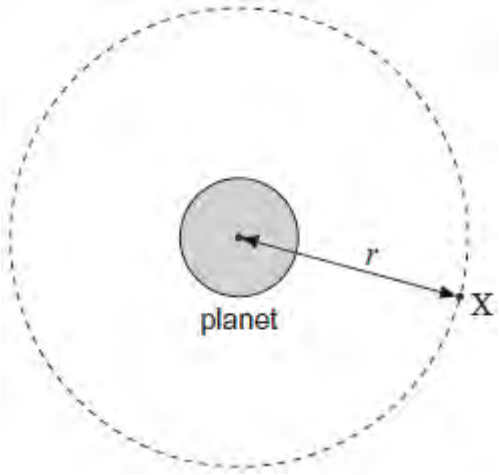
Q1. A satellite X is in a circular orbit of radius r about the centre of a spherical planet of mass M.



Which line, **A** to **D**, in the table gives correct expressions for the centripetal acceleration a and the speed v of the satellite?

	Centripetal acceleration a	**Speed v**
A	$\frac{GM}{2r}$	$\sqrt{\frac{GM}{2r}}$
B	$\frac{GM}{2r}$	$\sqrt{\frac{GM}{r}}$
C	$\frac{GM}{r^2}$	$\sqrt{\frac{GM}{2r}}$
D	$\frac{GM}{r^2}$	$\sqrt{\frac{GM}{r}}$

(Total 1 mark)

Q2.A satellite orbiting the Earth moves to an orbit which is closer to the Earth.

Which line, **A** to **D**, in the table shows correctly what happens to the speed of the satellite and to the time it takes for one orbit of the Earth?

	Speed of satellite	**Time For One Orbit Of Earth**
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

(Total 1 mark)

Q3.(a) (i) State what is meant by the term **escape velocity**.

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(1)

(ii) Show that the escape velocity, v, at the Earth's surface is given by $v = \sqrt{\frac{2GM}{R}}$

where M is the mass of the Earth
and R is the radius of the Earth.

(2)

(iii) The escape velocity at the Moon's surface is 2.37×10^3 m s^{-1} and the radius of the Moon is 1.74×10^6 m.

Determine the mean density of the Moon.

mean density ..... kg m^{-3}

(2)

(b) State **two** reasons why rockets launched from the Earth's surface do **not** need to achieve escape velocity to reach their orbit.

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(2)
(Total 7 marks)

Q4.(a) Explain why astronauts in an orbiting space vehicle experience the sensation of weightlessness.

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(2)

(b) A space vehicle has a mass of 16 800 kg and is in orbit 900 km above the surface of the Earth.

mass of the Earth = 5.97×10^{24} kg
radius of the Earth = 6.38×10^{6} m

(i) Show that the orbital speed of the vehicle is approximately 7400 m s^{-1}.

(4)

(ii) The space vehicle moves from the orbit 900 km above the Earth's surface to an orbit 400 km above the Earth's surface where the orbital speed is 7700 m s^{-1}.

Calculate the total change that occurs in the energy of the space vehicle. Assume that the vehicle remains outside the atmosphere after the change of orbit.
Use the value of 7400 m s^{-1} for the speed in the initial orbit.

change in energy ..... J

(4)
(Total 10 marks)

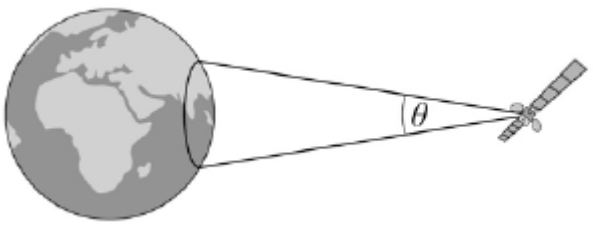
Q5.Read the following passage and answer the questions that follow

Satellites used for telecommunications are usually in geostationary orbits. Using

suitable dishes to transmit the signals, communication over most of the Earth's surface is possible at all times using only 3 satellites.

Satellites used for meteorological observations and observations of the Earth's surface are usually in low Earth orbits. Polar orbits, in which the satellite passes over the North and South Poles of the Earth, are often used.

One such satellite orbits at a height of about 12 000 km above the Earth's surface circling the Earth at an angular speed of 2.5×10^{-4} rad s^{-1}. The microwave signals from the satellite are transmitted using a dish and can only be received within a limited area, as shown in the image below.



not to scale

The signal of wavelength λ is transmitted in a cone of angular width θ, in radian, given by

$$\theta = \frac{\lambda}{d}$$

where d is the diameter of the dish.

The satellite transmits a signal at a frequency of 1100 MHz using a 1.7 m diameter dish. As this satellite orbits the Earth, the area over which a signal can be received moves. There is a maximum time for which a signal can be picked up by a receiving station on Earth.

(a) Describe **two** essential features of the orbit needed for the satellite to appear geostationary.

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(2)

(b) Calculate the time taken, in s, for the satellite mentioned in line 7 in the passage to complete one orbit around the Earth.

time taken = _____s

(1)

(c) Show that at a distance of 12 000 km from the satellite the beam has a width of 1900 km.

(3)

(d) The satellite is in a polar orbit and passes directly over a stationary receiver at the South Pole.

Show that the receiver can remain in contact with the satellite for no more than about 20 minutes each orbit.

radius of the Earth = 6400 km

maximum time = _____ minute

(3)

(e) The same satellite is moved into a higher orbit.

Discuss, with reasons, how this affects the signal strength and contact time for the receiver at the South Pole.

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(4)
(Total 13 marks)

Q6.(a) (i) Define gravitational field strength and state whether it is a scalar or vector quantity.

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(2)

(ii) A mass m is at a height h above the surface of a planet of mass M and radius R.
The gravitational field strength at height h is g. By considering the gravitational force acting on mass m, derive an equation from Newton's law of gravitation to express g in terms of M, R, h and the gravitational constant G.

(2)

(b) (i) A satellite of mass 2520 kg is at a height of 1.39×10^7 m above the surface of the Earth. Calculate the gravitational force of the Earth attracting the satellite. Give your answer to an appropriate number of significant figures.

force attracting satellite ..... N

(3)

(ii) The satellite in part (i) is in a circular polar orbit. Show that the satellite would travel around the Earth three times every 24 hours.

(5)

(c) State and explain **one** possible use for the satellite travelling in the orbit in part (ii).

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(2)
(Total 14 marks)

Q7. Two satellites P and Q, of equal mass, orbit the Earth at radii R and $2R$ respectively. Which one of the following statements is correct?

A P has less kinetic energy and more potential energy than Q.

B P has less kinetic energy and less potential energy than Q.

C P has more kinetic energy and less potential energy than Q.

D P has more kinetic energy and more potential energy than Q.

(Total 1 mark)

Q8. The Earth moves around the Sun in a circular orbit with a radius of 1.5×10^8 km. What is the Earth's approximate speed?

A $1.5 \times 10^3 \text{ms}^{-1}$

B $5.0 \times 10^{3} ms^{-1}$

C $1.0 \times 10^{4} ms^{-1}$

D $3.0 \times 10^{4} ms^{-1}$

(Total 1 mark)