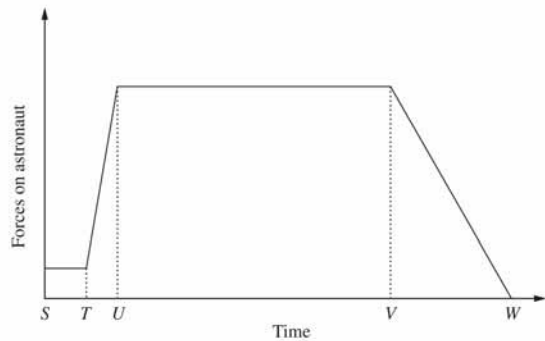


SPACE 2

Many factors have to be taken into account to achieve a successful rocket launch, maintain a stable orbit and return to Earth.

2001

- 5 The graph shows the forces experienced by an astronaut during a rocket launch into a stable orbit.



In which time interval was the acceleration of the rocket the greatest?

- (A) S–T
(B) T–U
(C) U–V
(D) V–W
- 7 An astronaut is standing on Mars. The astronaut throws an object of mass 0.30 kg vertically upward at an initial speed of 9.0 m s^{-1} . It reaches a maximum height of 11 metres.

What is the magnitude of the acceleration of the object?

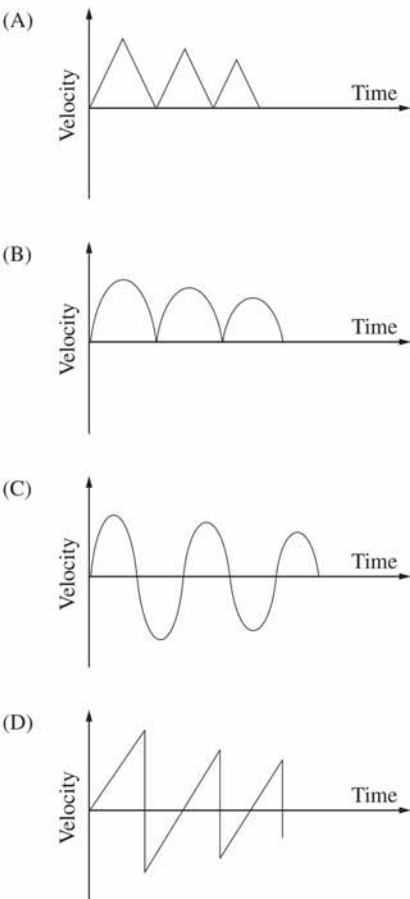
- (A) 1.4 m s^{-2}
(B) 3.7 m s^{-2}
(C) 9.0 m s^{-2}
(D) 9.8 m s^{-2}
- 13 A rocket car moves on a straight horizontal track. Half of the initial mass of the rocket car is propellant. During the run, propellant is consumed at a constant rate and ejected at a constant nozzle velocity.

Which of the following best describes the force propelling the rocket car, and the magnitude of the acceleration of the rocket car while the propellant is being ejected?

	Force	Acceleration
(A)	constant	constant
(B)	increasing	constant
(C)	constant	increasing
(D)	increasing	increasing

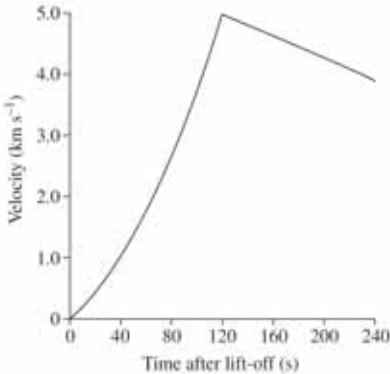
- 15 A student releases a ball from eye level. The ball bounces several times.

Which velocity vs time graph best represents the ball's motion?



Question 17 (6 marks)

A rocket was launched vertically to probe the upper atmosphere. The vertical velocity of the rocket as a function of time is shown in the graph.



- (a) Using either words or calculations, compare the acceleration of the rocket at $t = 20\text{ s}$ with its acceleration at $t = 100\text{ s}$.

2

- (b) Account for the shape of the graph over the range of time shown.

4

Assessors report & Marking criteria

This question tested candidates' understanding of the vertical acceleration of rockets. The most common error made by candidates was in thinking that the graph showed uniform acceleration – some candidates stated this explicitly while a significant number of candidates attempted to evaluate the acceleration using equations of uniform acceleration. A large number of candidates correctly justified the increase of acceleration shown in the graph by describing the constant force and decreasing mass experienced by a rocket. A minority of candidates evaluated the gradient of the curve at the points indicated.

Criteria	Marks
<ul style="list-style-type: none">Acceleration can be determined from the slope of velocity versus time graphThe acceleration is greater 100 s after lift-off <p>Note: either a visual determination of the slope or a measurement from the graph, is acceptable.</p>	2
<ul style="list-style-type: none">One only of the above points	1

Criteria	Marks
<ul style="list-style-type: none">Correctly explains the shape of both parts of the graph	4
EITHER	3
<ul style="list-style-type: none">Correct explanation of the first part of the graph	
OR	
<ul style="list-style-type: none">Partly-correct explanation for the first part, second part of the graph correct	
<ul style="list-style-type: none">Provides a correct statement relating to the first part of the graph, second part correct	2
EITHER	1
<ul style="list-style-type: none">A correct statement relating to the first part of the graph	
OR	
<ul style="list-style-type: none">A correct statement relating to the second part of the graph	

Suggested Answer – SUCCESS ONE

Assessors report & Marking criteria

This question tested candidates' understanding of projectile and circular motion. Part (a) involved a simple calculation and was handled well by most candidates. However, some candidates did not use the value of 'g' provided in the data sheet. The most common error in the calculation of part (b) was assuming that $u_y = 20 \text{ ms}^{-1}$, rather than zero. Another common error was not assigning similar directions to a_y and Δy . In the comparison required by part (c), most candidates did not recognise that gravitational force was common to both situations and that the centripetal force on B was the resultant of gravitational force and the tension force of the arm towards the pivot, and was larger than the force on A as a result.

Criteria	Marks
<ul style="list-style-type: none">Correctly calculates the force	1

Criteria	Marks
<ul style="list-style-type: none">Uses the correct formula and substitutes correct valuesIdentifies the correct formula	2
	1

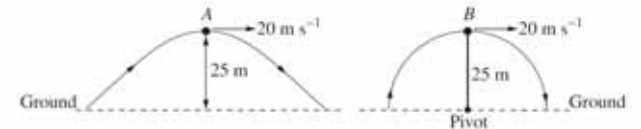
Criteria	Marks
<ul style="list-style-type: none">Correctly describes the resultant forces on A and B and correctly deduces that the force on B is greater than the forces on A	3
EITHER	2
<ul style="list-style-type: none">Correctly describes the resultant forces on A and B but has an incorrect comparison	
OR	
<ul style="list-style-type: none">Correctly describes the resultant force on either A or B (but not both) and makes a correct comparison	
One of the following:	1
<ul style="list-style-type: none">Correctly describes the resultant force on A	
OR	
<ul style="list-style-type: none">Correctly describes the resultant force on B	
OR	
<ul style="list-style-type: none">Gives a correct comparison	

Suggested Answer – SUCCESS ONE

Question 18 (6 marks)

A 30 kg object, A, was fired from a cannon in projectile motion. When the projectile was at its maximum height of 25 m, its speed was 20 m s^{-1} .

An identical object, B, was attached to a mechanical arm and moved at a constant speed of 20 m s^{-1} in a vertical half-circle. The length of the arm was 25 m.



Ignore air resistance.

- (a) Calculate the force acting on object A at its maximum height.

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- (b) Calculate the time it would take object A to reach the ground from its position of maximum height.

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- (c) Describe and compare the vertical forces acting on objects A and B at their maximum heights.

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2002

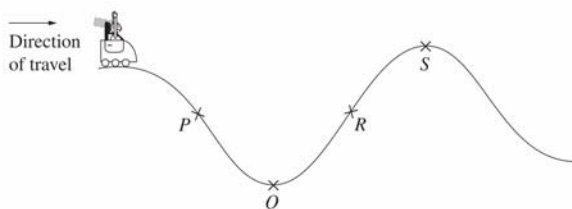
1 The diagram shows the trajectory of a golf ball.



Which set of arrows shows the direction of the acceleration of the ball at points P and Q respectively?

	At P	At Q
(A)	↑	↓
(B)	↓	↓
(C)	↗	↘
(D)	↖	↘

- 4 The diagram shows four positions of a car on a roller coaster ride.



At which point during this ride would the occupant experience maximum 'g force'?

- (A) P
(B) Q
(C) R
(D) S

- 5 The table contains information related to two planets orbiting a distant star.

Planets	Mass (kg)	Orbital radius (m)	Radius of planet (m)	Length of day (s)	Orbital period (s)
Alif	1.21×10^{25}	4.00×10^{11}	8.0×10^6	9.5×10^4	8.75×10^7
Ba	1.50×10^{24}	8.00×10^{11}	4.0×10^6	4.7×10^4	—

The orbital period of the planet Ba can be determined by using data selected from this table.

What is the orbital period of the planet Ba?

- (A) 3.10×10^7 s
(B) 5.51×10^7 s
(C) 1.39×10^8 s
(D) 2.47×10^8 s

Question 21 (4 marks)

In his science fiction novel *From the Earth to the Moon*, Jules Verne describes how to launch a capsule from a cannon to land on the moon. To reach the moon, the capsule must leave the cannon with a speed of $1.06 \times 10^4 \text{ m s}^{-1}$. The cannon has a length of 215 m, over which the capsule can be assumed to accelerate constantly.

- (a) Calculate the magnitude of the acceleration required to achieve this speed using this cannon. 2

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- (b) Referring to your answer in part (a), explain why Jules Verne's method is unsuitable for sending a living person to the moon. 2

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Assessors report & Marking criteria

- (a) Most candidates were able to do this question correctly, although a sizable number of candidates did not use the appropriate formula and/or made substitution errors in their calculations.
- (b) The majority of candidates were able to recognise the implications of such a large acceleration on a living person. This part, however, required a reference to the answer given in 21a) which meant that some candidates, who answered incorrectly in part (a) had difficulty in subsequently answering part (b) correctly.

Criteria	Marks
• Uses appropriate formula and substitutes correct values	2
• Uses appropriate formula and makes incorrect substitution	1
Criteria	Marks
• Gives clear explanation why method is not suitable using a reference to answer obtained in part (a)	2
• States that method is not suitable and refers to part (a)	1
OR	
• Explains why method is not suitable, without referring to part (a)	

Suggested Answer – SUCCESS ONE

2003

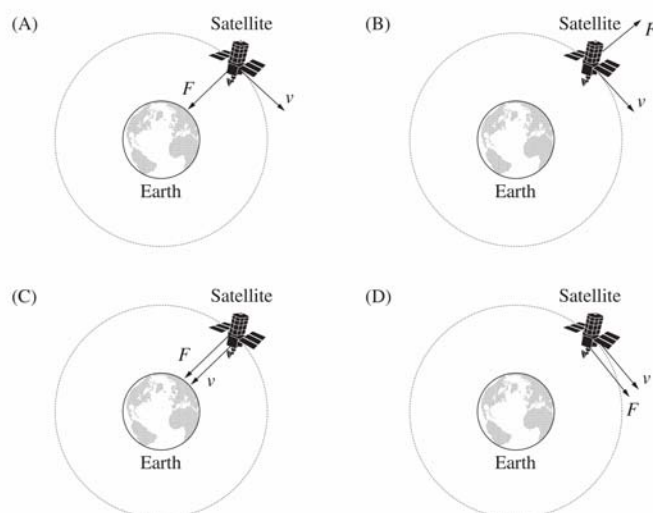
- 2 A satellite moves in uniform circular motion around Earth.

The following table shows the symbols used in the diagrams below. These diagrams are NOT drawn to scale.

Key

F	net force on satellite
v	velocity of satellite

Which diagram shows the direction of F and v at the position indicated?



- 3 For a satellite moving in uniform circular motion around Earth, the centripetal force is provided by the gravitational force.

The mass of Earth is M_E .

The mass of the satellite is M_S .

The distance of the satellite from the centre of Earth is d .

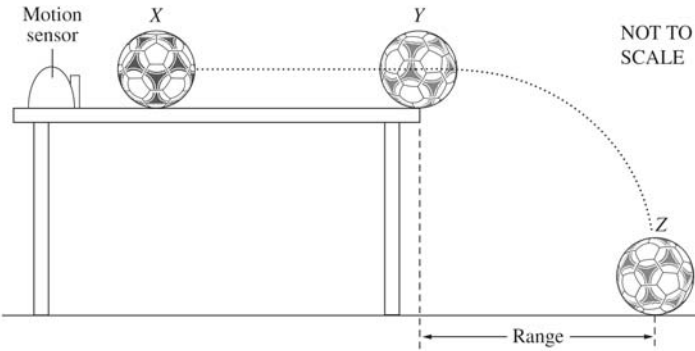
Which of the following equations should be used to calculate the speed of this satellite?

- (A) $v = \frac{GM_E}{d}$
(B) $v = \sqrt{\frac{GM_E}{d}}$
(C) $v = \sqrt{\frac{GM_E}{d^2}}$
(D) $v = \sqrt{\frac{GM_E M_S}{d}}$

Question 16 (6 marks)

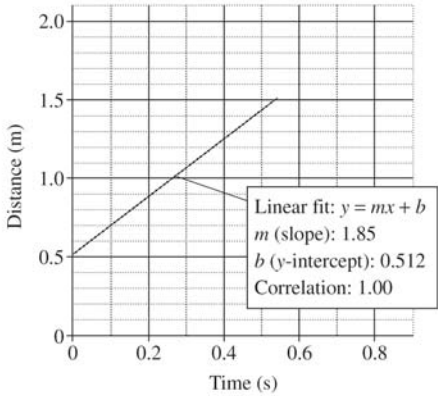
A student performed a first-hand investigation to examine projectile motion.

A ball resting on a horizontal table was given an initial push at X, resulting in the ball following the path XYZ as shown.



A data logger used the motion sensor to measure the horizontal distance to the ball. When the ball was at position Y, a distance of 1.50 m from the motion sensor, it left the edge of the table.

In the first trial, the range was 0.60 m. The graph below was obtained from the data logger.



Question 16 (continued)

- (a) For this trial, determine the horizontal speed of the ball as it left the edge of the table. 1
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-
- (b) The experiment was repeated with the ball leaving the table at different speeds. 3
- Graph the relationship between the range and the horizontal speed at Y. Identify on your graph the results from the first trial.



- (c) The apparatus described in this first-hand investigation was used to carry out an identical experiment on another planet where the acceleration due to gravity is less than that on Earth. 2
- The horizontal speed of the ball as it left the table on the planet was the same as in part (a). Compare the range of the ball on the planet to that on Earth. Explain your answer.
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Assessors report & Marking criteria

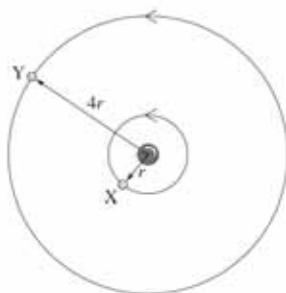
On balance all parts of this question were well answered and presented few difficulties to the bulk of the candidature. A common error in part (b) was the placement of dependent and independent variables on the wrong axes.

Criteria	Marks
<ul style="list-style-type: none">Students can read the gradient of the line from the content of the box on the graph gradient = velocity OR <ul style="list-style-type: none">Student correctly calculates gradient from data taken from the graph	1
Criteria	Marks
<ul style="list-style-type: none">Mark correctly labelled axes (includes units)Straight line indicating a linear relationship between horizontal velocity and range and approaching the originPoint (1.85, 0.6) must be clearly identified as being on the line. (The point 1.85, 0.6) may be implied by numerical divisions on the axes)	3
<ul style="list-style-type: none">Mark correctly labelled axes (includes units) AND <ul style="list-style-type: none">Straight line approaching origin or point (1.85, 0.6) identified OR <ul style="list-style-type: none">Straight line approaching origin and point (1.85, 0.6) identified, no axes labelled	2
<ul style="list-style-type: none">Correctly labelled axes (units not required) OR <ul style="list-style-type: none">Straight line approaching origin OR <ul style="list-style-type: none">Point (1.85, 0.6) identified	1
Criteria	Marks
<ul style="list-style-type: none">Range on the planet is longer because of the acceleration due to gravity (g) on the planet is smaller OR <ul style="list-style-type: none">Since g is smaller on the planet the time of flight is longer OR <ul style="list-style-type: none">Longer time of flight means that the ball travels a longer horizontal distance before it reaches the ground	2
<ul style="list-style-type: none">Longer because gravity on the planet is smaller OR <ul style="list-style-type: none">Longer because time of flight is longer	1

Suggested Answer – SUCCESS ONE

- 4 Two planets, X and Y, travel around a star in the same direction, in circular orbits.

Planet X completes one revolution about the star in time T . The radii of the orbits are in the ratio 1 : 4.



How many revolutions does planet Y make about the star in the same time T ?

- (A) $\frac{1}{8}$ revolution
(B) $\frac{1}{2}$ revolution
(C) 2 revolutions
(D) 8 revolutions

Question 17 (6 marks)

A satellite of mass 150 kg is launched from Earth's surface into a uniform circular orbit of radius 7.5×10^6 m.

- (c) Discuss the effect of Earth's rotational motion on the launch of this satellite. 2

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Question 17 a&b in SPACE 1

Assessors report & Marking criteria

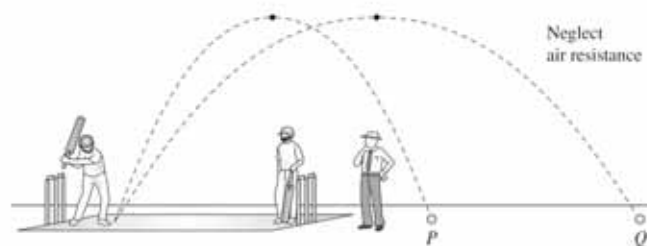
- (c) Many candidates had a very poor understanding of the physics behind launching a satellite. Even those who knew that most are launched towards the east, were not sure why.

Criteria	Marks
• An issue and relationship to direction of launch	2
• An issue such as assistance to motion or fuel usage	1

Suggested Answer – SUCCESS ONE

2004

- 1 The picture shows a game of cricket.



The picture shows two consecutive shots by the batsman. Both balls reach the same maximum height above the ground but ball Q travels twice as far as ball P.

Which of the following is DIFFERENT for balls P and Q?

- (A) Time of flight
(B) Initial velocity
(C) Gravitational force
(D) Gravitational acceleration

Question 16 (4 marks)

A projectile is fired at a velocity of 50 m s^{-1} at an angle of 30° to the horizontal. 4

Determine the range of the projectile.

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Assessors report & Marking criteria

A substantial number of candidates were able to gain full marks for this question.

Most responses correctly resolved the initial velocity vector into its vertical and horizontal components. Better responses used the vector components in the relevant equations and identified the direction of the acceleration.

Criteria	Marks
• Correct solution given (working shown) • Correct substitutions (both data and signs) into relevant formulae (arithmetic errors ignored)	4
• Relevant formulae used but u_x and u_y transposed consistently OR • All correct but time of flight value is halved OR • Lack of use of sign convention	3
• Relevant formulae used but u_x and u_y transposed inconsistently OR • Angle not taken into account but +ve and -ve convention used to determine answer OR • Initial velocity resolved into components correctly AND • Working data has value for 'g' and initial velocity in different directions (+ve and -ve)	2
• Initial velocity resolved into components correctly OR • Working data has value for 'g' and initial velocity in different directions (+ve and -ve)	1

Suggested Answer – SUCCESS ONE

Question 17 (6 marks)

In July 1969 the Apollo 11 Command Module with Michael Collins on board orbited the Moon waiting for the Ascent Module to return from the Moon's surface. The mass of the Command Module was 9.98×10^3 kg, its period was 119 minutes, and the radius of its orbit from the Moon's centre was 1.85×10^6 metres.

(a) Assuming the Command Module was in circular orbit, calculate

(i) the mass of the Moon:

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(ii) the magnitude of the orbital velocity of the Command Module.

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(b) The docking of the Ascent Module with the Command Module resulted in an increase in mass of the orbiting spacecraft. The spacecraft remained at the same altitude.

2

This docking procedure made no difference to the orbital speed. Justify this statement.

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Assessors report & Marking criteria

The better responses demonstrated a sound understanding of physics and were able to link the content drawn from several dot points, thus combining relevant equations to demonstrate the relationships involved.

- (a) (i) Better responses converted time to seconds, rearranged terms successfully and made no arithmetical or transcription errors. A significant number of responses showed an incorrect selection of equations from the data.
- (ii) Many responses incorrectly used the formula for escape velocity rather than calculating orbital velocity from the equations for centripetal and gravitational force.
- (b) In the better responses, candidates demonstrated their understanding of the link between orbital velocity and altitude. They were then able to use this to support their argument.

Criteria	Marks
• Correctly calculates mass of the moon	2
• Uses correct formula but makes incorrect substitution	1

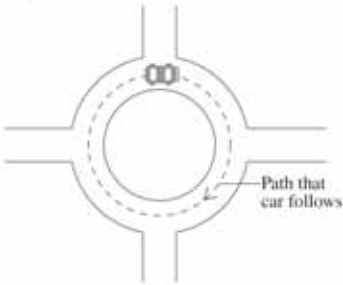
Criteria	Marks
• Correctly calculates the magnitude of the orbital velocity of the command module	2
• Uses correct relationship but makes incorrect substitution	1

Criteria	Marks
• Any valid reasoning that leads to the independence of the mass of an object and its orbital speed and altitude	2
• State period independent of mass or period only depends on radius/altitude OR • Orbital velocity depends on mass of central body not mass of orbiting body (statement only)	1

Suggested Answer – SUCCESS ONE

Question 18 (4 marks)

A car with a mass of 800 kg travels at a constant speed of 7.5 m s^{-1} on a roundabout so that it follows a circular path with a radius of 16 m. 4



A person observing this situation makes the following statement.

'There is no net force acting on the car because the speed is constant and the friction between the tyres and the road balances the centripetal force acting on the car.'

Assess this statement. Support your answer with an analysis of the horizontal forces acting on the car, using the numerical data provided above.

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Assessors report & Marking criteria

The better responses succinctly identified the two clear errors in the statement and used the centripetal force equation to support their judgement. Many candidates incorrectly interpreted the statement as being correct and therefore had difficulty as they tried to justify its elements.

Criteria	Marks
• Makes a correct judgement supported by arguments addressing horizontal forces and backed up by numerical data	4
• Makes a judgement insufficiently supported by argument and/or numerical data	2–3
• Makes correct statement about car moving in circular motion	1

Suggested Answer – SUCCESS ONE

Question 19 (6 marks)

On 11 June 2003 the Mars Rover called Spirit was launched on a satellite from Earth when the planets were in the positions shown in the diagram below. The satellite arrived at Mars on 3 December 2003.



- (a) Indicate on the diagram the approximate positions of Earth and Mars on 3 December 2003 and show the satellite's trajectory to Mars. 3
- (b) Discuss the effect of Earth's motion on the launch and trajectory to Mars of this satellite. 3

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Assessors report & Marking criteria

- (a) The better responses recognised that Mars travelled approximately a third of a revolution in the time that Earth completed half a revolution. Many responses incorrectly showed both planets orbiting clockwise as viewed in the diagram. Poorer responses had trajectories that did not show the Sun at one focus of an elliptical path.
- (b) Candidates are reminded that the gain in velocity due to the slingshot effect as a satellite passes by a planet does not provide velocity boost to the launch of a rocket from the Earth. Many responses clearly identified that both the Earth's rotation on its axis and revolution around the Sun contributed to the increased velocity of the rocket on launch but did not relate these to the effect of the Earth's motion on the trajectory.

Criteria	Marks
• Appropriately locates the positions of Earth and Mars and shows the trajectory correctly	3
• Locates Earth and Mars appropriately OR • Locates Earth correctly and has a trajectory that forms part of a plausible ellipse (with the sun at a focus) passing through launch location of Earth and the incorrect location of Mars	2
• Locates Earth correctly OR • Shows a plausible trajectory between incorrectly located planets i.e. orbit is plausibly elliptical around the sun	1

Criteria	Marks
• Identifies that velocity imparted by rocket motors to satellite is augmented by Earth's motion and provides any two of the following supporting points: • Axial rotation of Earth augmenting launch towards east • Orbital motion of Earth (revolution) augmenting departure from Earth orbit to interplanetary trajectory • The launch window from this position on the Earth's orbit provides the shortest trajectory	3
• Identifies that the velocity imparted by rocket motors to satellite is augmented by Earth's motion and provides one of the following supporting points: • Axial rotation of Earth augmenting launch towards east • Orbital motion of Earth (revolution) augmenting departure from Earth's orbit to interplanetary trajectory • The launch window from this position on the Earth's orbit provides the shortest trajectory	2
Provides one of the following supporting points: • Axial rotation of Earth augmenting launch towards east • Orbital motion of Earth (revolution) augmenting departure from Earth's orbit to interplanetary trajectory • The launch window from this position on the Earth's orbit provides the shortest trajectory	1

Suggested Answer – SUCCESS ONE

Question 27 (4 marks)

A sports magazine commenting on the athletic ability of Michael Jordan, the famous basketball player said:

'Being an athlete takes more brains than brawn. It takes time and effort. It takes endurance and commitment. It takes an athlete who can stay in the air for 2.5 seconds while shooting a goal; an athlete who knows which laws of physics keep him there.'

Assess the information presented in this magazine, using appropriate calculations to support your argument.

Assessors report & Marking criteria

Most candidates recognised this as a projectile motion question. A large number of responses used the appropriate equations to carry out calculations but many of these responses contained errors in the substitution of data. In better responses, a valid judgement was made using appropriate calculations to support the arguments. An example of such a response follows.

Now, $v_y = u_y + at$. If Jordan stayed in the air for 2.5 seconds, then by 1.25 seconds, he reaches maximum height.
 $\therefore 0 = u_y + 1.25 \times -9.8$, $\therefore u_y = 12.25 \text{ m/s}$

However, $\Delta y = u_y t + \frac{1}{2} a_y t^2$

$$\therefore \Delta y = 12.25 \times 1.25 + \frac{1}{2} \times 9.8 \times 1.25^2$$

$$= 7.66 \text{ m}$$

This states that Jordan reaches a maximum height of 7.66m, which is impossible for a human with physical legs! Since the basket of the basketball is between 2 and 3 metres it would take less than 1 second overall to reach a height of 3 metres above the ground. Therefore the magazine is exaggerating TOO MUCH and the information stated in the information is not valid at all.

Criteria	Marks
• Correctly determines the take off speed and recognises that this is impossible OR correctly determines that the height to which the athlete jumps is impossible AND hence the information is not accurate	4
• Correctly determines the take off speed and recognises that this is impossible OR correctly determines that the height to which the athlete jumps is impossible BUT does NOT make an assessment of the article	3
• Makes a correct calculation but does not recognise the answer as being impossible nor the flawed nature of the article OR • Makes a conclusion based on incorrect value for the time of flight OR • Makes an incorrect substitution into a correct equation with conclusion and assessment of the article consistent with the calculated values	2
• States that staying in the air for 2.5 seconds is impossible, with no justification OR • Makes a correct statement OR • Substitutes incorrect time of flight	1

Suggested Answer – SUCCESS ONE

1 A ball thrown in the air traces a path as shown below.



- Which of the following statements is true?
- (A) The velocity of the ball keeps changing.
 - (B) The acceleration of the ball keeps changing.
 - (C) The velocity of the ball at the top of its motion is zero.
 - (D) The acceleration of the ball at the top of its motion is zero.

2 Why would a satellite in low orbit around Earth eventually fall to Earth?

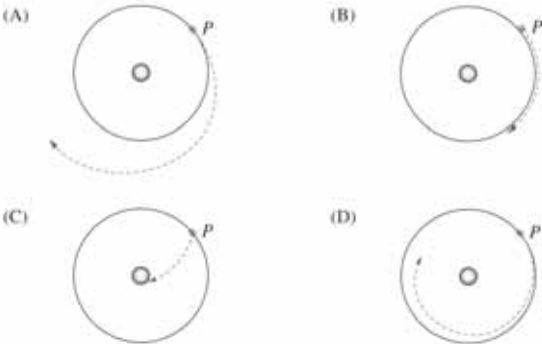
- (A) It is not in a geostationary orbit.
- (B) Gravity is too strong at low orbits.
- (C) The sun's solar wind pushes it out of orbit.
- (D) The upper atmosphere gradually slows it down.

3 The initial velocity required by a space probe to just escape the gravitational pull of a planet is called *escape velocity*.

- Which of the following quantities does NOT affect the magnitude of the escape velocity?
- (A) Mass of the planet
 - (B) Mass of the space probe
 - (C) Radius of the planet
 - (D) Universal gravitational constant

4 A space probe, *P*, is in a stable orbit around a small, distant planet. The probe fires a forward-facing rocket that reduces its orbital speed by half.

Which of the following best illustrates the subsequent motion of the probe?



5 Napoleon attacked Moscow in 1812 with his cannon firing a shot at an elevation angle of 40°. Napoleon then decided to fire a second shot at the same speed but at an elevation angle of 50°.

Which of the following observations would Napoleon expect to be true about the second shot when compared with the first?

- (A) Longer range
- (B) Shorter range
- (C) Longer time of flight
- (D) Shorter time of flight

Question 16 (5 marks)

From nearest to furthest, the four satellite moons of Jupiter first observed by Galileo in the year 1610 are called Io, Europa, Ganymede and Callisto. For the first three moons, the orbital period *T* of each is exactly twice the period of the one orbiting immediately inside it. That is,

$$T_{\text{Europa}} = 2 \times T_{\text{Io}}$$

$$T_{\text{Ganymede}} = 2 \times T_{\text{Europa}}$$

The mass of Jupiter is 1.90×10^{27} kg, and the orbital radius of Io is 421 600 km.

(a) Use Kepler's Law of Periods to calculate Ganymede's orbital radius. 2

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(b) Calculate Ganymede's orbital speed. 3

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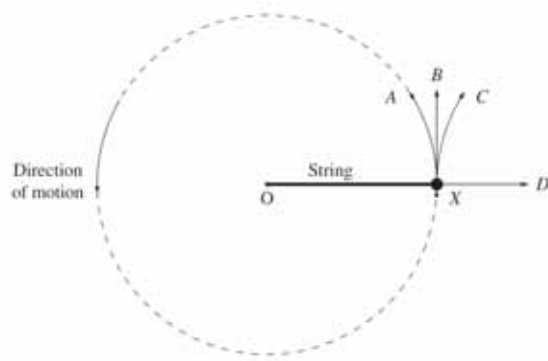
Assessors report & Marking criteria

- (a) In better responses, candidates demonstrated recognition of the required formula provided in the Formulae Sheet and provided correct substitution of values to determine the period of Io and hence the period of Ganymede. The responses included the use of Kepler's formula again to determine the orbital radius of Ganymede.
In the best responses, candidates recognised that $\frac{GM}{4\pi^2}$ was a constant and determined the radius using ratios.
Weaker responses involved substitution errors or the use of incorrect units.
- (b) In better responses, candidates recognised that centripetal force and gravitational force had to be equated to derive an equation for orbital velocity and substituted the correct values and units.
The weaker responses included substitution errors or used 'r' values in kilometres rather than metres.

Criteria	Marks
• Correctly substitutes into relevant formula	2
• Rearranges Kepler's Law of Periods into a ratio of periods OR • Uses the equation from the data sheet and substitutes incorrectly	1
Criteria	Marks
• Correct substitution	3
• Manipulates the equations correctly	2
• Identifies relevant equation	1

Suggested Answer – SUCCESS ONE

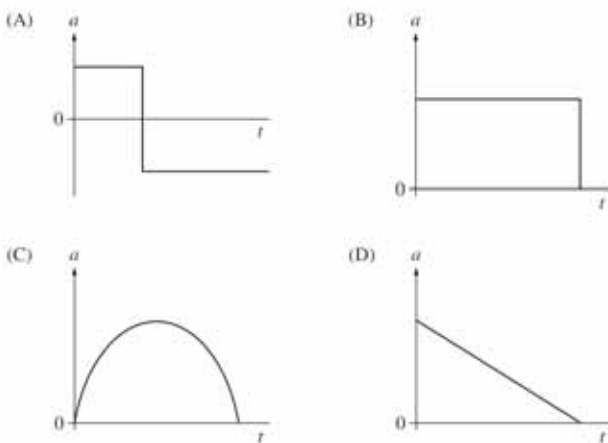
- 2 A mass attached to a length of string is moving in a circular path around a central point, O, on a flat, horizontal, frictionless table. This is depicted in the diagram below. The string breaks as the mass passes point X.



Which line best depicts the subsequent path of the mass?

- (A) Line A
(B) Line B
(C) Line C
(D) Line D

- 4 A stone is thrown horizontally from the top of a cliff and falls onto the beach below.
Which acceleration–time graph best describes the motion of the stone?



- 5 Two satellites, X and Y, are in circular orbits around Earth. Their masses are identical and their orbital radii are R and 16R, respectively.

What is the ratio of their orbital periods, $T_X:T_Y$?

- (A) 1 : 4
(B) 1 : 16
(C) 1 : 32
(D) 1 : 64

Question 16 (6 marks)

A projectile leaves the ground at point A with velocity components as shown in the diagram. It follows the path given by the dotted line and lands at point B.



- (a) State the horizontal component of the projectile's velocity when it lands. 1
- (b) Find the magnitude of the initial velocity of the projectile. 1
- (c) Calculate the maximum height attained by the projectile. 2
- (d) Calculate the range of the projectile, if it lands level with its starting position. 2

Assessors report & Marking criteria

- (a) Better responses displayed recognition of the vector nature of velocity and gave both magnitude and direction in the answer.
- (b) Better responses used Pythagoras' theorem to calculate the initial velocity.
- (c) Better responses used the relevant equation, correctly substituted data, and identified the directions of the vector quantities involved.

Criteria	Marks
• Gives correct answer	1
Criteria	Marks
• Correctly determines magnitude of initial velocity	1
Criteria	Marks
• Correctly calculates maximum height	2
• Identifies the equation(s) required but uses them incorrectly OR • Calculates time to reach maximum height, but does not correctly determine the height	1
Criteria	Marks
• Correctly determines the range	2
• Correctly determines time of flight but not the range OR • Identifies the equation(s) required to produce the correct answer	1

Suggested Answer – SUCCESS ONE

Question 17 (6 marks)

Parts of a space mission involve a spacecraft spending time in geostationary orbit, and then returning safely to Earth.

Analyse the forces acting on this spacecraft during these parts of the mission.

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Assessors report & Marking criteria

Better responses focused on the forces on the spacecraft rather than on the astronauts and provided the analysis of two parts – geostationary orbit and re-entry. These responses clearly indicated that the centripetal force needed to maintain a stable orbit is provided by the gravitational force between the earth and the spacecraft and that the two forces do not cancel each other out. Better responses also described some of the forces involved in re-entry and explained their effects on the motion of the spacecraft.

Sample response:

During stationary orbit, the spacecraft travels at a constant speed in orbit around the Earth. The Earth's gravity provides the centripetal force for the spacecraft's orbit. In order to return to Earth, the spacecraft must decelerate by firing its boosters in the opposite direction of motion. This creates a force to slow the speed of the spacecraft and hence reduce its energy. When the energy is reduced, its radius of orbit must also decrease since the two are related so the spacecraft descends. The particles in the upper atmosphere provide a friction force opposite to the direction of motion of the craft, slowing it down further which lowers its orbit and increases the friction. Gravity pulls the spacecraft back to Earth where the craft can land.

Criteria	Marks
• Describes forces both during stable orbit and upon re-entry, and relates these to the result	5–6
• Describes forces either during stable orbit or upon re-entry, and relates to the result	3–4
• Identifies forces both during stable orbit and upon re-entry but does not relate them to the result	2
• Identifies one of the forces during stable orbit or upon re-entry	1

Suggested Answer – SUCCESS ONE

2007

- 1 A satellite is in orbit around Earth with tangential velocity v as shown.

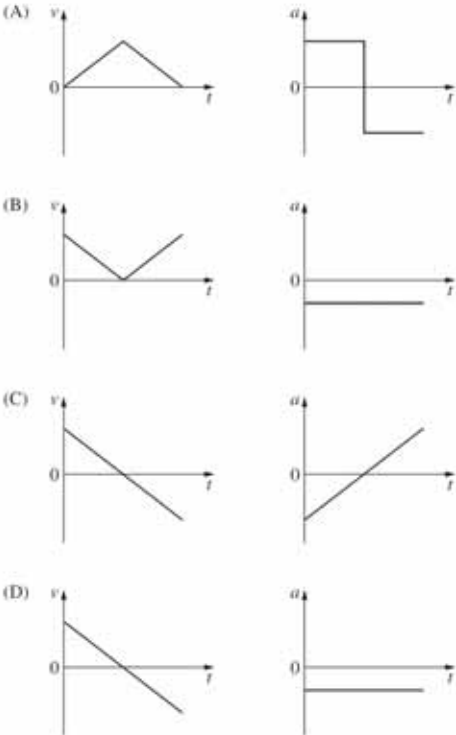


Which of the following describes the direction of the centripetal force acting on the satellite?

- (A) Same direction as the gravitational force
(B) Opposite direction to the gravitational force
(C) Same direction as the tangential velocity
(D) Opposite direction to the tangential velocity

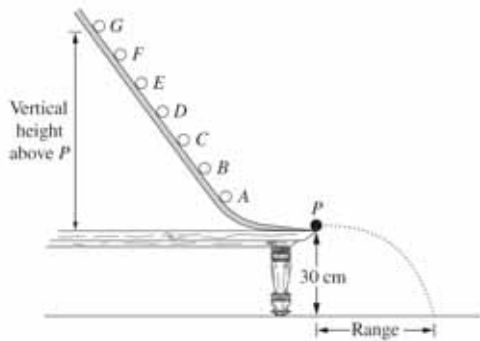
- 5 A cannon ball is fired vertically upward from a stationary boat.

Which pair of graphs best describes the velocity, v , and acceleration, a , of the cannon ball as functions of time, t ? Ignore air resistance.



Question 16 (5 marks)

A group of students conducted an investigation in which ball bearings were released from various points on a ramp. The ball bearings rolled down the ramp to the edge of a table at point P as shown. Their ranges were measured.

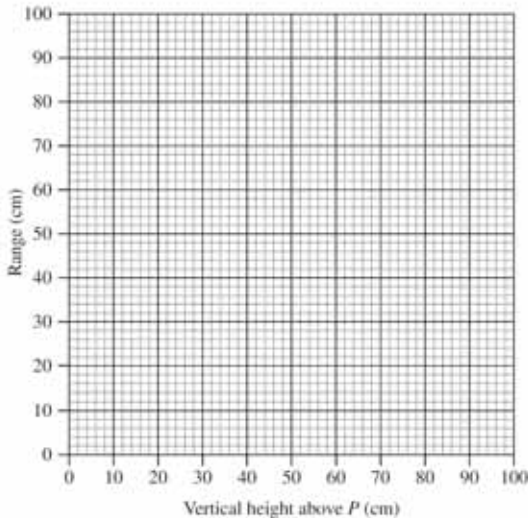


The results are shown in the table.

Point of release	Vertical height above P (cm)	Range (cm)
A	10	32
B	20	44
C	30	58
D	40	66
E	50	76
F	60	82
G	70	87

Question 16 (continued)

- (a) Plot the data from the table and draw a curve of best fit.



- (b) (i) Using your graph, predict the range of a ball bearing released from a height of 80 cm above point P.
- (ii) Calculate the horizontal velocity of the ball bearing released from a height of 80 cm above point P.

Assessors report & Marking criteria

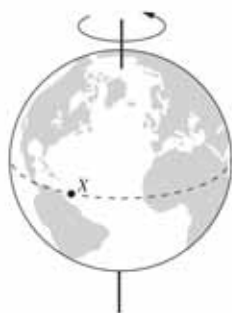
- (a) Better responses utilised a curved line of best fit as required in the question.
- (b)(ii) Better responses used the correct height when calculating the time of fall before calculating the ball's horizontal velocity. Better responses converted data to SI units when substituting into formulae.
- (c) Better responses used the relevant equation, correctly substituted data, and identified the directions of the vector quantities involved.

Criteria	Marks
<ul style="list-style-type: none">Draws line of best fit which is:<ul style="list-style-type: none">a curveclose to all pointshas approximately the same number (if any) of points above and below the line AND EITHER <ul style="list-style-type: none">Correctly plots all seven points OR <ul style="list-style-type: none">Plots SIX points correctly and seventh incorrectly by not more than TWO divisions OR <ul style="list-style-type: none">Plots FIVE points correctly and sixth and seventh incorrectly by not more than ONE division	2
<ul style="list-style-type: none">Correctly plots all seven points ONLY OR <ul style="list-style-type: none">Plots SIX points correctly and seventh incorrectly by not more than TWO divisions ONLY OR <ul style="list-style-type: none">Plots FIVE points correctly and sixth and seventh incorrectly by not more than ONE division ONLY OR <ul style="list-style-type: none">Draws a line (close to all points and approximately the same number of points above and below the line)	1
Criteria	Marks
<ul style="list-style-type: none">Predicts the range as 92 cm \pm 1cm (whether or not marked on the graph) OR <ul style="list-style-type: none">Predicts the range consistent with correct extrapolation of graph	1
Criteria	Marks
<ul style="list-style-type: none">Calculates correct velocity for range chosen	2
<ul style="list-style-type: none">Identifies correct equations to calculate velocity	1

Suggested Answer – SUCCESS ONE

Question 17 (4 marks)

The diagram shows the position *X* on Earth's surface from which a satellite is to be launched into a geostationary orbit.



- (a) On the diagram, draw an arrow to show the direction of launch from *X*, and justify your choice. **1**

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- (b) Given that the radius of Earth is 6.38×10^6 m, calculate the height of the satellite above Earth's surface. **3**

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Assessors report & Marking criteria

- (a) Better responses connected the direction of the Earth's rotational velocity with the launch direction and not to the Earth's orbital velocity.
- (b) The best responses were those in which candidates substituted all terms into the correct formula to calculate the satellite's height above the surface. Weaker responses showed some confusion about the satellite described as being on the Earth's surface yet being expected to calculate its height when in orbit.

Criteria	Marks
<ul style="list-style-type: none"> Draws arrow towards East from <i>X</i> Provides an appropriate justification 	1
Criteria	Marks
<ul style="list-style-type: none"> Identifies correct formula Correctly substitutes <i>G</i>, <i>M</i> and <i>T</i> Subtracts the Earth's radius to calculate value <i>r</i> 	3
<ul style="list-style-type: none"> Any two of the above OR <ul style="list-style-type: none"> Recalls correct value for satellite radius and subtracts radius of Earth 	2
<ul style="list-style-type: none"> Any one of the above OR <ul style="list-style-type: none"> Recalls correct value of altitude 	1

Suggested Answer – SUCCESS ONE

2008

- 2 Which of these statements best describes the forces acting on a satellite in orbit around Earth?
- (A) Although gravity has no effect, there is still an outward force.
- (B) The satellite is kept up by an outward force that balances the force due to gravity.
- (C) Gravity is the only force acting on the satellite and this results in an inward acceleration.
- (D) The effect of gravity is negligible, the satellite is kept in orbit by its momentum and the net force on it is zero.

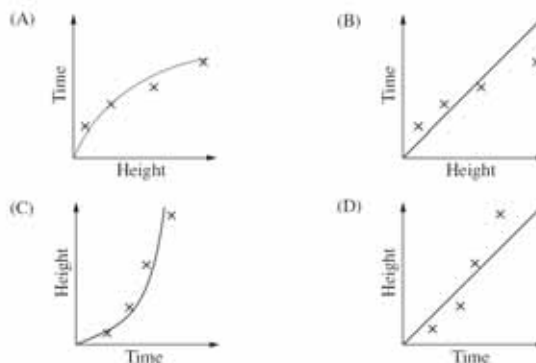
- 3 An aeroplane is flying horizontally over level ground. It has an altitude of 490 m and a velocity of 100 m s^{-1} . As the aeroplane passes directly above a cross marked on the ground, an object is released from the aeroplane.

How far away from the cross will this object land?

- (A) 490 m
- (B) 1000 m
- (C) 10 000 m
- (D) 49 000 m

- 4 An investigation was performed to determine the acceleration due to gravity. A ball was dropped from various heights and the time it took to reach the ground from each height was measured. The results were graphed with the independent variable on the horizontal axis.

Which graph best represents the relationship between the variables?



Question 19 (8 marks)

- (a) Explain the changes in momentum when a satellite fires its propulsion system. 3

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- (b) A satellite is propelled from Orbit 1 to Orbit 2 as shown in the diagram.



- Orbit 2 has a radius of 27 000 km. What is the satellite's speed in this orbit? 3

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- (c) The radius of Orbit 2 is four times that of Orbit 1. What is the ratio of the new orbital period to the original period? 2

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