Marks

16. In 1920 a prominent newspaper published the following editorial about the pioneering experiments of Robert H. Goddard, dismissing the notion that a rocket could operate in a vacuum:

> " That Professor Goddard, … does not know the relation of action and reaction, and of the need to have something better than a vacuum against which to react – to say that would be absurd. Of course he seems only to lack the knowledge ladled out daily in our high schools"

Discuss the merits of the central argument proposed by the paper that the action-reaction principle does not apply in a vacuum. **3**

17. A 6000 kg rocket is set for vertical firing on the surface of the earth.

(a) Calculate the constant thrust that must be supplied by the engines if the rocket is to be given an initial upward acceleration of 20 ms^{-2}. **2**

(b) If the exhaust speed is 1000 m/s what mass of gas must be ejected each second to give the rocket this acceleration. **1**

18. A 10,000 kg rocket is moving through space at a speed of 100ms^{-1}. The exhaust gases of the rocket are emitted in the direction opposing motion with a velocity of 500 ms^{-1} and at a rate of 100 kgs^{-1}. What is the velocity of the rocket after 15 seconds? **4**

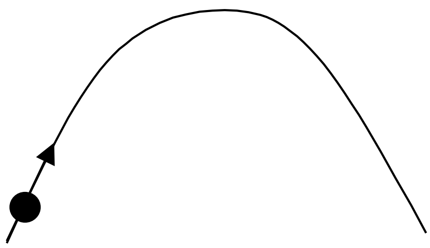
19. Explain, in terms of forces, why astronauts are seated in a horizontal position during launch of a rocket. **2**

20. Describe how a slingshot effect is provided by planets for space probes. **2**

HSCFocus.com

Marks

21. The diagram shows the path of a projectile under the influence of a gravitational force only.

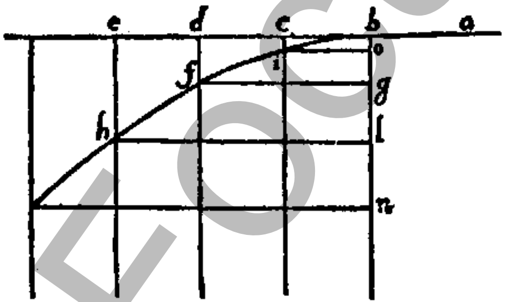


The point "X" represents the highest point reached by the projectile.

(a) Draw a vector representing the direction of the acceleration at the point marked "X" on the diagram. **1**

(b) Draw a vector representing the velocity at the point marked "X" on the diagram. **1**

22. Galileo was responsible for deducing the parabolic shape of the trajectory of a projectile in the seventeenth century. The following diagram is taken from Galileo's book "Two New Sciences".



Drawing of a parabolic trajectory from Galileo's *Two New Sciences*.

Explain using scientific principles why the horizontal displacements (b-c, c-d, d-e) remain constant, whereas the vertical displacements increase in the same times. **4**

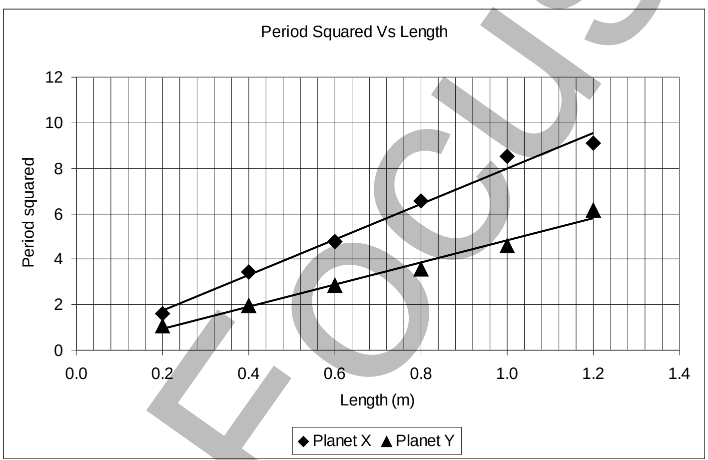
HSCFocus.com

Marks

23. An astronaut used a simple pendulum to calculate a value for acceleration due to gravity on two different planets. The astronaut measured the period of the motion for different length pendulums. The results from the two experiments are shown below in the table.

Planet X		Planet Y	
Length(m)	Period(s)	Length(m)	Period(s)
0.2	1.26	0.2	1.03
0.4	1.85	0.4	1.41
0.6	2.18	0.6	1.69
0.8	2.56	0.8	1.89
1.0	2.92	1.0	2.15
1.2	3.02	1.2	2.48

The astronaut consulted the following equation for the period of the pendulum, $T = 2p\sqrt{\frac{l}{g}}$ where T represents the period of the pendulum, l represents the length and g represents the acceleration due to gravity. The astronaut then graphed the data as shown.



(a) For a length of 1m, state which planet produced the shortest period for the pendulum. **1**

(b) By examining the graph, and consulting the formula, determine the value of "g" for planet X. **3**

(c) Calculate the weight of a 5 kg mass on planet X. **1**

24. The asteroid Toro, discovered in 1964, has a radius of about 5.0 km and a mass of 2.0×10^{15} kg. Discuss whether a person could reach the escape velocity for this asteroid simply by running. Justify your answer. **3**

25. A satellite is moving in a geostationary orbit. Calculate the altitude of the satellite above the earth's surface. The mass of the earth is 5.97×10^{24} and the average radius of the earth is 6.38×10^{6}. **3**

HSCFocus.com

Marks

26. Pluto orbits the sun in a nearly circular orbit with radius 5.90×10^{12} m and an orbital period of 247.7 years. Use this data to make an estimate of the mass of the sun. **3**

27. Outline a thought experiment that demonstrates that if the speed of light is constant as measured from any inertial reference frame then events that are said to be simultaneous as viewed by an observer in one reference frame may not be simultaneous when observed from another reference frame. **5**

28. A muon is an unstable elementary particle. A stationary muon has a lifetime of approximately 2.2 μs. If the muon is accelerated to a high speed in a particle accelerator, its lifetime is measured to be 2.9 μs.

(a) State what this phenomenom is called. **1**

(b) Calculate the speed of the muon. **2**

29. The diagram below shows a galvanometer.

Insert diagram here

Explain why larger deflections of the pointer are produced by larger currents passing through the galvanometer. **3**

30. Explain why you cannot build an electric motor entirely out of permanent magnets. **4**

31. Compare the structure and function of a generator to an electric motor. **4**

HSCFocus.com

Physics

Mapping Grid

Question	Marks	Content	Syllabus Outcomes	Targeted Performance Bands
16	3	9.2.2	H6	3-4
17	3	9.2.2	H6	3-4
18	4	9.2.2	H6, H7	4
19	2	9.2.2	H6, H9, H13	2-3
20	2	9.2.2	H9, H13	2-3
21	2	9.2.2	H9	2-3
22	4	9.2.2	H2	4-6
23	5	9.2.1	H14	4-5
24	3	9.2.1	H6, H7	3-4
25	3	9.2.2	H6, H9	3-4
26	3	9.2.2	H6, H9, H14	3-4
27	5	9.2.4	H1	5-6
28	3	9.2.4	H6	3-4
29	3	9.3.1	H6	3-4
30	4	9.3.1	H9, H13	4
31	4	9.3.3	H7, H9	4-5

HSCFocus.com

Marks

16. In 1920 a prominent newspaper published the following editorial about the pioneering experiments of Robert H. Goddard, dismissing the notion that a rocket could operate in a vacuum:

> " That Professor Goddard, … does not know the relation of action and reaction, and of the need to have something better than a vacuum against which to react – to say that would be absurd. Of course he seems only to lack the knowledge ladled out daily in our high schools"

Discuss the merits of the central argument proposed by the paper that the action-reaction principle does not apply in a vacuum. **3**

Content Area: Space 9.2.2
Syllabus Outcomes: H6
Targeted Bands: 3-4

Criteria	Marks
• The argument proposed by the paper is incorrect, a rocket will work in a vacuum.	1
• A rocket will work in a vacuum because the rocket exerts a force on the fuel ejecting it out behind it	1
• The fuel exerts an equal and opposite force on the rocket propelling it forward.	1

HSCFocus.com

Marks

17. A 6000 kg rocket is set for vertical firing on the surface of the earth.

(a) Calculate the constant thrust that must be supplied by the engines if the rocket is to be given an initial upward acceleration of 20 ms^{-2}. **2**

(b) If the exhaust speed is 1000 m/s what mass of gas must be ejected each second to give the rocket this acceleration. **1**

Content Area: Space 9.2.2
Syllabus Outcomes: H6
Targeted Bands: 3-4

Criteria	Marks
(a) Correct calculation of thrust using correct sum of forces acting on rocket i.e. $F_{net} = ma = T - W$ (T = thrust) (2 Marks)	2
Calculation of Thrust (T) using $F_{net} = ma = T$ only	1
(b) Correct Calculation of mass of gas using Ft = change in momentum	1

HSCFocus.com

Marks

18. A 10,000 kg rocket is moving through space at a speed of 100ms^{-1}. The exhaust gases of the rocket are emitted in the direction opposing motion with a velocity of 500 ms^{-1} and at a rate of 100 kgs^{-1}. What is the velocity of the rocket after 15 seconds? **4**

Content Area: Space 9.3.2
Syllabus Outcomes: H6, H7
Targeted Bands: 4

Criteria	Marks
• Calculation/Statement of initial momentum	1
• Calculation of mass of exhaust gases and subsequent mass of space craft.	1
• Application of conservation of momentum	2

Answers could include:

Calculate the initial momentum of the rocket
as 10,000 kg x 100 ms^{-1} = 1,000,000 kgms^{-1}.

At time = 15s 1500 kg of exhaust gas has been emitted so mass of the rocket = 10,000 kg –1500 kg = 8500 kg

speed of exhaust gases is -500ms^{-1} (backwards) less forward velocity of 100 ms^{-1} = -400ms^{-1}

starting momentum = final momentum
1,000,000 kgms^{-1}= 1500 kg x -400 ms^{-1}+8500kg x $u_{\textbf{rocket}}$

$$u_{\textbf{rocket}} = \frac{1{,}000{,}000\ \text{kgms}^{-1} + 600{,}000\ \text{kgms}^{-1}}{8500\text{kg}} = 188\ \text{ms}^{-1}$$

OR

Students may choose to work initially in the frame of reference of the rocket.

Thus initial momentum = 0

Conservation of momentum becomes

$0 = m_{rocket}\, v_{rocket} - m_{fuel}v_{fuel}$

$$v_{rocket} = m_{fuel}v_{fuel}/\ m_{rocket} = 1500*500/8500 = 88\ \text{ms}^{-1}$$

The velocity of the rocket in the original reference frame is then
100 + 88 = 188 ms^{-1}

HSCFocus.com

Marks

19. Explain, in terms of forces, why astronauts are seated in a horizontal position during launch of a rocket. **2**

Content Area: Space 9.2.2
Syllabus Outcomes: H6, H9, H13
Targeted Bands: 3

Criteria	Marks
• During launch, acceleration many times normal may be experienced	1
• If acceleration is directed perpendicular to the bodies long axis, acceleration of up to 10X may be tolerated for short periods. This prevents blood being pushed by forces to the head (redout) or to the feet resulting in a blackout, during launch.	1

HSCFocus.com

Marks

20. Describe how a slingshot effect is provided by planets for space probes. **2**

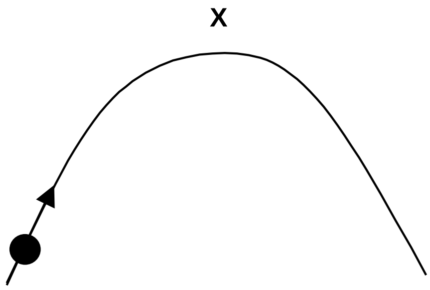
Content Area: Space 9.2.2
Syllabus Outcomes: H9, H13
Targeted Bands: 2-3

Criteria	Marks
• As the probe approaches a planet, the planets gravitational attraction accelerates the probe, relative to the planet. The probe also gains angular momentum of the planet, relative to the sun.	1
• As the probe leaves the planet's gravitational field it loses the acceleration gained but retains the angular momentum gained.	1

HSCFocus.com

Marks

21. The diagram shows the path of a projectile under the influence of a gravitational force only.

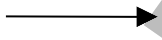


The point "X" represents the highest point reached by the projectile.

(c) Draw a vector representing the direction of the acceleration at the point marked "X" on the diagram. **1**

(d) Draw a vector representing the velocity at the point marked "X" on the diagram. **1**

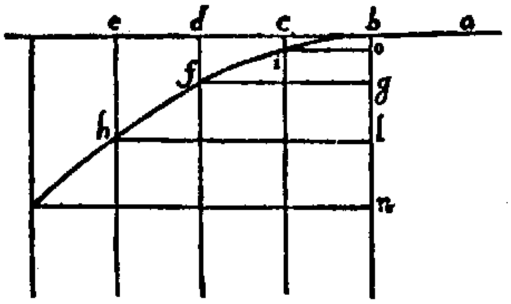
Content Area: Space 9.2.2
Syllabus Outcomes: H9
Targeted Bands: 2-3

Criteria	Marks
(a) 	1
(b) 	1

HSCFocus.com

Marks

22. Galileo was responsible for deducing the parabolic shape of the trajectory of a projectile in the seventeenth century. The following diagram is taken from Galileo's book "Two New Sciences". **4**



Drawing of a parabolic trajectory from Galileo's *Two New Sciences*.

Explain using scientific principles why the horizontal displacements (b-c, c-d, d-e) remain constant, whereas the vertical displacements increase in the same times.

Content Area: Space 9.2.2
Syllabus Outcomes: H2
Targeted Bands: 4-6

Criteria	Marks
Students argue logically through the following • Force of gravity is vertical • Therefore vertical accelerations or vertical change in momentum • Therefore only vertical velocities change • So horizontal displacements in equal times remain constant while vertical displacements increase with increasing velocity.	4
Students do not make the link between force and acceleration (or change in momentum), but explain the rest satisfactorily.	3
Relate the displacements to the velocities without stating why the velocities change or remain the same.	2
Discusses only one of the directions of motion	1

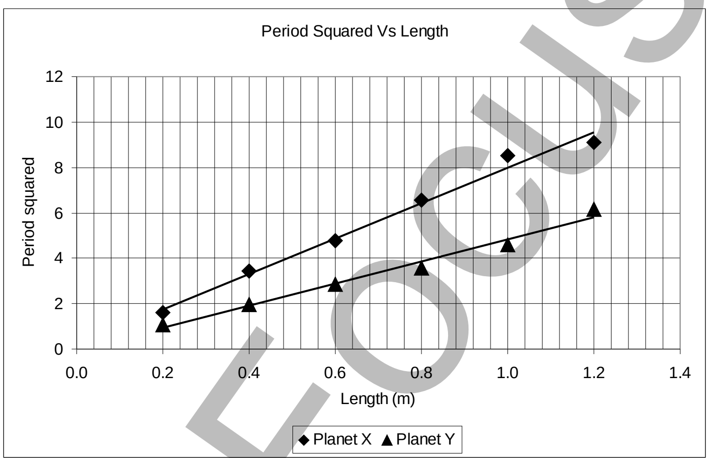
HSCFocus.com

Marks

23. An astronaut used a simple pendulum to calculate a value for acceleration due to gravity on two different planets. The astronaut measured the period of the motion for different length pendulums. The results from the two experiments are shown below in the table.

Planet X		Planet Y	
Length(m)	Period(s)	Length(m)	Period(s)
0.2	1.26	0.2	1.03
0.4	1.85	0.4	1.41
0.6	2.18	0.6	1.69
0.8	2.56	0.8	1.89
1.0	2.92	1.0	2.15
1.2	3.02	1.2	2.48

The astronaut consulted the following equation for the period of the pendulum, $T = 2p\sqrt{\frac{l}{g}}$ where T represents the period of the pendulum, l represents the length and g represents the acceleration due to gravity. The astronaut then graphed the data as shown.



(a) For a length of 1m, state which planet produced the shortest period for the pendulum. **1**

(b) By examining the graph, and consulting the formula, determine the value of "g" for planet X. **3**

(c) Calculate the weight of a 5 kg mass on planet X. **1**

HSCFocus.com

Content Area: Space 9.2.1
Syllabus Outcomes: H14
Targeted Bands: 4-5

Criteria		Marks
(a)	Planet Y	1
(b)	Rearranges formula to get $g = \frac{4p^2 l}{T^2}$	
	Recognises that $\frac{l}{T^2}$ is $\frac{1}{gradient}$	
	finds gradient from line of best fit and substitutes	3
	OR	OR
	Picks a point on the line of best fit and substitutes into formula	2
	OR	OR
	Picks a data point from the table and substitutes into formula	1
(c)	Calculates weight from W=mg	1

HSCFocus.com

24. The asteroid Toro, discovered in 1964, has a radius of about 5.0 km and a mass of 2.0 x 10^{15} kg. Discuss whether a person could reach the escape velocity for this asteroid simply by running. Justify your answer.

Marks

3

Content Area: Space 9.2.1
Syllabus Outcomes: H6, H7
Targeted Bands: 3-4

Criteria	Marks
• Statement that the person would need to have sufficient KE to overcome the gravitational attraction of the asteroid. • $\frac{Gm_1m_2}{r} = \frac{1}{2}m_1v^2 \therefore v = \sqrt{\frac{2Gm}{r}}$	2
OR • Student simply states escape velocity as $v = \sqrt{\frac{2Gm}{r}}$	OR 1
• Uses appropriate units for r and m	1
• Compares velocity against top speed for human	1

Answers could include:

V= 7.3 m/s, which is equivalent to running 100m in about 13.7 s. This is a speed that is attainable by a human. Other factors however may stop a human from running at this speed in a low g environment.

HSCFocus.com

Marks

25. A satellite is moving in a geostationary orbit. Calculate the altitude of the satellite above the earth's surface. The mass of the earth is 5.97×10^{24} and the average radius of the earth is 6.38×10^{6}. **3**

Content Area: Space 9.2.2
Syllabus Outcomes: H6, H9
Targeted Bands: 3-4

Criteria	Marks
• Geostationary orbit T=24 x 60 x 60s	1
• Correct use of $\frac{T^2}{r^3} = \frac{4p^2}{Gm}$	1
• subtraction of the radius of the earth to gain altitude	1

Answers could include:
T=86400s
$R=4.22\times10^{7}$ m
$\text{Altitude}=3.58\times10^{6}$m

HSCFocus.com

Marks

26. Pluto orbits the sun in a nearly circular orbit with radius 5.90 x 10^{12} m and an orbital period of 247.7 years. Use this data to make an estimate of the mass of the sun. **3**

Content Area: Space 9.2.2
Syllabus Outcomes: H6, H9, H14
Targeted Bands: 3-4

Criteria	Marks
• correct period in seconds • correct substitution • correct understanding of significant figures	1 1 1

Answers could include:
T=247.7x365.25x24x60x60=7.89 E09 s
M=2 E30 kg

HSCFocus.com

Marks

27. Outline a thought experiment that demonstrates that if the speed of light is constant as measured from any inertial reference frame then events that are said to be simultaneous as viewed by an observer in one reference frame may not be simultaneous when observed from another reference frame. **5**

Content Area: Space 9.2.4
Syllabus Outcomes: 9.2.4
Targeted Bands: 5-6

Criteria	Marks
• clearly describes a thought experiment using sketches / diagrams	1
• indicates that the velocity of one frame of reference relative to other is a significant proportion of the speed of light	1
• notes that relative velocities do not add together in a classical manner at this speed as this would violate the constant nature of the speed of light	1
• the constant "c" will effect how people measure time, ie times become relative	1
• observers will then disagree about the order of events	1

HSCFocus.com

Marks

28. A muon is an unstable elementary particle. A stationary muon has a lifetime of approximately 2.2 μs. If the muon is accelerated to a high speed in a particle accelerator, its lifetime is measured to be 2.9 μs.

(a) State what this phenomenom is called. **1**

(b) Calculate the speed of the muon. **2**

Content Area:	Space 9.2.4
Syllabus Outcomes:	H6
Targeted Bands:	3-4

Criteria	Marks
(a) Time dilation	1
(b) Correct substitution / rearrangement of time dilation formula	2

Answers could include:

From $t = \dfrac{t_0}{\sqrt{1-\left(\dfrac{v}{c}\right)^2}}$ rearrange to $v = c\sqrt{1-\dfrac{t_0}{t}}$

Note that the μ cancels, or students could enter the appropriate power of ten.

V=1.47 E+08

HSCFocus.com

29. The diagram below shows a galvanometer. **Marks**

Insert diagram here

Explain why larger deflections of the pointer are produced by larger currents passing through the galvanometer. **3**

Content Area: Motors and Generators 9.3.1
Syllabus Outcomes:
Targeted Bands: 3-4

Criteria	Marks
• Relates linear increase of the torque on the coil to the current passing through the coil, ie $t \propto I$	2
OR	OR
• bigger current bigger torque	1
• the larger torque will rotate the pointer further against the restoring torque of the spring	1

HSCFocus.com

Marks

30. Explain why you cannot build an electric motor entirely out of permanent magnets. **4**

Content Area: Motors and Generators 9.3.1
Syllabus Outcomes: H9, H13
Targeted Bands: 4

Criteria	Marks
In such a motor, the rotor would orient itself so that its magnetic poles were as close as possible to opposite poles of the stationary magnets. After a brief period of settling, the rotor would become motionless.	4

HSCFocus.com

Marks

31. Compare the structure and function of a generator to an electric motor. **4**

Content Area: Motors and Generators 9.3.3
Syllabus Outcomes: H7, H9
Targeted Bands: 4-5

Criteria	Marks
Motors and generators are essentially the same as motors, particularly synchronous AC motors. If you connect a synchronous AC motor to the power line and let it turn, it will draw energy out of the electric circuit and provide work. But if you connect the same motor to a light bulb and turn its rotor by hand, it will generate electricity and light the bulb. Whether the motor acts as a generator or a motor depends on which way energy is transferred.	4

HSCFocus.com