

Name of the Student: _____

Max. Marks : 18 Marks

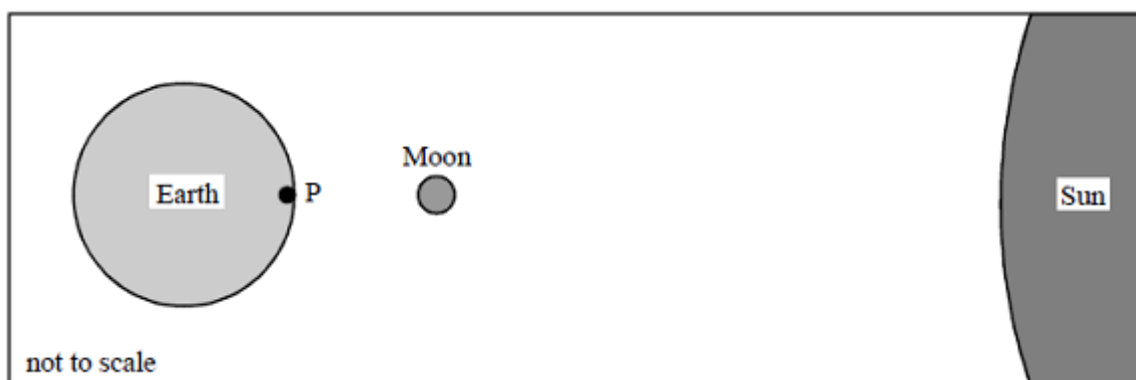
Time : 18 Minutes

Q1.

- (a) Define *gravitational field strength* at a point in a gravitational field.

(1)

- (b) Tides vary in height with the relative positions of the Earth, the Sun and the moon which change as the Earth and the Moon move in their orbits. Two possible configurations are shown in **Figure 1**.



Configuration A



Configuration B

Figure 1

Consider a 1 kg mass of sea water at position **P**. This mass experiences forces F_E , F_M and F_S due to its position in the gravitational fields of the Earth, the Moon and the Sun respectively.

- (i) Draw labelled arrows on **both** diagrams in **Figure 1** to indicate the three forces experienced by the mass of sea water at **P**.

(3)

- (ii) State and explain which configuration, **A** or **B**, of the Sun, the Moon and the Earth will produce the higher tide at position **P**.

(2)

- (c) Calculate the magnitude of the gravitational force experienced by 1 kg of sea water on the Earth's surface at **P**, due to the **Sun's** gravitational field.

$$\text{radius of the Earth's orbit} = 1.5 \times 10^{11} \text{ m}$$

$$\text{mass of the Sun} = 2.0 \times 10^{30} \text{ kg}$$

$$\text{universal gravitational constant, } G = 6.7 \times 10^{-11} \text{ Nm}^2 \text{ kg}^{-2}$$

(3)

(Total 9 marks)

Q2.

For an object, such as a space rocket, to escape from the gravitational attraction of the Earth it must be given an amount of energy equal to the gravitational potential energy that it has on the Earth's surface. The minimum initial vertical velocity at the surface of the Earth that it requires to achieve this is known as the escape velocity.

- (a) (i) Write down the equation for the gravitational potential energy of a rocket when it is on the Earth's surface. Take the mass of the Earth to be M , that of the rocket to be m and the radius of the Earth to be R .

(1)

- (ii) Show that the escape velocity, v , of the rocket is given by the equation

$$v = \sqrt{\frac{2GM}{r}}$$

(2)

- (b) The nominal escape velocity from the Earth is 11.2 km s^{-1} . Calculate a value for the escape velocity from a planet of mass four times that of the Earth and radius twice that of the Earth.

(2)

- (c) Explain why the actual escape velocity from the Earth would be greater than the nominal value calculated from the equation given in part (a)(ii).

(2)

(Total 7 marks)

Q3.

Satellites N and F have the same mass and move in circular orbits about the same planet. N is the nearer satellite and F is the more distant. Which one of the following is smaller for N than for F?

- A gravitational force on the satellite
- B speed
- C kinetic energy
- D time for one orbit

(Total 1 mark)

Q4.

Two identical conducting spheres on insulating supports carry charges of magnitude Q and $2Q$ respectively. When separated by distance d , the electrostatic repulsive force is F . The spheres are made to touch and then restored to their original separation d . If there is no loss of charge what is the new force of repulsion?

- A $\frac{F}{2}$

B $\frac{3F}{\cdot}$

C $\frac{9F}{8}$

D $\frac{4F}{3}$

(Total 1 mark)