by 3.00 cm when a 500 g mass is hung from it. Assuming that the spring is still operating in its proportional region, how much energy is stored in the spring when 500 g is hung from it?

$E = ½ F x$ *(1)*

$E = 0.5 \times 0.5 \times 9.8 \times 0.03$ *(2)*

$E = 7.35 \times 10^{-2}$ J ***(1)***

A13 A 30.0 m length of steel cable has a Hooke's Law constant of 2.20×10^6 N m^{-1}. The diameter of the cable is 2.00 cm. A 10.0 m section of cable is cut from the original 30.0 m. 2000 kg is hung from the 10.0 m cable.

a) What is the Young's Modulus for the 30 m cable?

(2 marks)

$Y = F l/(A \Delta l)$

$F = (Y A / l) \times \Delta l$

$k = Y A / L$ *(1)*

$2.20 \times 10^6 = Y \pi 0.01^2 / 30$

$Y = 2.1 \times 10^{11}$ Nm^{-2} ***(1)***

b) By how much will 10.0 m cable stretch?

(2 marks)

$Y = F l/(A \Delta l)$

$2.1 \times 10^{-11} = 2000 \times 9.8 \times 10 / (\pi 0.01^2 \times \Delta l)$ *(1)*

$\Delta l = 2.97 \times 10^{-3}$ m ***(1)***

You are up to here

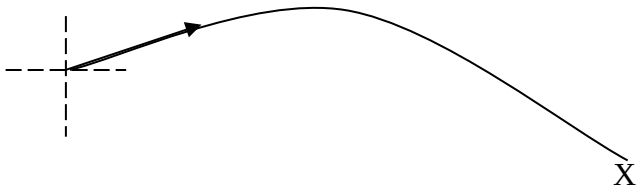
SECTION B : Problem Solving - 82 Marks (50%)

Attempt ALL 7 questions.

B1. (Total = 12 marks)

Sam has joined the circus and has been loaded into an air cannon. She is a human cannon ball! The cannon is pointed at an angle of 35.0 ° above the horizontal. The open end of the cannon is positioned 4.00 m above the ground and the net which will catch Sam is positioned 2.00 m above the ground. Sam's initial speed on leaving the end of the cannon is 13.0 m s^{-1}.

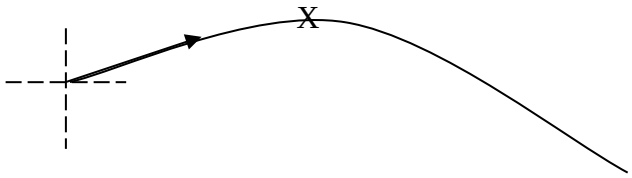
a) At what range from the cannon should the centre of the net be placed? (4 marks)



Vertical	***Horizontal***
	S_h = ?
$u_v = 13 \sin 35$	$u_h = 13 \cos 35$
	$u_h = s / t$
	$s_h = u_h \times t$ (1)
Need time	
$s = ut + ½ at^2$	
$v = u + at$	
$v^2 = u^2 + 2as$	
$s = ut + ½ at^2$ (1)	
$-2 = (13 \sin (35) \times t) + (1/2 \times -9.8 \times t^2)$	
Using solve mode	
$t = 1.75$ (1)	$s = u_h \times t$
	$s_h = 13 \cos (35) \times 1.75$
	$s_h = 18.7$ m (1)

b) What is the greatest height that Sam will achieve relative to the ground?

(4 marks)



Vertical	***Horizontal***
$u_v = 13 \sin 35$ $s = ut + ½ at^2$ $v = u + at$ $v^2 = u^2 + 2as$ $v^2 = u^2 + 2as$ (1) $0 = (13 \sin (35))^2 + (2 \text{ x} -9.8 \text{ x } s)$ (1) $s_v = 2.84$ m (1) *add on height of origin above round* ***6.84 m (1)***	

c) The barrel (tube) inside the cannon is 3.5 m long. If Sam has a mass of 90 kg while wearing safety equipment, what is the average force exerted on Sam as she accelerates continuously along the barrel of the cannon?

(2 marks)

F = ma

v = 13 m/s
u = 0 m/s
s = 3.5 m
a = ?

$v^2 = u^2 + 2as$
$13^3 = 0 + 2 \times a \times 3.5$

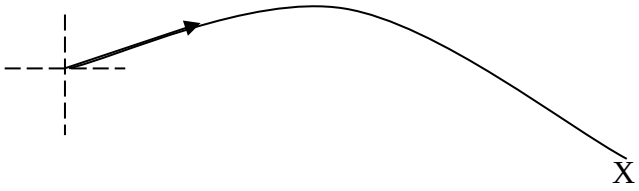
a = 24.1 m/s^2 along the barrel of the cannon. ***(1)***

F = ma
F = 90 x 24.1
F = 2.17 x 10^3 N along the barrel of the cannon. *(1)*

d) Unfortunately the performance circle in the centre of the circus tent is only

15.0 m in diameter. At what new angle must the cannon be pointed above the horizontal in order for Sam to make a safe landing in the net 15.0 m away from the open end of the cannon? Assume the speed at which Sam leaves the cannon is still 13.0 m s^{-1} and the open end of the cannon is still 4.00 m above the ground.

(2 marks)



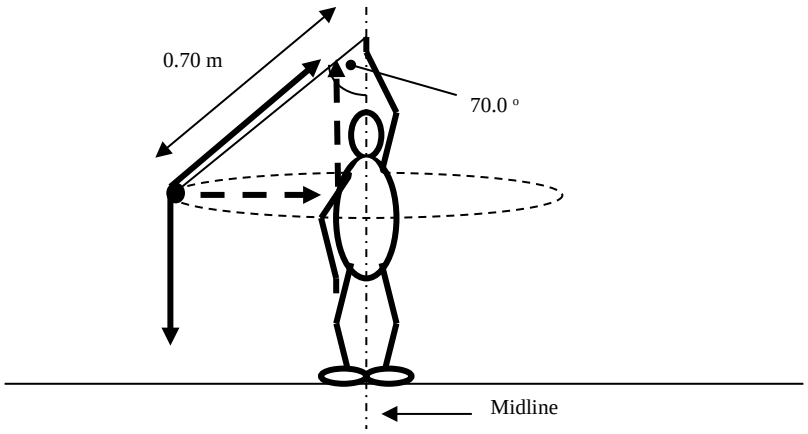
Vertical	***Horizontal***
$u_v = 13 \sin \theta$	$u_h = 13 \cos \theta$
$s = ut + ½ at^2$ $v = u + at$ $v^2 = u^2 + 2as$	$u_h = s / t$ $t = s_h / u_h$
$s = ut + ½ at^2$	$t = 15 / 13 \cos (\theta)$
$-2 = (13 \sin (\theta) \times t) + (1/2 \times -9.8 \times t^2)$	

Sub to eliminate t

$-2 = (13 \sin(\theta) \times (15 / 13 \cos(\theta))) + (1/2 \times -9.8 \times (15 / 13 \cos(\theta))^2)$ (1)
$-2 = (\tan(\theta) \times 15) - (4.9 \times 15^2 / (13^2 \cos(\theta)^2))$
Solve mode
$t = 19.6^0$ (1)Lower angle must be stated or they will hit the roof of the circus tent.

B2. **(Total = 12 marks)**

Alecia is playing the part of "David" in a biblical play called "David and Goliath". Alecia's character will swing a stone in a horizontal circle around her head on the end of a piece of string, and at just the right moment release the string to throw the stone at Goliath and kill him. Alecia does not know what the mass of the stone is.



a) The string attached to the centre of the stone is 0.70 m long. The string forms an angle of 70.0 ° with the vertical. What is the speed at which Alecia is swinging the stone?

(4 marks)

r = 0.70 Sin (70) *(1)*

Vertical	*Horizontal*
(-mg) + (T_v) = 0 *(1)* *T_v = mg* *T Cos (70) = mg* *T = mg / Cos (70)*	*T_h = m v^2 / r* *(1)* *T Sin (70) = mv^2 / r* *T = mv^2 / (r Sin (70))*

mg / cos (70) = mv^2 / (r Sin (70))

g / cos (70) = v^2 / (r Sin (70))

Tan (70) = v^2 / (r g)

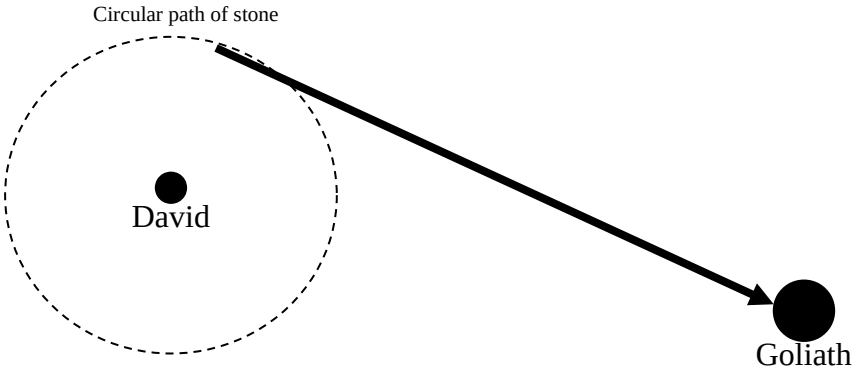
Tan (70) = v^2 / ((0.7 x sin (70))x 9.8)

v = 4.21 m/s ***(1)***

b) The stone is being swung in a clockwise direction when viewed from above. Mark onto the diagram the position of the stone when the string is released, if the stone is to successfully hit Goliath? Explain the reasoning behind your choice.

(2 marks)

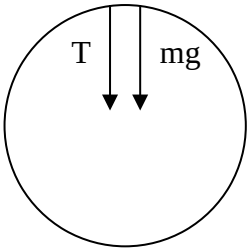
Top View diagram of "David and Goliath" situation



When the string is released, the sum of the forces becomes 0 in the horizontal. Accordng to newtons first law the object will maintain a constant velocity unless ther is an unbalanced force.

c) Alecia decides to change her swinging technique and now swings the stone in a vertical circle. Draw a free body diagram of all the forces acting on the stone at the top of the vertical circle.

(2 marks)



d) At what speed should the stone be swung if the tension in the string is to be twice the weight of the stone, when the stone is at the top of the circle?

(2 marks)

(- mg) + (- T) = - (mv^2 / r)

mg + T = mv^2 / r

mg + 2mg = mv^2 / r

3g = v^2 / r

3 x 9.8 = v^2 / 0.7

v = 4.54 m/s

e) The string will break when the tension in the string is equal to or greater than 7mg. Will the string break at the top of the circle or at the bottom of the circle? Explain?

(2 marks)

At the bottom ***(1)***

Top

-mg + -T = -mv^2 / r

T = (mv^2 / r) – (mg)

Bottom

-mg + +T = +mv^2 / r

T = (mv^2 / r) + (mg)

Tension is larger at the bottom of the circle is larger because the two terms are added. Not subtracted. *(1)*

B3. (Total = 11 marks)

While looking though a telescope Eloise discovers a solar system in which two stars are orbiting around each other. The first star has a mass equal to the earth's sun. The second star has a mass 4 times the mass of the earth's sun.

a) What is the average gravitational field strength at a distance of 10.0 astronomical units created by the combined mass of these stars? Note that 1 astronomical unit is equal to the distance from the earth to the sun.

(3 marks)

$r = 10 \times 1.5 \times 10^{11}$ m

$r = 1.5 \times 10^{12}$ m *(1)*

$g = G m / r^2$ *(1)*

$g = 6.67 \times 10^{-11} \times 5 \times 1.99 \times 10^{30} / (1.5 \times 10^{12})^2$

$g = 2.95 \times 10^{-4}$ ms^{-2} ***(1)***

b) The small star takes 1 minute to orbit the larger star. What is the distance at which the centre of the smaller star is orbiting the centre of the larger star?

(4 marks)

$r^3 / T^2 = G m / (4 pi^2)$ *(1)*

$r^3 / 60^2 = 6.67 \times 10^{-11}$ 4 x 1.99 x $10^{30} / (4 pi^2)$ *(2)*

$r = 3.64 \times 10^7$ m *(1)*

c) What is the force of attraction between the two stars?

(4 marks)

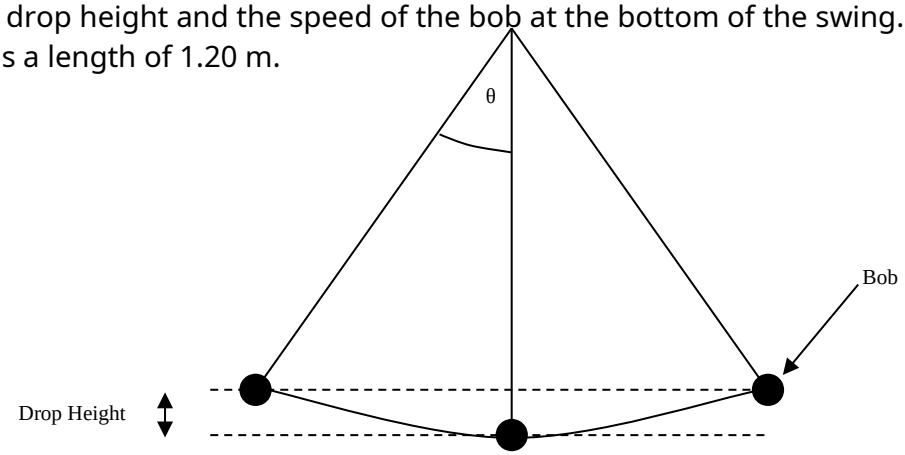
$F = G\ m_1\ m_2 / r^2$ *(1)*

$F = 6.67 \times 10^{-11}\ 4 \times (1.99 \times 10^{30})^2 / (3.64 \times 10^{7})^2$ *(2)*

$F = 7.95 \times 10^{35}$ N ***(1)***

B4. (Total = 10 marks)

A pendulum is being tested. The student changes the angle that the pendulum makes with the vertical and then measures the maximum speed of the bob which occurs at the bottom of the swing. Changing the angle alters the height through which the bob falls. The student wishes to determine the relationship between drop height and the speed of the bob at the bottom of the swing. The string has a length of 1.20 m.



a) Predict, using the law of conservation of energy, the speed of the bob when the pendulum is dropped through a height of 16.0 cm.

(2 mark)

$mgh = ½ mv^2$
$gh = ½ v^2$

$9.8 \times 0.16 = 0.5 \times v^2$ (1)

$v = 1.77\ m\ s^{-1}$ (1)

b) Rearrange the law of conservation of energy to form a relationship between the independent variable "h" and the dependant variable "v"

(2 mark)

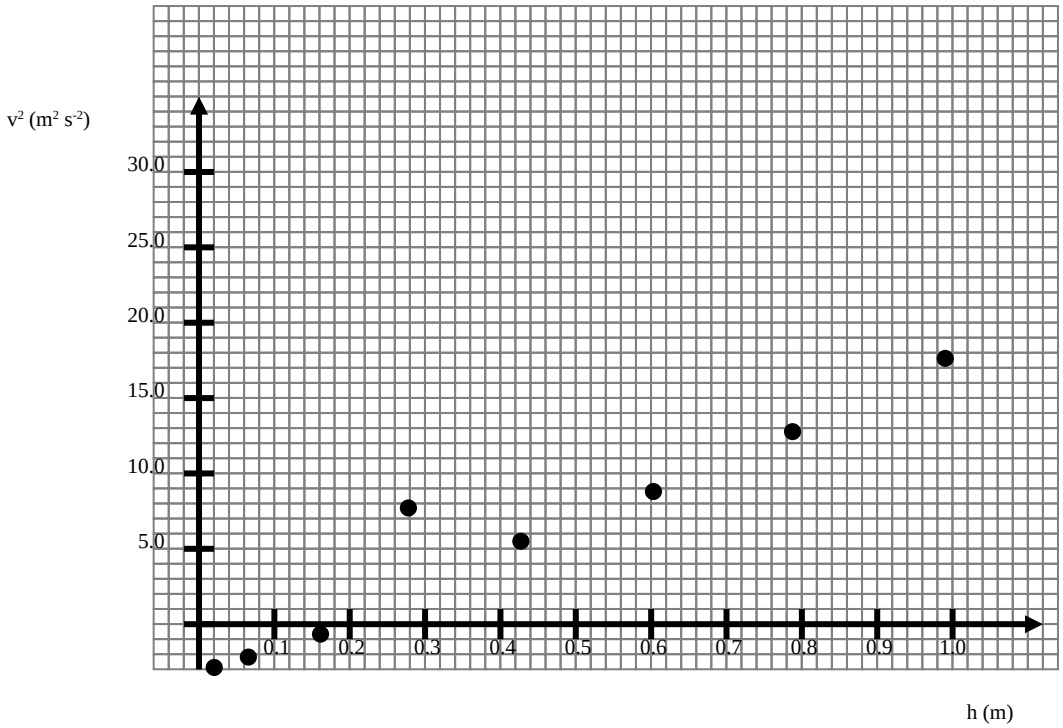
$mgh = ½ mv^2$
$gh = ½ v^2$
$v = (2\ g\ h)^{(1/2)}$ or $v^2 = 2\ g\ h$ (2)

The data is as shown in the data table below and then graphed on the next page.

Angle	Degrees	10	20	30	40	50	60	70	80
Drop Height	(m)	0.018	0.072	0.161	0.281	0.429	0.6000	0.790	0.992

Speed	(m/s)	0.60	1.19	1.78	3.25	2.90	3.43	3.93	4.41
Speed^2	$(m/s)^2$	0.36	1.41	3.17	10.56	8.41	11.76	15.44	19.45

Graph of the relationship between v^2 and h.



c) From the graph mathematically determine the slope of the line

(2 marks)

Slope = rise / run = 19.6 (from graphics calculator) (2)

d) Algebraically what does your answer from part c) represent in the formula stated in part b)?

(2 mark)

The slope represents (2 x g)

e) What are the units of the slope of the line?

(2 mark)

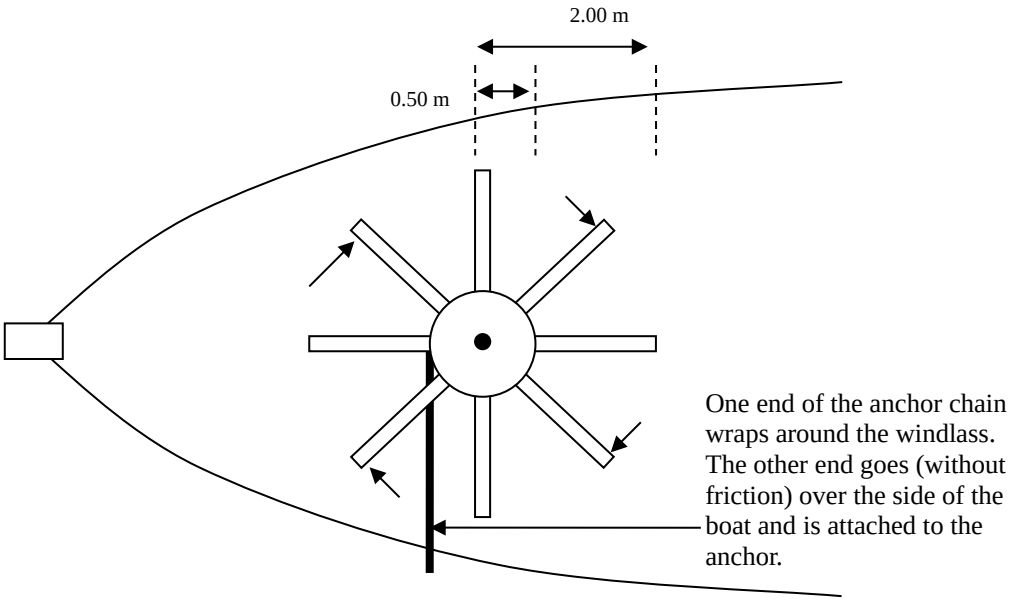
Slope = v^2 / h (1)

Slope = $m^2 s^{-2}$ / m

Slope = $m s^{-2}$ (1)

B5. (Total = 10 marks)

A group of students have taken a trip on a replica of an old fashioned tall ship (sailing ship). The ship contains a windlass which is used to pull up the anchor. A top view of the windlass is shown below.



The students are all equally strong and push on the ends of the bars in a clockwise direction to hoist (lift) the anchor. The anchor is initially stationary.

a) The anchor has an apparent mass of 600 kg when immersed in water. Four (4) students each applying a force of 200N to the ends of the handles will not be enough to raise the anchor? Explain with the support of calculations why.

(3 marks)

Moments clock = Moments anti (for equilibrium)

$4 \times (200 \times 2.0) = 0.5 \times 600 \times 9.8$ (1)

$1.60 \times 10^3 \neq 2.940$ (1)

Anchor can not be lifted because the anticlockwise moment is too large. (1)

b) How many students each pushing with a force of 200N on the ends of the handles at right angles to the handle will be required to lift the anchor. Please state your answer as a whole number.

(2 marks)

n x (200 x 2.0) = 0.5 x 600 x 9.8 *(1)*

n = 7.35

n = 8 *(1)*

c) With the students in part b) applying their forces at the ends of the handles, and ignoring friction, at what rate of acceleration does the anchor rise from the sea floor? Explain with the support of calculations.

(3 marks)

Difference in clockwise and anti clockwise torque results in net torque causing acceleration.

8 x (200 x 2.0) - 0.5 x 600 x 9.8 = net torque

net torque = 2.60 x 10^2 *(1)*

net force = 2.60 x 10^2 / 0.5

net force = 5.20 x 10^2 N *(1)*

Net acceleration = 5.2 x 10^2 / 600 = 0.867 m/s *(1)*

d) The anchor is to be raised at a constant velocity. To achieve this, the students need to reduce their torque. They decide to change the position at which they exert their force on the handles. How far along each handle from the centre of the windlass should the students push? Assume that each student continues to push with a force of 200 N.

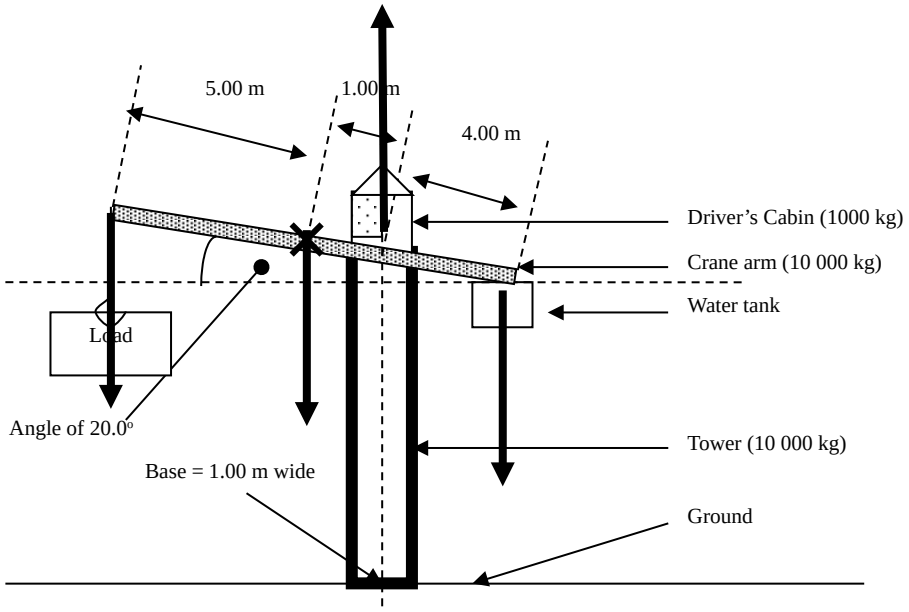
(2 marks)

8 x (200 x r) = 0.5 x 600 x 9.8 *(1)*

r = 1.84 m *(1)*

B6. (Total = 15 marks)

An engineering student has designed a new crane which uses the weight of water to counterbalance the torque of heavy loads. The design is shown below.



Water is pumped from the water supply to the water tank at the right hand end of the crane arm to balance the load placed onto the hook of the crane. The driver's cabin exerts no force on the crane arm. The crane arm is uniform and has a mass of 10 000 kg acting at its centre at point X. The crane arm makes an angle of 20.0° with the horizontal.

a) Draw all forces acting **on** the crane arm in the diagram above. (assume all forces are purely vertical)

(1 mark)

All forces required but not necessarily labelled. (1)

b) What type of static equilibrium is the crane in? Explain.

(2 marks)

Stable (1) – the center of mass of the crane system must act through its base or it will topple. (1). The crane is not circular – not neutral. The crane does not have a point base – not unstable

c) When the crane is not carrying a load, the weight of the crane arm is balanced by the weight of the empty water tank. What is the weight of the empty water tank? Assume that the crane hook and cables are weightless.

(3 marks)

Take moments about center of tower to eliminate normal force

Moments Clock = Moments Anti

Method 1

$4 \times F_{(tank)} \cos(20) = 1 \times 10\,000 \times 9.8 \cos(20)$ *(2)*

$\boldsymbol{F_{(tank)} = 2.45 \times 10^4\ N}$ ***(1)***

d) The crane now lifts and holds a 2000 kg elephant a short distance above the ground. What weight of water must be **added** to the water tank to counterbalance the load?

(4 marks)

$4 \times F_{(tank)} \cos(20) = [1 \times 10\,000 \times 9.8 \cos(20)] + [2000 \times 9.8 \times 6 \times \cos(20)]$ (2)

$F = 5.39 \times 10^4$ N (1)

*Increase in weight due to water = 5.39×10^4 N - **2.45×10^4***

Weight of water = 2.94×10^4 N (1)

e) If each litre of water has a mass of 1 kg. How many litres of water does this represent?

(2 marks)

Weight = mg
$2.94 \times 10^4 = m \times 9.8$ (1)

$m = 3.00 \times 10^3$ kg (1)

f) What is the force that the crane arm exerts on the tower when the crane is holding the elephant and water as described in part d)?

(3 marks)

Sum of forces = 0

F up = F down

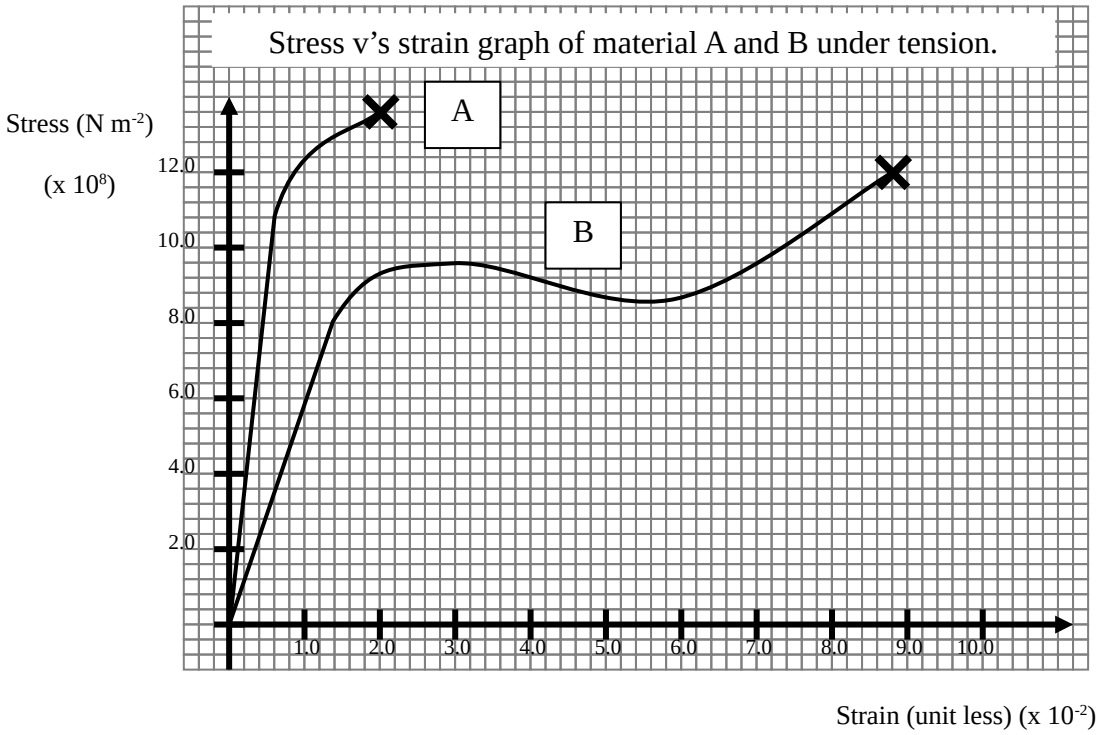
$N = 5.39 \times 10^4 + (10\,000 \times 9.8) + (2000 \times 9.8) = N$ (1)

$N = 1.72 \times 10^5$ N up on the crane arm

$N = 1.72 \times 10^5$ N down on the tower (2)

B7. (Total = 12 marks)

Below is a stress strain graph for two materials. Both materials are cylindrical in shape, with a length of 30.0 cm and a cross sectional area of 78.5 mm^2.



a) Which material, A or B has the greater ultimate strength? Explain

(2 marks)

A – snaps at the highest stress

b) Which material, A or B is tougher? Explain.

(2 marks)

B – It has a greater area under the curve and so can absorb more energy.

c) Name a material that will produce a similarly shaped graph to A and B above

(2 marks)

A ____Glass _____ B ___Copper _____

d) For what range of strain values is material B behaving plastically?

(1 mark)

(3.0 → 8.8) x 10^{-2} strain

e) What is the Young's Modulus of the brittle material?

(2 marks)

Material A

Y = rise/ run

$Y = 10.8 \times 10^{8} / 0.6 \times 10^{-2}$ *(1)*

$Y = 1.80 \times 10^{11}$ N m^{-2} *(1)*

f) Mark the proportional limit on both graphs with a star (*). Which graph, A or B, stores more energy in its proportional region. Support your answer with calculations for both graphs.

(3 marks)

Star markings = 1 mark total (½ mark each)

Energy is proportional to area – which ever has the larger area has the larger stored energy

Area A = ½ $10.4 \times 10^{8} \times 0.6 \times 10^{-2}$ *(1)*

Area A = 3.12×10^{6} area units

Area B = $8. \times 10^{8} \times 1.4 \times 10^{-2}$ *(1)*

Area B = 5.60×10^{6} area units

B has the larger area and so the larger energy stored *(1)*

SECTION C : Comprehension and Interpretation - 33 Marks (20%)
Read the passage below carefully and answer all of the questions at the end of the passage. Candidates are reminded of the need for correct English and clear and precise presentation of answers.
Show all working out for questions requiring numerical answers.

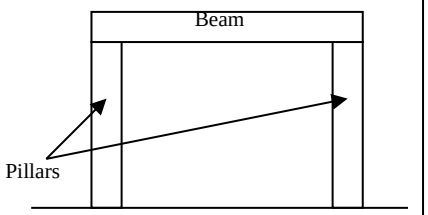
Spanning a gap in a wall to create a doorway

---

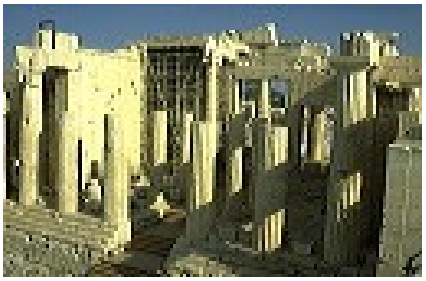
an age old problem.

A building is of little use if you can not get in or out. Unfortunately if you make a doorway or hole in a wall, the building materials above the door tend to fall in on your head shortly after followed by the roof collapsing. Consequently the wall and roof above a doorway need to be supported by some "strong structure" or device to transfer the weight of the building material above the doorway to the walls on either side.

Beam and Pillars
A stone beam and two pillars was the first attempt at solving this problem. The stone pillars on the sides worked well, but the stone beam above the doorway tended to crack in the middle and fall in. It is for this reason that so many ancient structures using this method of construction have the beam missing and only the pillars remaining.



Beam and Pillars



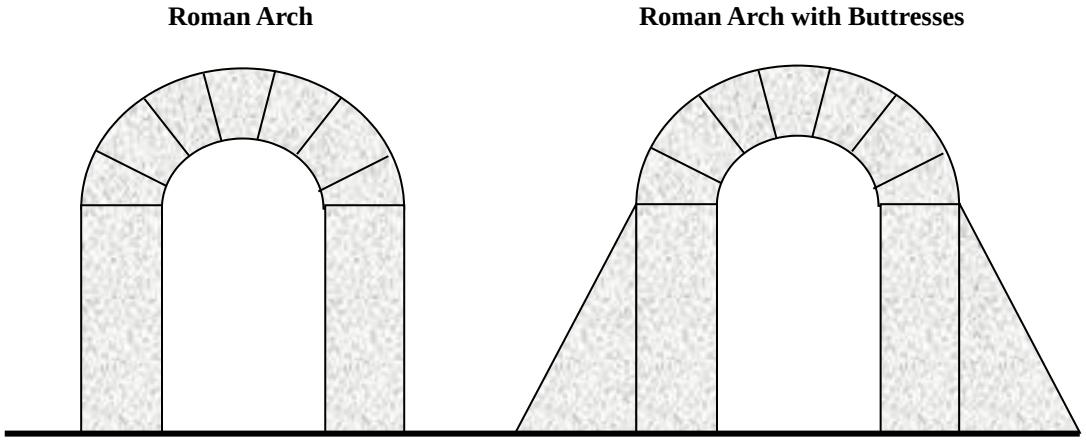
Pillars near Acropolis
acropropylaia/index.html 2/5/2008

Wood was tried as an alternative material for the beam to stone. The wood was harder to crack but suffered from rot and pestilence not to mention combustion. It also tended to expand and contract as the season changed, resulting in lateral, cracking forces on the pillars.

Arches

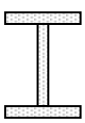
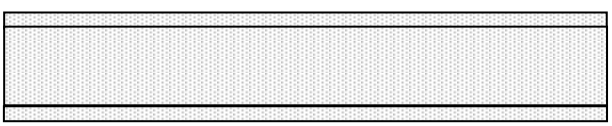
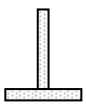
Next, in a stroke of genius, the archway was invented. The stones of the arch were capable of withstanding the weight of the wall and roofing materials above the gap without cracking. Unfortunately, the weight forces had to be borne by some part of the structure. The pillars or walls took the load, tending to topple if too slender. Buttresses were used to reinforce the pillars or walls to transfer the weight force to ground with a minimum of toppling effect.

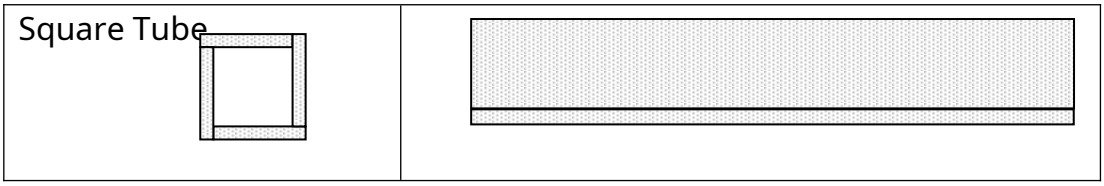
The arch had cracked the problem. Many arches still stand today from the ancient world. They were expensive and slow to build, requiring skill and carefully designed scaffolding. The stone from which they were made (like the rest of the building) was heavy and difficult to transport and shape.



Steel Beams or Girders

As peoples ability to extract and refine metals progressed, steel (iron) became an expensive possibility as a building material. Steel beams or girders as they are called are capable of withstanding large bending forces. Moisture and precipitation slowly converts steel to rust unfortunately, weakening metal structures. Rusting can be reduced by painting and chemical means but requires expensive ongoing maintenance.

End View	Side View
I Beam 	
T Beam 	

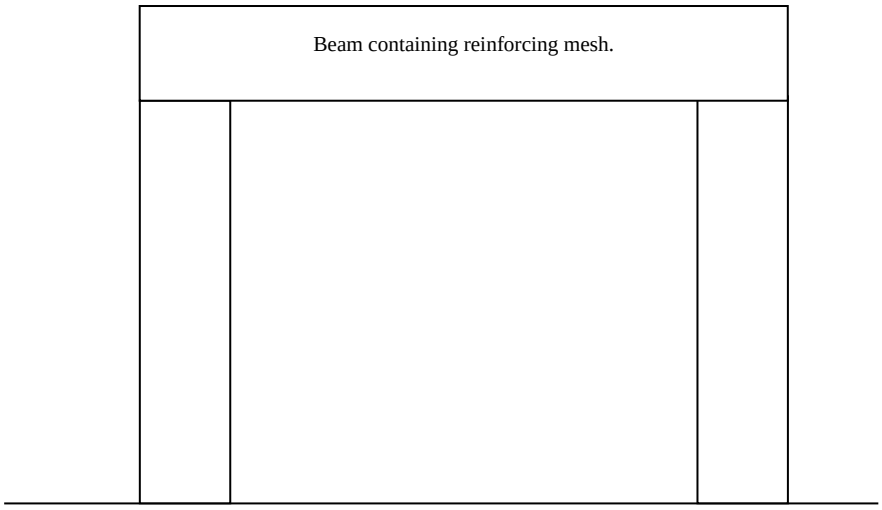


Pictures of Steel Beams

If only stone beams were not so prone to cracking…

Reinforced Concrete

Concrete (artificial stone) whose ingredients can be transported more easily in bags, mixed and molded into shape in its final resting place, developed in parallel with advancements in steel refining. Like natural stone however, pure concrete still suffered from cracking when spanning a gap. Steel mesh or cables were added to reinforce / strengthen the concrete to reduce its tendency to crack, so creating a hybrid material that could withstand tension and compression. Reinforced concrete is now the favoured building material of many but not all architects.

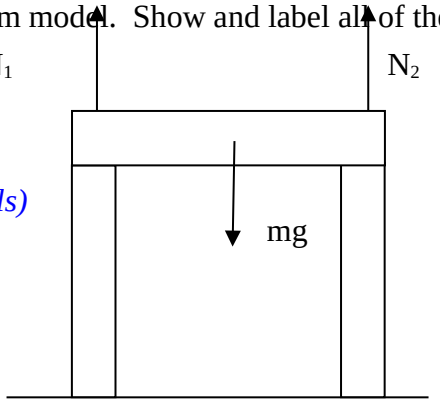


So, the next time you walk in a door, look up and consider what structure stops the roof falling in on you.

Questions

1. Draw a pillar and beam model. Show and label all of the forces acting on the beam.

(3 marks)

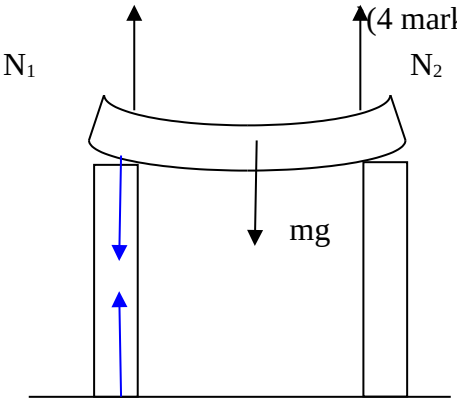


1 mark per force (with labels)

2. In a pillar and beam model made from natural stone, why is it that over time the beam cracks but the posts do not? Use diagrams to assist your explanation.

(4 marks)

lower surface of beam under tension due to sag. Stone can not handle tension and so cracks. (1)
(1)posts not under tension and so don't crack
(2) - diagrams



3. If a builder has to use a beam made from natural stone, what 2 things can the builder do to reduce the bending and cracking. Support your explanation with diagrams.

(4 marks)

Make the beam thicker from top to bottom. Diagram longer distance for crack to travel (2)

Put the posts closer together to reduce the sag. Diagram less bending = less tension = less cracking (2)

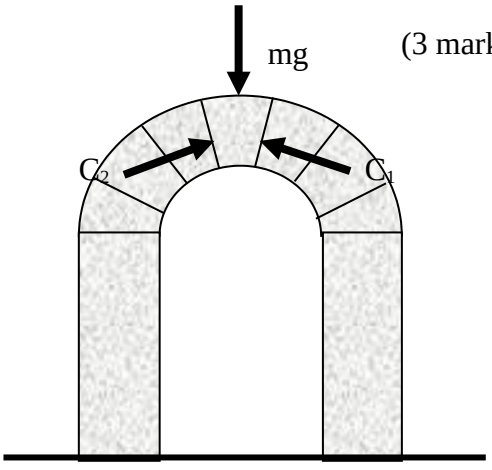
4. Why does the stone in an arch not crack? Explain by analyzing any **one** stone in the diagram provided.

(3 marks)

1 mark - diagram

All forces acting on the key stone are compression forces. (1)

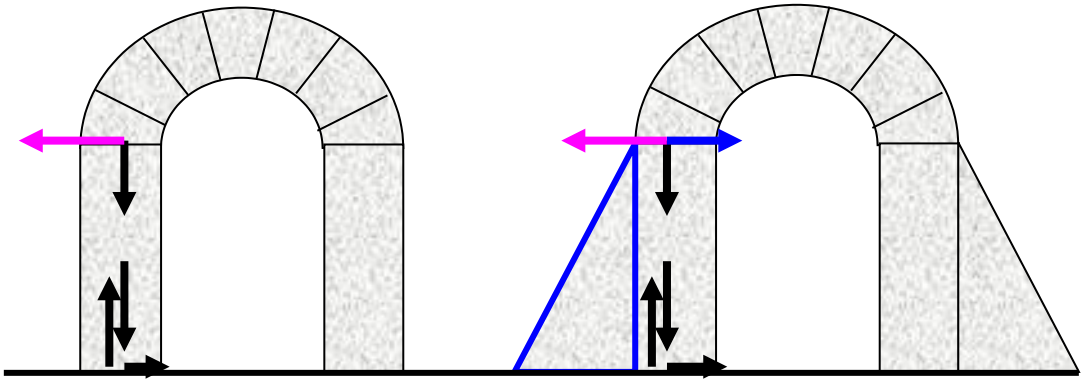
Stone can withstand compression and so the stone does not crack. (1)



5. Why do the pillars of an arch tend to topple unless buttresses support them? Explain using the diagrams provided.

(4 marks)

Roman Arch **Roman Arch with Buttresses**



2 marks for diagrams

The combination of the forces acting at the top of the pillar produce a force that does not act through the base of the pillar. This induces a moment at the top of the pillar that is large than the moment created by the weight force acting through the base of the pillar. The pillar topples.

If a buttress is used the combination of forces acting at the top of the pillar acts through he base of the buttress and so the pillar doesn't topple. Alternatively the buttress provides a counterbalancing moment to oppose the moment created by the arch. This maintains static equilibrium.

(2 marks for explanation)

Summary – version 1 – arch creates toppling force / moment. Buttress provides counter-balancing moment.

Summary – version 2 – combination of vertical and horizontal forces at top of pillar produces force not acting through base of pillar → toppling. Buttress increases size of base and so avoids toppling.

6. Name one advantage and one disadvantage for each of the following materials when it is used as a building material.

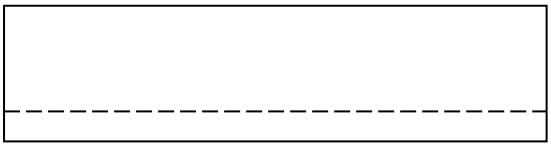
(6 marks)

Material	Advantage	Disadvantage
Natural Rock or Concrete	*String under compress* *Withstands weathering* *Relatively cheap*	*Heavy* *Poor under tension*
Metal	*Strong under tension and compression*	*Rusts* *High maintenance to prevent rust*
Reinforced Concrete	*Cheep* *Good under T and compression*	*Heavy* *Concrete cancer if not properly manufactured*

(1 mark per correct answer)

7. Draw a reinforced concrete beam. Explain the purpose and reason for the location of the reinforcing.

(4 marks)



Labelled diagram *(1)*

Reinforcing in lower portion *(1)*

Explanation as to why in lower portion *(1)*

Explanation as to why not in upper portion *(1)*

8. A free standing concrete beam and pillars is to be used at the entrance to a school car park frequented by many learner drivers. Would you put reinforcing in the pillars as well as the beam? Explain why or why not?

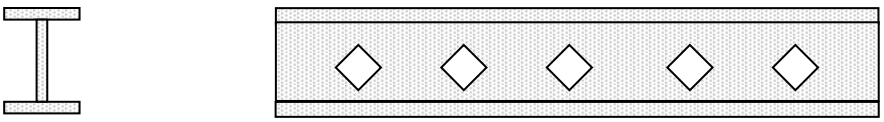
(2 marks)

Yes *(1)*

Drivers colliding with the pillars will induce a bending effect on the posts causing tension and compression as the post bends over. The tension created in the bending of the post could cause cracking. *(1)*

9. A builder wishes to use an "I" beam with diamond shapes cut out of the middle section (web). Will the beam still be safe to use? Explain.

(3 marks)



Yes *(1)*

The web does not take the majority of the force and so can afford to be weaker / thinner. *(1)*

The web contains the neutral line or line of no tension or compression force. *(1)*

END OF EXAM