

SPACE 1

The Earth has a gravitational field that exerts a force on objects both on it and around it.

2001

1 A person has a mass of 70.0 kg. What is the weight of the person at the Earth's surface?

- (A) 70.0 kg
- (B) 70.0 N
- (C) 686 kg
- (D) 686 N

2002

3 The table shows the value of the acceleration due to gravity on the surface of Earth and on the surface of Mercury.

	Acceleration due to gravity (ms ⁻²)
Earth	9.8
Mercury	3.8

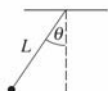
A person has a weight of 550 N on the surface of Earth.

What would be the person's weight on the surface of Mercury?

- (A) 56.1 N
- (B) 213 N
- (C) 550 N
- (D) 1420 N

Question 16 (8 marks)

Two students, Kim and Ali, performed an experiment to determine the acceleration due to gravity (g) using a simple pendulum consisting of a small mass hanging from a light string.



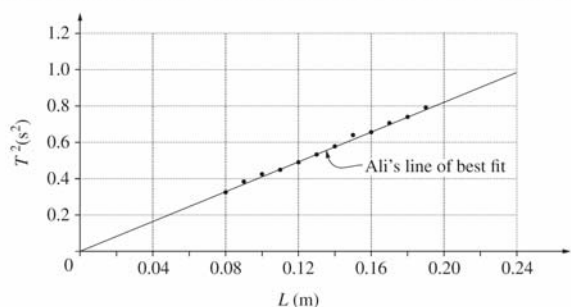
Their procedure was as follows:

- Adjust the length of the string (L) to measure 0.08 m.
- Hold the mass to the side to give a small angular displacement, θ .
- Release the mass and measure the time for one period (T).
- Record the result in a table.
- Repeat using a string length (L) of 0.09 m and continue until the string length is 0.19 m (going up in 0.01 m increments, using the same initial angular displacement each time).
- Calculate g using the relationship $T = 2\pi\sqrt{\frac{L}{g}}$.

The results are shown in the table:

L (m)	0.08	0.09	0.10	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19
T (s)	0.57	0.62	0.65	0.67	0.70	0.73	0.76	0.80	0.81	0.84	0.86	0.89

Kim used the data in the table to obtain a mean value for g . Kim's result was $g = 9.3 \text{ m s}^{-2}$. Ali used the results to produce the following graph. Ali's line of best fit was used to calculate g .



Question 16 (continued)

- (a) Outline TWO changes that could be made to the experimental procedure that would improve its accuracy. 2

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- (b) Compare Kim's and Ali's methods of calculating g and identify the better approach. 3

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- (c) Calculate the value of g from the line of best fit on Ali's graph. 3

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Assessors report & Marking criteria

- (a) This question was answered well by most candidates. Some candidates thought that maintaining a constant angle for release improved accuracy. Many candidates successfully identified replication as a means of improving accuracy of the experiment.
- (b) Many candidates thought incorrectly that Kim's method was the better approach due to the subjectivity of the line of best fit used in Ali's method. Few candidates could successfully 'compare' and 'identify' Ali's method clearly as the better approach. Many candidates identified weaknesses in Ali's approach using vague terms such as 'human error'. Some candidates misinterpreted the question by providing an alternative method to the experiment.
- (c) Few candidates calculated g using the gradient. Most resorted to finding a data point ON the line and substituting it into the equation. A number of candidates assumed that the gradient was the value of g . The most common manipulation error was candidates omitting to square the 2π term. Some candidates failed to show 'all relevant working' and were penalised.

Criteria	Marks
• Outlines two changes that would improve the accuracy of the results	2
• Outlines one change that would improve the accuracy of the results	1

Criteria	Marks
• Identifies features of both methods and the differences between them • Identifies Ali's method as being superior OR • Kim's as being inferior	3
EITHER • Identifies the features of only one method and identifies which method is superior/inferior OR • Identifies the features of both methods but does not identify a superior/inferior method	2
• States Ali's method is superior OR • States Kim's method is inferior	1

Criteria	Marks
• Calculates the gradient using the line-of-best-fit (LOBF) or a point on the LOBF and correctly substitutes into the equation to determine g	3
• Calculates a value of g using the operations listed, but with an error in substitution, gradient determination or equation manipulation	2
• Uses data points not on the LOBF in calculation of g OR • Calculates the gradient only OR • Only identifies a point on the LOBF for substitution into the equation	1

Suggested Answer – SUCCESS ONE

2003

- 1 The weight of an astronaut on the Moon is $\frac{1}{6}$ of her weight on Earth.

What is the acceleration due to gravity on the Moon?

- (A) $\left(\frac{6}{9.8}\right) \text{ms}^{-2}$
 (B) $\left(\frac{9.8}{6}\right) \text{ms}^{-2}$
 (C) 9.8ms^{-2}
 (D) $(9.8 \times 6) \text{ms}^{-2}$

Question 17 (6 marks)

A satellite of mass 150 kg is launched from Earth's surface into a uniform circular orbit of radius $7.5 \times 10^6 \text{m}$.

- (a) Calculate the magnitude of the gravitational potential energy E_p of the satellite. 1

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- (b) From this uniform circular orbit, the satellite can escape Earth's gravitational field when its kinetic energy is equal to the magnitude of the gravitational potential energy. 3

Use this relationship to calculate the escape velocity of the satellite.

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Assessors report & Marking criteria

- (a) Many candidates wrongly substituted 9.8 for G and others used Newton's very similar equation for gravitational force.
 (b) Most candidates appreciated the equality of energies but then had trouble manipulating the equations to give v .

Criteria	Marks
<ul style="list-style-type: none"> Identify correct equation Correct substitution 	1

Criteria	Marks
<ul style="list-style-type: none"> Relationship given in question hence equating $E_p = E_k$ is given AND <ul style="list-style-type: none"> Correct expression for v, or inferred AND <ul style="list-style-type: none"> Correct substitution, note that the answer (even if wrong) from (a) can be substituted 	3
<ul style="list-style-type: none"> Relationship given in question hence equating $E_p = E_k$ is given AND <ul style="list-style-type: none"> Mark given for correct expression for v, or inferred 	2
<ul style="list-style-type: none"> $E_p = E_k$ 	1

Suggested Answer – SUCCESS ONE

2006

- 1 Given that G is the universal gravitational constant, and g is the magnitude of the acceleration due to gravity, which statement is true?

- (A) The values of G and g depend on location.
 (B) The values of G and g are independent of location.
 (C) G is the same everywhere in the universe, but g is not.
 (D) g is the same everywhere in the universe, but G is not.

Question 18 (3 marks)

An object is stationary in space and located at a distance 10 000 km from the centre of a certain planet. It is found that 1.0 MJ of work needs to be done to move the object to a stationary point 20 000 km from the centre of the planet.

Calculate how much more work needs to be done to move the object to a stationary point 80 000 km from the centre of the planet.

Assessors report & Marking criteria

Better responses recognised the inverse relationship between E_p and r in the formula, and used ratios to logically determine the absolute value of E_{p3} and subtract it from 1MJ.

Criteria	Marks
<ul style="list-style-type: none"> Demonstrates appropriate problem solving techniques to completion 	3
<ul style="list-style-type: none"> Calculates GPE at any of satellite positions OR <ul style="list-style-type: none"> Calculates value of Gm_1m_2 	2
<ul style="list-style-type: none"> Identifies correct equation OR <ul style="list-style-type: none"> Recognises $W = \Delta GPE$ 	1

Suggested Answer – SUCCESS ONE

2007

- 3 The gravitational potential energy of a given mass is known at both Earth's surface and at a fixed distance above Earth.

What CANNOT be determined by comparing these two values of gravitational potential energy?

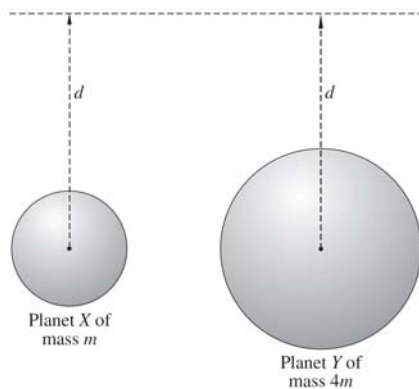
- (A) The mass of Earth
 (B) The speed of rotation of Earth
 (C) The escape velocity of a satellite from Earth
 (D) The work done in moving between the two points

- 4 The acceleration due to gravity on Earth's surface is g . Suppose the radius of Earth was reduced to a quarter of its present value while its mass remained the same.

What would be the new value of the acceleration due to gravity on the surface?

- (A) $\frac{1}{16}g$
 (B) $\frac{1}{4}g$
 (C) $4g$
 (D) $16g$

- 2 The diagram shows two planets X and Y of mass m and $4m$ respectively.



At the distance d from the centre of planet Y the acceleration due to gravity is 4.0 m s^{-2} .

What is the acceleration due to gravity at distance d from the centre of planet X ?

- (A) 1.0 m s^{-2}
- (B) 2.0 m s^{-2}
- (C) 2.8 m s^{-2}
- (D) 4.0 m s^{-2}