

# PHYSICS

Insert School Logo

## UNIT 3 2020

Name: \_\_\_\_\_

Teacher: \_\_\_\_\_

### ***TIME ALLOWED FOR THIS PAPER***

Reading time before commencing work: Ten minutes

Working time for the paper: Three hours

### ***MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER***

#### **To be provided by the supervisor:**

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

#### **To be provided by the candidate:**

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

### ***IMPORTANT NOTE TO CANDIDATES***

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

## Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Short answer	10	10	50	54	30
Section Two: Extended answer	6	6	90	90	50
Section Three: Comprehension and data analysis	2	2	40	36	20
			<b>Total</b>	180	100

### Instructions to candidates

- The rules for the conduct of Western Australian external examinations are detailed in the *Year 12 Information Handbook 2019*. Sitting this examination implies that you agree to abide by these rules.
- Write answers in this Question/Answer Booklet.
- When calculating numerical answers, show your working or reasoning clearly. Give final answers to **three** significant figures and include appropriate units where applicable.  
  
When estimating numerical answers, show your working or reasoning clearly. Give final answers to a maximum of **two** significant figures and include appropriate units where applicable.
- You must be careful to confine your responses to the specific questions asked and follow any instructions that are specific to a particular question.
- Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.
  - Planning: If you use the spare pages for planning, indicate this clearly.
  - Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Refer to the question(s) where you are continuing your work.

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

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

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

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

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

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.

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- 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 that you are continuing to answer at the top of the page

Suggested working time for this section is 50 minutes.

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**Question 1**

Two positively charged point charges of magnitude (in Coulombs) ' $q_1$ ' and ' $q_2$ ' are separated by a distance ' $d$ ' and experience an electrostatic force ' $F$ '.

The charge sizes are changed to ' $2q_1$ ' and ' $3q_2$ ' and the distance is reduced to ' $0.50d$ '. Calculate an expression for the electrostatic force between these two charges in terms of ' $F$ '.

(3 marks)

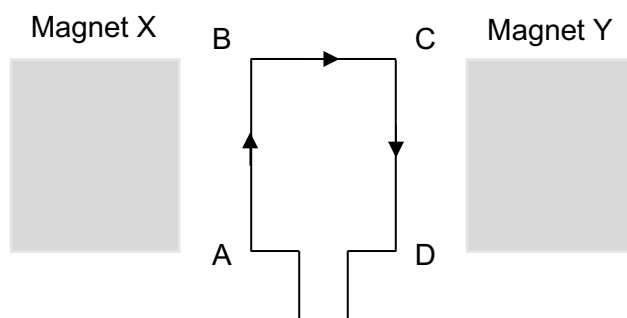
**Question 2**

Planet X and Planet Y orbit the same Sun. Planet X has a mass 'M' and a radius equal to 'R'. The value of 'g' on its surface is equal to  $7.80 \text{ N kg}^{-1}$ . Planet Y has a mass of '1.5M' and radius of '1.1R'. Calculate the value of 'g' on the surface of Planet Y.

(5 marks)

**Question 3**

The diagram below shows the structure of a simple DC Motor. A rectangular coil (ABCD) consisting of a single loop is sitting in a magnetic field created by the poles of two bar magnets (X and Y).



- a) As shown by the arrows on the coil, at a particular instant in time, conventional current flows from A to D. At this instant, side AB experiences a force OUT OF THE PAGE and side CD experiences a force INTO THE PAGE. In the spaces provided below, write down the polarity (North or South) of Magnets X and Y that would create these forces.

(1 mark)

MAGNET X: \_\_\_\_\_ MAGNET Y: \_\_\_\_\_

The dimensions of the coil are as follows:  $AB = CD = 20.0 \text{ cm}$ ;  $BC = AD = 10.0 \text{ cm}$ . The current flowing is equal to  $1.50 \text{ A}$  and the strength of the magnetic field is  $0.400 \text{ T}$ .

- b) Calculate the torque acting on the coil when it is in this position.

(3 marks)

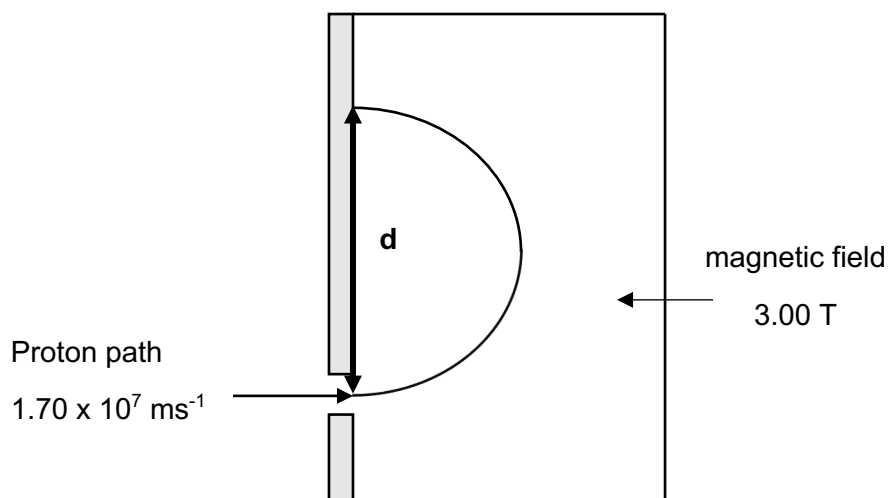
- c) On the set of axes below, SKETCH how the torque experienced by this simple DC motor would vary over the course of ONE FULL ROTATION. Assume that a commutator is present in the motor and the coils starts in the position shown in the diagram above.

(2 marks)



**Question 4**

A proton with a speed of  $1.70 \times 10^7 \text{ ms}^{-1}$  enters a mass spectrometer which has a magnetic field of 3.00 T. It is bent into a circular arc by this magnetic field and crashes into the detector as shown below. In the questions that follow, ignore relativistic effects.



- a) On the diagram, in the region labelled 'magnetic field', draw the direction of the field that would bend the protons into the path shown.

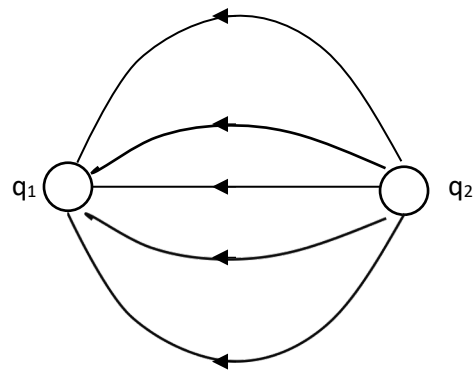
(1 mark)

- b) Calculate the distance 'd' shown on the diagram. Show working.

(4 marks)

**Question 5**

The diagram below shows a partially completed electric field diagram for two point charges  $q_1$  and  $q_2$ .



- a) Describe the polarity of charges  $q_1$  and  $q_2$ .

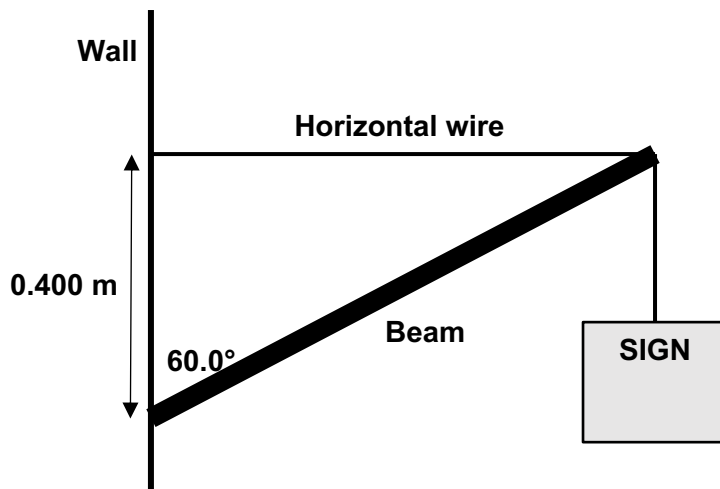
(2 marks)

- b) Draw six (6) more flux lines to complete the electric field diagram.

(3 marks)

**Question 6**

A 20.0 kg sign is hung off the end of a uniform beam of length 80.0 cm and mass of 15.0 kg. The beam is fixed to the wall and forms an angle of  $60.0^\circ$  to the vertical as shown in the diagram below. It is held in place by a horizontal wire which can safely withstand a maximum tension of 200 N.



- a) Will the wire snap? Answer by calculating the tension 'T' in the horizontal wire when it holds the beam in the position shown. Show working.

(4 marks)

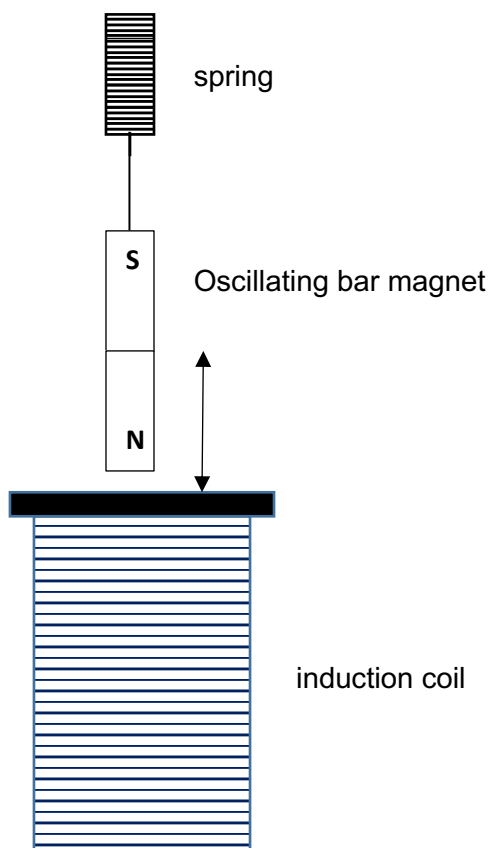
- b) In which direction (clockwise or anticlockwise) would the beam have to rotate to put the wire at more risk of snapping under tension? The wire remains in a horizontal position during the rotation. Briefly explain.

(2 marks)



**Question 7**

A student sets up the equipment below to study electromagnetic induction.



The bar magnet is initially pulled downwards, stretching the spring. It is then allowed to oscillate freely in an upwards and downwards direction as indicated by the arrow in the diagram. When the spring is fully stretched, the magnet is in the middle of the coil. After a short period of time, the student notices that the oscillation of the bar magnet ceases.

For the questions that follow, losses of energy in the spring and due to air resistance can be considered to be negligible.

- a) Consider the bar magnet as it moves in an UPWARDS direction out of the induction coil. On the coil in the diagram, draw an arrow to indicate the direction (ie – to the left or right) of the conventional current induced.
- b) As time proceeds, the student notices that the amplitude of the magnet's oscillation DECREASES to zero. Explain why using electromagnetism concepts.

(1 mark)

(3 marks)

- c) On the set of axes below, sketch how the induced EMF in the induction coil will change until it reaches a value of zero. Assume it starts in the position described in the introduction to this question.

(4 marks)



### Question 8

The manufacturer of a CD-ROM claims that their machine can make a circular CD rotate at 1200 revolutions per minute. A particular CD is covered with specks of dust.

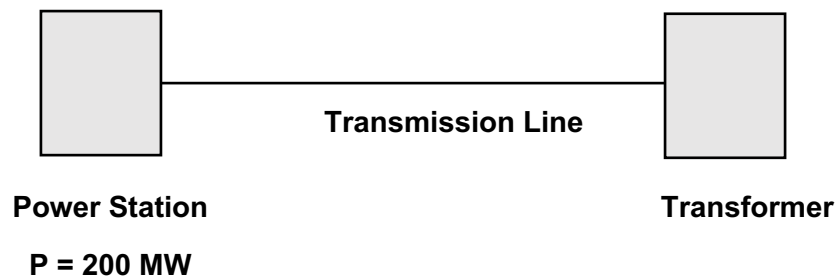
A speck of dust is far more likely to fly off the CD when it is at the outer edge of the disk than when it is closer to its centre. Explain.

(5 marks)

**Question 9**

A power station generates electric power at a rate of  $2.00 \times 10^2$  MW. The power is transmitted along a 40.0 km long transmission line to a transformer at voltage of 220 kV. The line has a resistance rating of  $0.15 \Omega\text{km}^{-1}$ . Calculate the voltage delivered to the primary coil of the transformer at the end of this transmission line. Show working.

(5 marks)



**Question 10**

Khai is playing soccer in the driveway of his home. The driveway slopes upwards at an angle of  $8.00^\circ$  to the horizontal. He kicks the ball at such a speed that it eventually rolls back down the driveway to his feet.

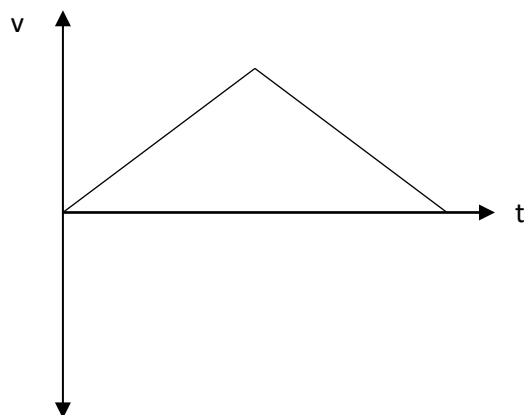
- a) Calculate the acceleration experienced by the ball when it is on the slope. Include direction. Show working.

(3 marks)

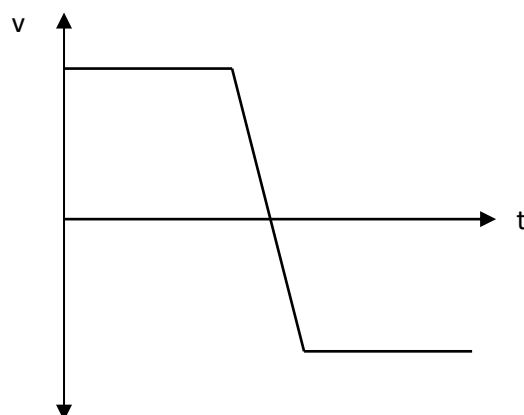
**Question 10(b) continues on the next page.**

- b) Which one the following graphs best describes the velocity of the soccer ball as it rolls up and down the slope. Briefly explain your answer.

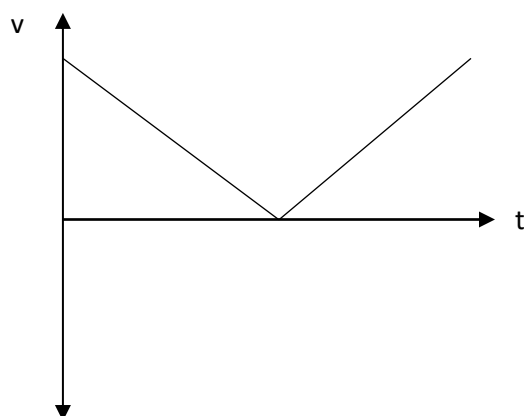
(3 marks)



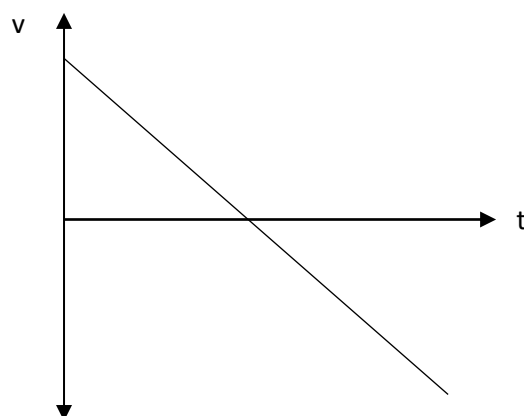
GRAPH 1



GRAPH 2



GRAPH 3



GRAPH 4

CHOICE: \_\_\_\_\_

EXPLANATION OF CHOICE:

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

This section has **six (6)** 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.

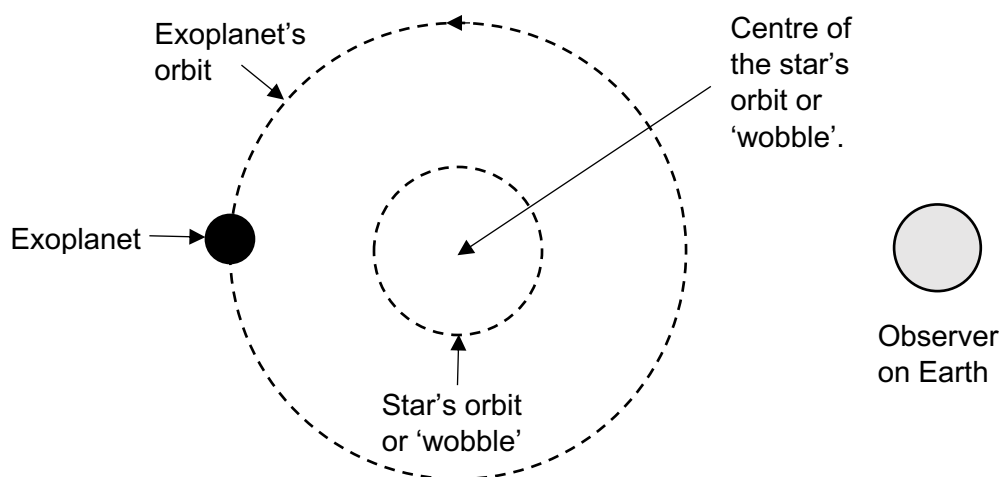
- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question that you are continuing to answer at the top of the page.

Suggested working time for this section is 90 minutes.

**Question 11****(18 marks)**

One branch of astronomy involves the search for exoplanets – planets that are orbiting stars outside of our own Solar System. One way this is done is using a method called ‘watching for the wobble’ in the radial velocity of a star. In short, if an orbiting exoplanet’s mass is significant compared to the star’s mass, it can affect the motion of the star and cause it to ‘wobble’ or rotate around the central point of the planet’s orbit in a periodic way in space. This motion, in turn, can cause the spectra of the light observed from these stars to also change in a periodic way.

The diagram below illustrates this phenomenon by showing two motions: the orbit of an exoplanet (outer circle in an anticlockwise direction); and the ‘wobble’ motion of the star due to the exoplanet’s orbit around it (inner circle).



- a) Describe how this ‘wobble’ in the star’s motion is caused by an exoplanet. State the force responsible for this.

(3 marks)

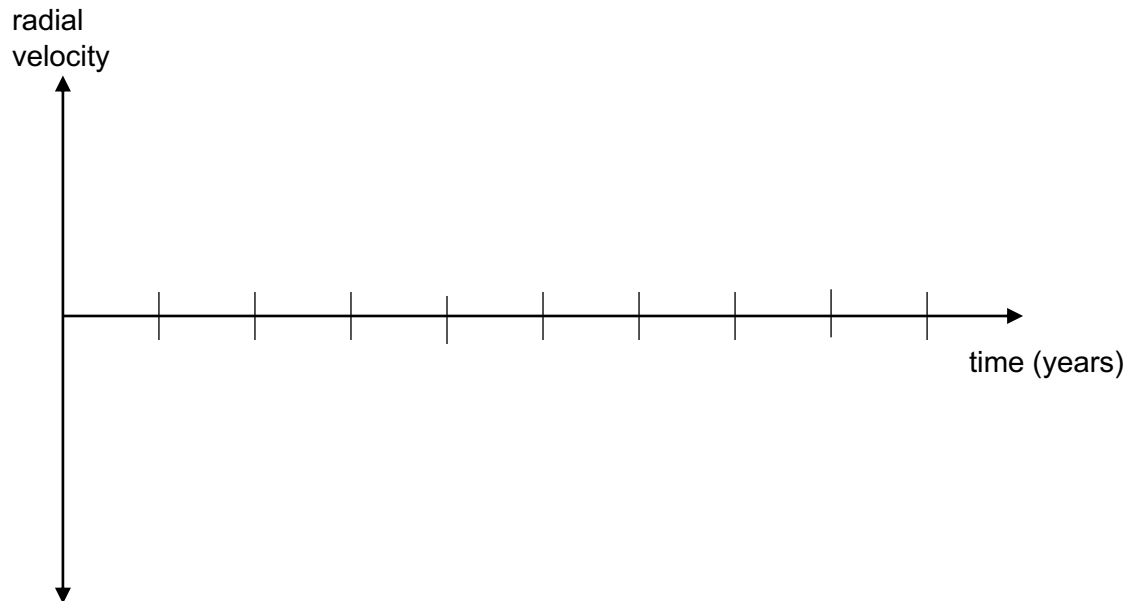
- b) At the instant shown, on the diagram, draw the position of the star and an arrow showing the direction of the star's 'wobble' or revolution. (2 marks)
- c) (i) Compare the 'wobble' of a star observed for a small orbiting exoplanet and a large orbiting exoplanet. Explain your answer. (3 marks)

- (ii) Compare the period of the star's 'wobble' (ie – circular rotation due to the 'tug' of the exoplanet) to that of the exoplanet orbiting it. Explain your answer. (2 marks)

An exoplanet called 18 Delphini b was discovered in 2008 by the radial velocity method described in this question. This exoplanet orbits around a yellow star called Delphini b in the constellation of Delphinus which is about 250 million light years from the Earth. 18 Delphini b has an orbital period of about 3 years around Delphini b.

The diagram at the beginning of this question includes the position of an observer on Earth. This observer measures the 'radial velocity' of the star Delphini b; the radial velocity is equal to the speed of the star relative to Earth as it 'wobbles'.

- d) On the set of axes below, sketch a graph of **radial velocity  $v$  time for Delphini b** as measured from the Earth. An accurate scale for time (in years; on the horizontal axis) must be provided; no scale is required for radial velocity.
- (3 marks)

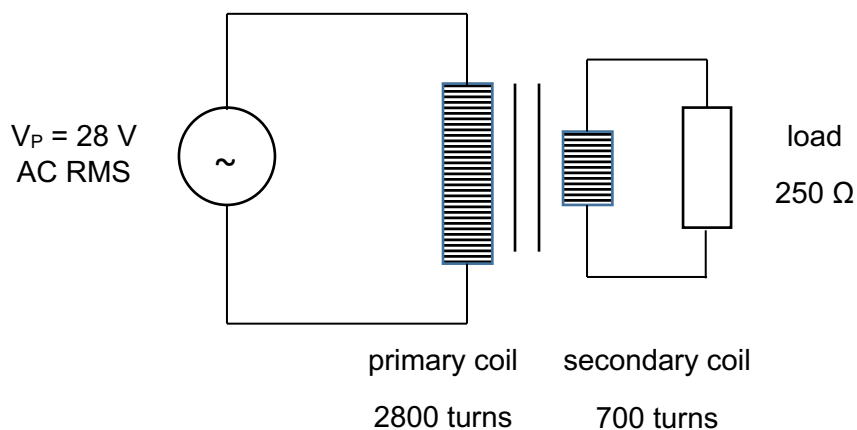


- e) As stated, the exoplanet 18 Delphini b has an orbital period round the star Delphini b of 3.0 years. Its orbital radius is equal to 2.6 AU (1AU = average Earth-Sun distance). Use this data to calculate a value for the mass of the star Delphini b. For this question, ignore the 'wobble' of the star. Show all working.
- (5 marks)



**Question 12****(8 marks)**

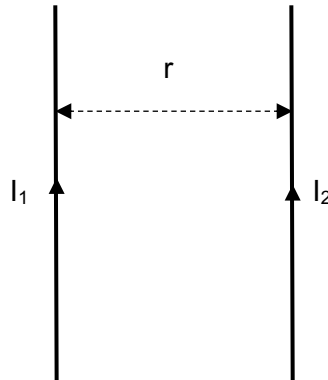
A transformer has an input voltage of 28 V RMS AC. For the questions that follow, assume the transformer is 100% efficient.



- a) Calculate the output voltage ( $V_s$ ) for this transformer. Show working. (2 marks)
- b) Calculate the current flowing through the load in the secondary circuit ( $I_s$ ). (2 marks)
- c) Hence, calculate the power generated in the primary coil of this transformer. (2 marks)
- d) In reality, transformers are not 100% efficient – they experience energy losses through a combination of factors. State one type of energy loss experienced in a transformer and describe how it is reduced via its design. (2 marks)

**Question 13****(20 marks)**

A group of students conducted an investigation measuring the force between two parallel current-carrying wires. They called the currents in these wires ' $I_1$ ' and ' $I_2$ ' and ensured these currents flowed in the same direction. The perpendicular distance ' $r$ ' between the two wires was measured. The diagram below illustrates this experiment.



The diagram below illustrates this experiment from a front-on view.



- a) On the above diagram, draw the NET magnetic field around these two wires. (2 marks)
- b) Draw vectors representing the forces that each conductor would experience due to the currents  $I_1$  and  $I_2$ . (2 marks)

Throughout the investigation, the students kept 'r' constant at a value of 5.00 cm. The values of  $I_1$  and  $I_2$  were kept identical and were gradually increased in value for each trial. The resultant mutual force on each conductor was then measured with very sensitive force probes.

- c) If  $I_1$  and  $I_2$  are both equal to 1.00 A, calculate the strength of the magnetic field 'B' at each conductor's location.

(3 marks)

The formula for calculating the mutual force acting between the two parallel current-carrying wires in this investigation is given by the formula below:

$$\frac{F}{\Delta L} = \frac{\mu_0 I_1 I_2}{2\pi r}$$

Where:  $F$  = the mutual force acting between the two current-carrying wires

$\Delta L$  = the length of the wires experiencing the calculated force

$I_1 = I_2$  = currents carried in both wires

$r$  = perpendicular distance between the two wires

$\mu_0$  = magnetic constant

**For the investigation, the following values were controlled throughout:**

$$r = 5.00 \text{ cm}; \Delta L = 1.00 \text{ m}$$

The students collected the following data during their investigation. They used this data to calculate an experimental value for  $\mu_0$  - the magnetic constant.

$I_1$ (A)	$I_2$ (A)	$I_1 \times I_2$ (A <sup>2</sup> )	$F$ (x 10 <sup>-6</sup> N)
1.00	1.00	1.00	3.85
2.00	2.00	4.00	16.1
3.00	3.00	9.00	36.5
4.00	4.00	16.00	63.0
5.00	5.00	25.00	101.0
6.00	6.00		142.5

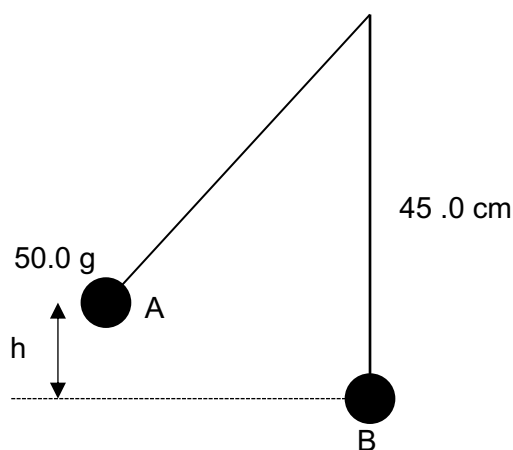
- d) Complete the table by calculating the missing piece of data. Any working can be shown below. (1 mark)
- e) On the grid provided on the next page, plot 'F' against ' $I_1 \times I_2$ '. Place 'F' on the vertical axis. Draw a line of best fit for this data. (4 marks)
- f) Calculate the gradient for the line of best fit. Include units. Write your answer to an appropriate number of significant figures. (4 marks)
- g) Use the slope you calculated in part f) to calculate a value for ' $\mu_0$ '. Show working. (4 marks)



**Question 14****(16 marks)**

A 50.0 g mass is connected to 45.0 cm long piece of string which is fixed at one end. Hence, it is able to act as a pendulum. The string has a breaking tension of 0.700 N.

The mass is raised to a height 'h' (point A) and released. At point B, the string is vertical and just reaches its breaking tension of 0.700 N – hence, it snaps. This situation is illustrated in the diagram below.



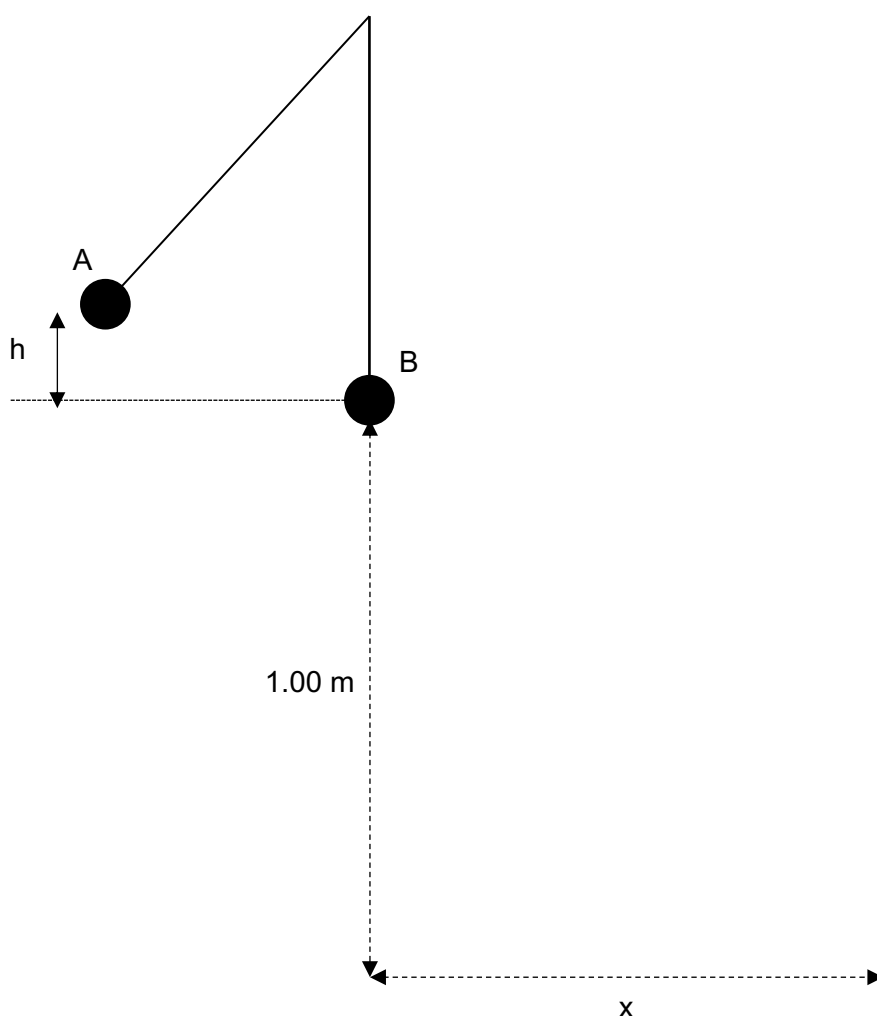
- a) Given that string only just reaches its breaking tension of 0.700 N at point B, calculate the instantaneous speed of the 50.0g mass at this point. Show working.

(5 marks)

- b) Hence, calculate the height (h) at which the mass was released.  
[If you were unable to calculate an answer for part a), use a speed of  $1.40 \text{ ms}^{-1}$  at point B]

(4 marks)

The string snaps at point B; hence, the 50.0g mass becomes a projectile. For the questions that follow the diagram below, assume air resistance is negligible.

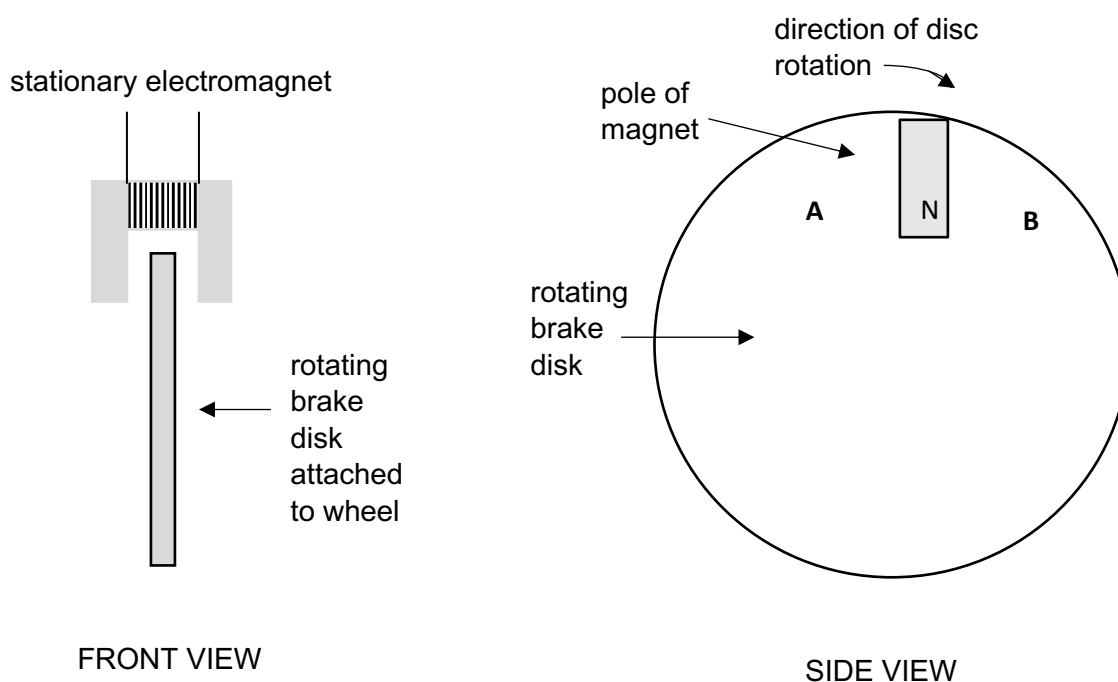


- c) On the diagram above, draw a vector representing the instantaneous velocity of the 50.0 g mass at B. Label this vector with the magnitude of this velocity. (2 marks)
- d) Calculate the value of ' $x$ ' - the horizontal range of the projectile. Show all working. (5 marks)

**Question 15****(12 marks)**

Eddy currents can be used to apply 'magnetic braking' to a vehicle like a train. Like conventional 'friction brakes', the wheels of the train have a 'brake disc' attached to them that rotates with the wheel as the train is moving. Around the top of the disc – but without touching it – is an iron core electromagnet. When the brakes are applied, the electromagnet is switched on and the train is decelerated.

The figures below show the arrangement of disc and electromagnet.



- a) Of what type of material does the disc need to be made? Explain.

(3 marks)

- b) Explain how the electromagnet and disc work together to decelerate the train.

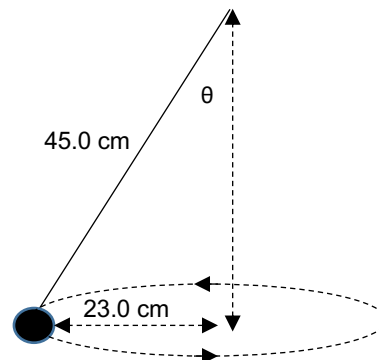
(3 marks)



- c) On the diagram marked 'SIDE VIEW', draw a diagram representing the eddy currents generated at points A and B by the rotating disc and electromagnet. Clearly indicate their direction.  
(3 marks)
- d) Magnetic brakes of this type need to be constructed with an effective cooling system. Explain why.  
(3 marks)

**Question 16****(16 marks)**

During a Physics experiment investigating horizontal circular motion, a student is swinging a 150 g mass in a horizontal circle of radius 23.0 cm. the mass is attached to a string that is 45.0 cm in length.



- a) Draw a vector diagram showing the forces acting on the mass and the net force that results.

(3 marks)

- b) Use the dimensions of the string and the radius of the path to perform a calculation that shows that the value of ' $\theta$ ' is about  $30^\circ$ .

(3 marks)

- c) Hence, calculate the tension in the string.  
[If you could not calculate a value for ' $\theta$ ', use  $30^\circ$ ]

(4 marks)

- d) Calculate the period (T) of revolution for the mass.

(6 marks)

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

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

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.
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Suggested working time for this section is 40 minutes.

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**Question 17****(18 marks)**

From <https://www.telegraph.co.uk/news/worldnews/1555945/Leaning-Tower-of-Pisa-is-saved-from-collapse.html>

# Leaning Tower of Pisa is saved from collapse

By Malcolm Moore in Rome

12:01AM BST 28 Jun 2007



The Leaning Tower of Pisa no longer leans quite so much after a £20 million project to save it was hailed a complete success yesterday. The tower, which was on the verge of collapse, has been straightened by 45 centimetres returning it to its 1838 position.

"It has straightened a little bit more than we expected, but every little helps," said Prof John Burland, an expert in soil mechanics at Imperial College London, who was the only British member of the 14-strong rescue committee.

He said the tower was still "very slightly moving" towards being upright, but that it had stabilised.

The tower, which has been leaning almost since building work first began in 1173, was closed to the public in 1990 because of safety fears. The 55.8 metres tall tower was nearly 4.57 metres off vertical and its structure was found to have been weakened by centuries of strain.

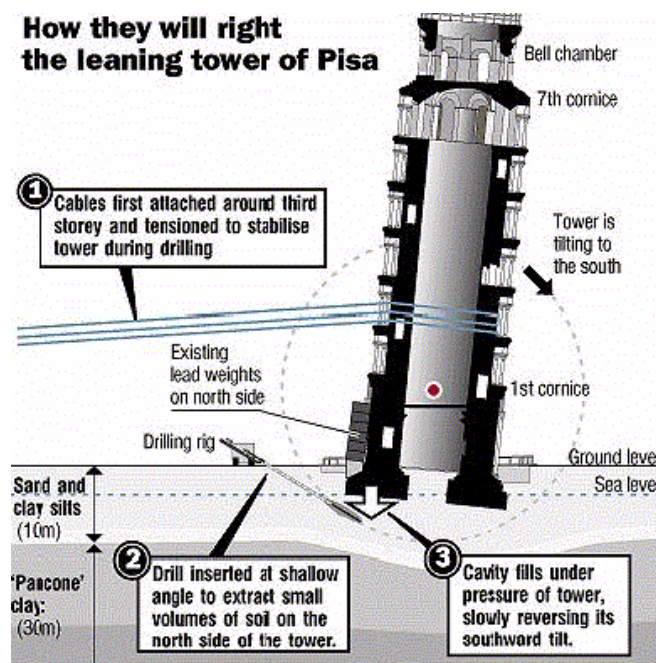
Prof Burland said it could have collapsed "at any moment". However, it took nine years of bureaucratic wrangling before any work was done. "That was the difficult bit, getting the work going," Prof Burland said.

The straightening work involved the extraction of around 70 tonnes of earth from the northern side of the tower, causing it to sink on that side. Before the digging started, the tower was anchored with steel cables and 600 tonnes of lead weights.

However, halfway through the project, concerns at the ugliness of the weights led to their removal and the tower lurched dramatically. "In one night, the tower moved more than it had averaged in an entire year," said Prof Burland. The weights were hastily reattached.

"If we had not stepped in the tower would have collapsed between 2030 and 2040," said Salvatore Settis, the president of the committee. "This is crucial for the tower's stability and it was a totally Italian success."

- The Leaning Tower is the bell-tower of Pisa Cathedral and sits in the Campo dei Miracoli, or Field of Miracles
- It weighs 14,500 tonnes and is actually curved, because its builders tried to compensate for its subsidence during construction.



From <https://leaningtowerpisa.com/facts/how/how-pisa-leaning-tower-was-stabilized>

The leaning Tower of Pisa is 55.8 metres tall and can be considered to be of a uniform width of 4.09 metres from the base to the top. For the purposes of the questions that follow, the Tower mass of 14 500 tonnes can be considered to be uniform (in reality, it is not uniform in shape – the Tower is much narrower at the top than at the bottom).

- a) The rectangle below represents a front-on diagram of the Leaning Tower of Pisa when in a vertical position. Clearly label its dimensions including the location of its centre of mass. (3 marks)



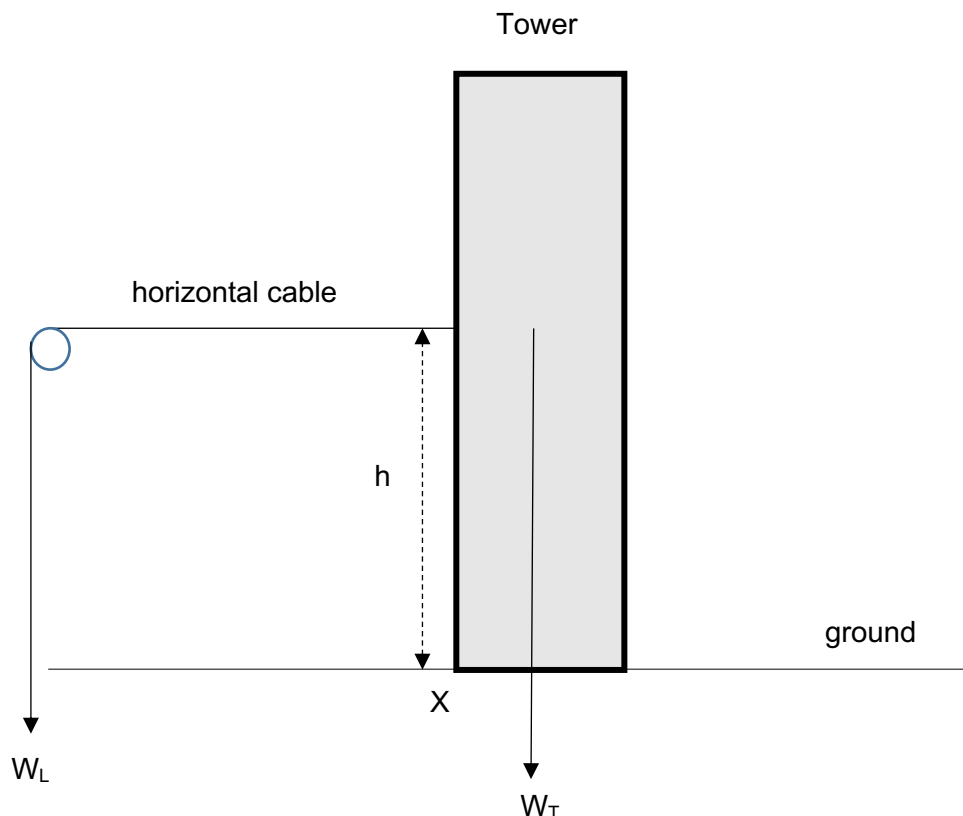
- b) (i) On the diagram you drew in part a), mark the angle through which the Tower could lean over before toppling without any assistance from the foundations (ie – if it was free-standing). Call this angle ' $\theta$ '. (1 mark)
- (ii) Using the dimensions you have labelled in the diagram in part a), calculate the size of the angle ' $\theta$ ' and show that it is about  $4^\circ$ . (3 marks)

- c) It has been calculated that the Tower actually rotated through an angle of more than that calculated in part b) (ii). Describe one (1) reason why the Tower did not topple despite this large rotation. Include a diagram in your answer. (4 marks)
- d) Describe why 70 tonnes of earth was extracted from the northern side of the Tower before any straightening of the Tower to a vertical position was attempted. (3 marks)

The diagram below shows the uniform Tower with two forces acting on it: its own weight acting through its centre of mass; and the tension in the attached cables created by 600 tonnes of lead weights. These weights were used to 'straighten' the Tower into a vertical position.

$W_T$  represents the weight of the Tower;  $W_L$  represents the weight of the lead weights (and the tension in the cable); 'h' is the vertical height from the ground to the point on the Tower where the cable is attached.

In the questions that follow, the cable – as shown - can be assumed to be horizontal. Despite its slight 'lean' before the straightening process began, the Tower can be assumed to be vertical.



- e) Assume that any rotations due to these weights occur around 'X'. Calculate the minimum distance 'h' at which the lead weights just begin to 'straighten' the Tower into a more vertical position.

(4 marks)



## Question 18

(18 marks)

**Real World Physics problems - The Physics of Basketball – Hang Time**From <https://www.real-world-physics-problems.com/physics-of-basketball.html>Source: <http://www.flickr.com/photos/sprungli/3346666564>

Jumping is a major component in the physics behind basketball. When a basketball player jumps in the air to make a shot he can appear to be suspended in mid-air during the high point of the jump. This is a consequence of projectile motion. When an object is thrown in the air, it will spend a large percentage of its flight time in the top part of its path.



Professional basketball players can jump as high as 1.2 metres in the air (vertically). The higher they jump, the greater the 'jump time' (the total time they are airborne), and the greater the time they will appear to be 'suspended' in mid-air during the highest part of their jump. **This part of the 'jump time' is called 'hang time'.**

Typically, there is a horizontal and vertical component in the basketball player's launch velocity at take-off. The magnitude of the vertical component of the launch velocity at take-off will determine the time the player spends in flight (since gravity acts in the vertical direction and will act on the player to bring them back down). Thus, the vertical component of velocity, after take-off, will change with time. The horizontal component of velocity remains constant throughout the jump since it is not affected by gravity.

The figure below shows the typical trajectory a basketball player takes as they make a jump.

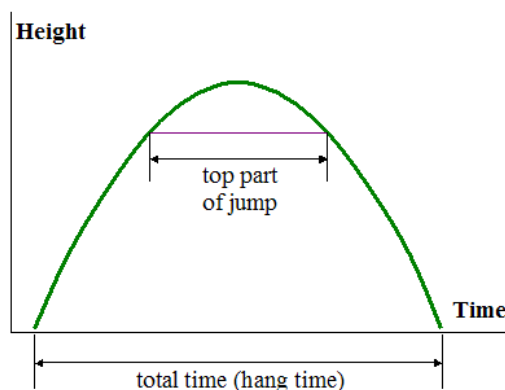


Figure 1

Using some mathematics, it can be calculated that **about half of the 'jump time' (ie – the 'hang time') is spent near the top of the arc.**

The following formula is used for linear motion with constant acceleration:

$$s = ut - 0.5gt^2 \quad (1)$$

Where:

- $s$  = vertical jump distance
- $u$  = vertical component of jump velocity at take-off
- $t$  = time
- $g$  = acceleration due to gravity, which is  $9.80 \text{ ms}^{-2}$

**Maximum jump height ( $s_{\text{max}}$ ) is reached at a time ( $t$ ):**

$$t = \frac{u}{g} \quad (2)$$

Using the above formula for ' $s$ ', **the maximum height ( $s_{\text{max}}$ ) reached by the basketball player is:**

$$s_{\text{max}} = \frac{(u)^2}{(2g)} \quad (3)$$

Now,

$$t_{\text{half}} = \frac{u}{2g} \quad (4),$$

will be equal to **half the time it takes to reach maximum height**.

Using equation (1), it can be shown that **the height reached at  $t_{\text{half}}$  ( $s_{\text{half}}$ ) is:**

$$s_{\text{half}} = \frac{3(u)^2}{(8g)} \quad (5)$$

Hence, the following ratio is:

$$\frac{s_{\text{half}}}{s_{\text{max}}} = 0.75 \quad (6)$$

This interesting result tells us that **half the 'jump time' of a basketball player is spent in the bottom 75% of the jump**.

The remaining half of the 'jump time' – **the 'hang time'** - is spent in **the top 25% of the jump**.

This explains why a basketball player appears to "hang" during the jump.

So, a player who can jump 1.2 metres vertically will have a 'jump time' of about a second; and their 'hang time' will be about half a second.

- a) Throughout this article, an assumption is made about the force(s) acting on the basketball player and the resultant path a projectile takes in flight.

- (i) State this assumption.

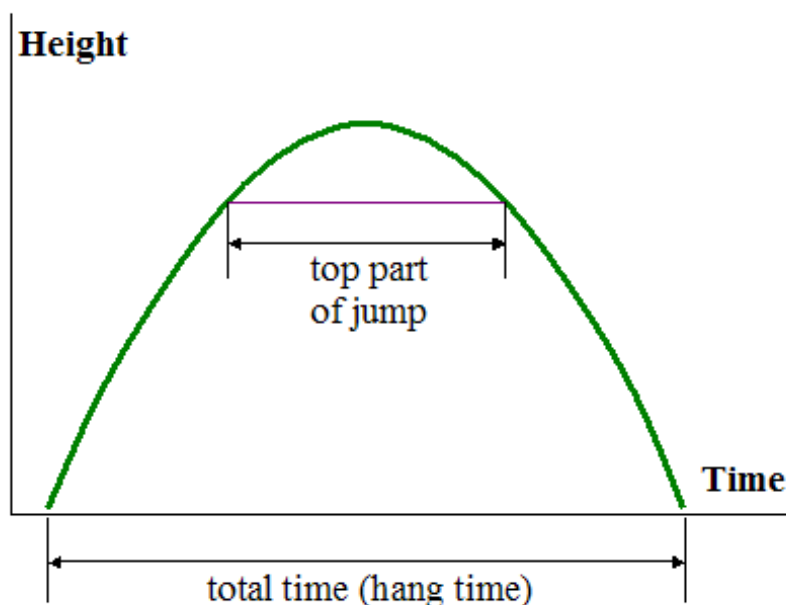
(1 mark)

- (ii) State two (2) aspects of the basketball player's path as they jump that would be different to that assumed in this article given your answer to part (i).

(2 marks)

- (iii) The diagram below shows the basketball player's actual flight path in flight if the assumption stated in (i) is made. On the diagram, draw a possible path for the basketball player if this assumption is NOT made.

(3 marks)



The expression that can be used to calculate the height of the vertical jump at any time 't' is given by equation (1). This can be derived by substituting the appropriate symbols into the motion equation:

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

- b) Using a similar method, show that the maximum height achieved by a basketball player is given by equation 2. Show your derivation clearly. In addition, clearly state any assumptions that must be made for this equation to be true (note: this a different assumption to that in part a)).

(4 marks)

A basketball player reaches a maximum height of 1.10 m ( $s_{\max} = 1.10$  m).

- c) (i) Using equation (3), calculate 'u' (initial upward launch velocity of basketball player).  
(3 marks)
- (ii) Use equation (2) – and the answer you calculated in part (i) - to calculate the time taken for the basketballer to reach maximum height in their jump ( $s_{\max}$ ).  
[If you were unable to calculate an answer for part (ii), use  $u = 4.70 \text{ ms}^{-1}$ ]  
(2 marks)
- (iii) Calculate the total time taken for the basketballer's entire jump.  
(1 mark)
- (iv) Using information from the article, calculate the 'hang time' of this particular basketball player.  
(2 marks)

**End of Section 3**

**End of Examination**

### Additional working space

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### Additional working space

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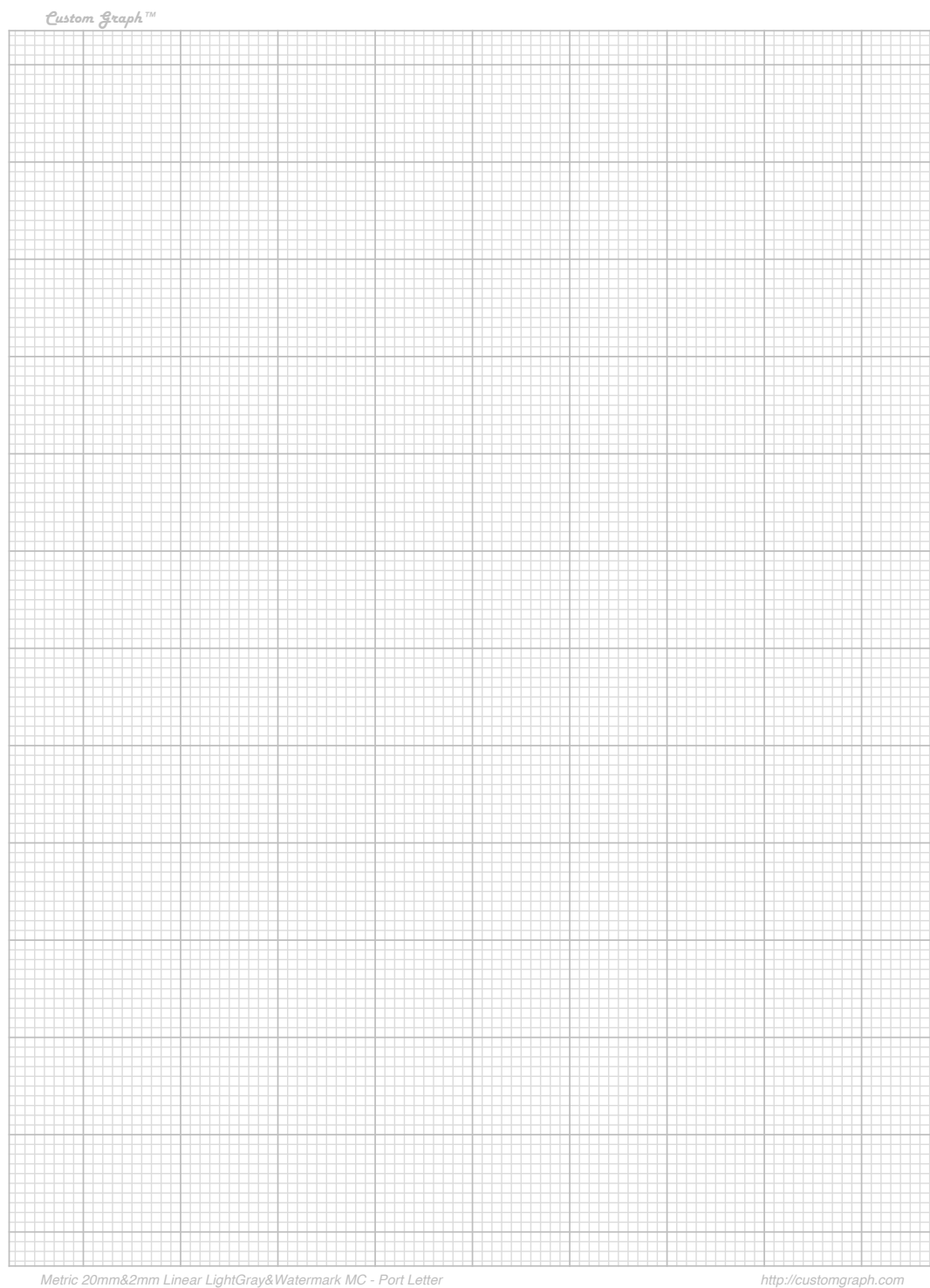
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### Additional working space

[illegible]

**Additional graph if required.**



**End of examination**

### ACKNOWLEDGMENTS

- Question 18 Article reproduced from  
<https://www.telegraph.co.uk/news/worldnews/1555945/Leaning-Tower-of-Pisa-is-saved-from-collapse.html>
- Question 19 From <https://www.real-world-physics-problems.com/physics-of-basketball.html>

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