Gravitation

MCQ

Gravitational Force

1 The Earth experiences gravitational forces from the Sun, mass M_S, and from the Moon, mass M_M. The distance of the Sun from the Earth is r_S and the distance of the Moon from the Earth is r_M. What is the ratio of the force on the Earth due to the Sun to the force on the Earth due to the Moon?

A $\frac{M_S}{M_M}\left(\frac{r_S}{r_M}\right)$ **B** $\frac{M_S}{M_M}\left(\frac{r_M}{r_S}\right)$ **C** $\frac{M_S}{M_M}\left(\frac{r_S}{r_M}\right)^2$ **D** $\frac{M_S}{M_M}\left(\frac{r_M}{r_S}\right)^2$

2 An experimental satellite is found to have a weight W when assembled before launching from a rocket site. It is placed in a circular orbit at a height h = 6R above the surface of the Earth (of radius R). What is the gravitational force acting on the satellite whilst in orbit?

A W/6 **B** W/7 **C** W/36 **D** W/49

3 Two stationary particles of masses M_1 and M_2 are a distance d apart. A third particle, lying on the line joining the particles, experiences no resultant gravitation force. What is the distance of this particle from M_1?

A $d\left(\frac{M_2}{M_1}\right)$ **B** $d\sqrt{\left(\frac{M_1}{M_2}\right)}$ **C** $d\sqrt{\left(\frac{M_1}{M_1+M_2}\right)}$ **D** $d\left(\frac{\sqrt{M_1}}{\sqrt{M_1}+\sqrt{M_2}}\right)$

Gravitational Field Strength

4 The distance between a point, X, in space and the centre of the Earth is 25 times the radius of Earth. If the gravitational field strength on the surface of the Earth is 9.81 N kg^{-1}, what is the gravitational field strength due to Earth at X?

A 1.56×10^{-2} N kg^{-1}
B 1.57×10^{-2} N kg^{-1}
C 3.90×10^{-2} N kg^{-1}
D 3.92×10^{-2} N kg^{-1}

5 Outside a uniform sphere of mass M, the gravitational field strength is the same as that of a point mass M at the centre of the sphere. The Earth may be taken to be a uniform sphere of radius r. The gravitational field strength at its surface is g. What is the gravitational field strength at a height h above the ground?

A $\frac{gr^2}{(r+h)^2}$ **B** $\frac{gr}{(r+h)}$ **C** $\frac{g(r-h)}{r}$ **D** $\frac{g(r-h)^2}{r^2}$

6 The acceleration of free fall on the surface of the Earth is 6 times its value on the surface of the Moon. The mean density of the Earth is 5/3 times the mean density of the Moon. What is the ratio of the radius of the Earth to the radius of the Moon?

A 1.9 **B** 3.6 **C** 6.0 **D** 10

7 A rock is thrown vertically upward near the surface of Planet X with a velocity of 45 m s^{-1} and it comes to an instantaneous rest 5.2 s later. If the same rock is now thrown up near the surface of Planet Y with the same initial velocity as that on Planet X, at 5.2 s later it is still moving upwards at a speed of 25 m s^{-1}. If both planets do not have atmosphere, what is the ratio of the gravitational field strength near the surface of Planet Y to that of Planet X?

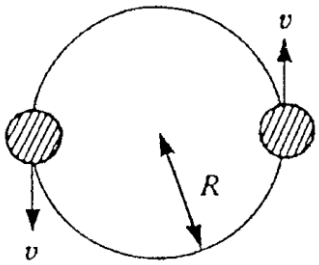
A 0.25 **B** 0.38 **C** 0.44 **D** 0.62

Circular Orbits

8 A 20 kg satellite requires a speed of 2.0 km s^{-1} to stay in a circular orbit at a certain height above the Earth. What would be the speed, in km s^{-1}, of a 100 kg satellite in the same orbit?

A 1.0 **B** 1.4 **C** 2.0 **D** 4.0

9 Two stars of equal mass M move with constant speed v in a circular orbit of radius R about their common centre of mass as shown in the figure below.



What is the net force on each star?

A $\frac{GM^2}{4R^2}$ **B** $\frac{Mv^2}{2R}$ **C** $\frac{2Mv^2}{R}$ **D** $\frac{GM^2}{R^2}$

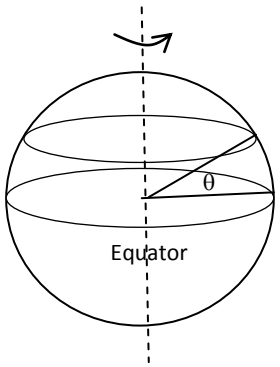
10 Two satellites A and B of the same mass are moving in circular orbits round the Earth. The radius of A's orbit is r and that of B's orbit is 2r. Their kinetic energies are T_A and T_B respectively. Which of the following is true?

A $T_A = 2T_B$ **B** $T_A = \frac{1}{2}T_B$ **C** $T_A = \sqrt{2}\,T_B$ **D** $T_A = \frac{1}{\sqrt{2}}T_B$

11 Planet X of mass M and planet Y of mass 3M revolve around a common centre. The two planets are constantly separated by a distance of D. Where is this common centre of their rotation?

A D/3 from planet X
B D/3 from planet Y
C D/4 from planet X
D D/4 from planet Y

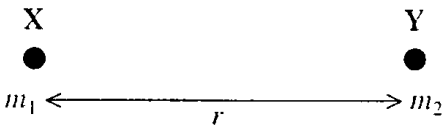
12 The Earth has a radius of 6.38 x10^6 m, and rotates on its axis once every 24 hours. At what latitude (i.e., the angle θ in the drawing) is the tangential speed one third that of a person living at the equator? Take the mass of the Earth to be 6.0×10^{24} kg.



A 20.5° **B** 30.5° **C** 60.5° **D** 70.5°

Structured Questions

13 Two small masses m_1 and m_2 are placed at X and Y respectively and are separated by a distance r as shown below.



(a) Draw on the figure above the direction of the gravitational field which m_1 causes at Y.

(b) What is the value of the gravitational field strength which m_1 causes at Y?

(c) What is the force which m_1 causes on m_2?

14 A satellite P of mass 2400 kg is placed in a geostationary orbit at a distance of 4.23×10^7 m from the centre of the Earth.

(a) Explain what is meant by the term geostationary orbit.

(b) Calculate

(i) the angular velocity of the satellite,

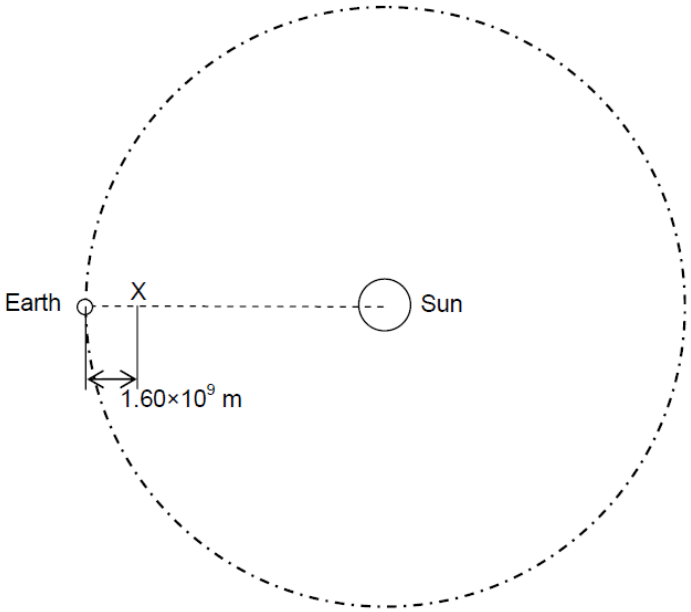
(ii) the speed of the satellite,

(iii) the acceleration of the satellite,

(iv) the force of attraction between the Earth and the satellite,

(v) the mass of the Earth.

15 In order to observe the Sun continuously, a satellite of mass 425 kg is at a point X, a distance of 1.60×10^9 m from the centre of the Earth as shown in the figure below.



mass of Sun = 1.99×10^{30} kg
mass of Earth = 5.98×10^{24} kg
Earth-Sun distance = 1.50×10^{11} m

(a) Using the data given above, calculate
- **(i)** the pull of the Earth on the satellite,
- **(ii)** the pull of the Sun on the satellite.

(b) On the above figure, sketch two arrows to represent the two forces acting on the satellite. Label the arrows with the magnitude of the forces.

(c) Calculate the magnitude and direction of the resultant force on the satellite. Hence, determine the resultant field strength at X.

(d) State the acceleration of the satellite and, assuming the satellite is in a circular orbit around the sun, calculate the angular velocity of the satellite.

(e) Considering your answer to (a)ii, describe the motion of the satellite relative to the Earth. Suggest why this orbit is preferable to a satellite orbit around the Earth.