Name of the Student:_____
Max. Marks : 22 Marks **Time : 22 Minutes**

Q1.

The distance between the centres of the Earth and the Moon is 3.8×10^8 m. The mass of the Earth is 6.0×10^{24} kg and the mass of the Moon is 7.4×10^{22} kg.

A spacecraft of mass 10×10^3 kg is moving along a line joining their centres.

At what distance from the centre of the Earth would the spacecraft experience no resultant force due to the Earth and the Moon?

A 3.8×10^7 m ⬭

B 4.8×10^7 m ⬭

C 3.4×10^8 m ⬭

D 3.8×10^8 m ⬭

(Total 1 mark)

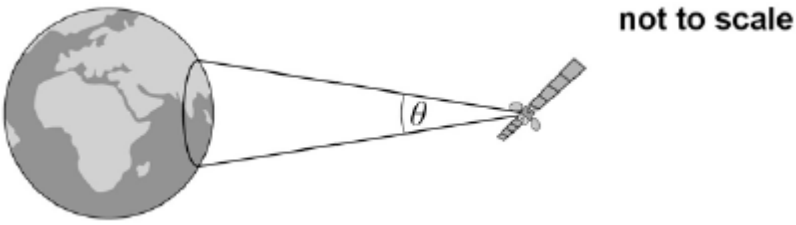
Q2.

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. 5

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. 10



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. 15

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

_____

_____

(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.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 13 marks)

Q3.

The planet Venus may be considered to be a sphere of uniform density 5.24×10^3 kg m^{-3}.
The gravitational field strength at the surface of Venus is 8.87 N kg^{-1}.

(a) (i) Show that the gravitational field strength g_s at the surface of a planet is related to the the density ρ and the radius R of the planet by the expression

$$g_s = \frac{4}{3}\pi GR\rho$$

where G is the gravitational constant.

(2)

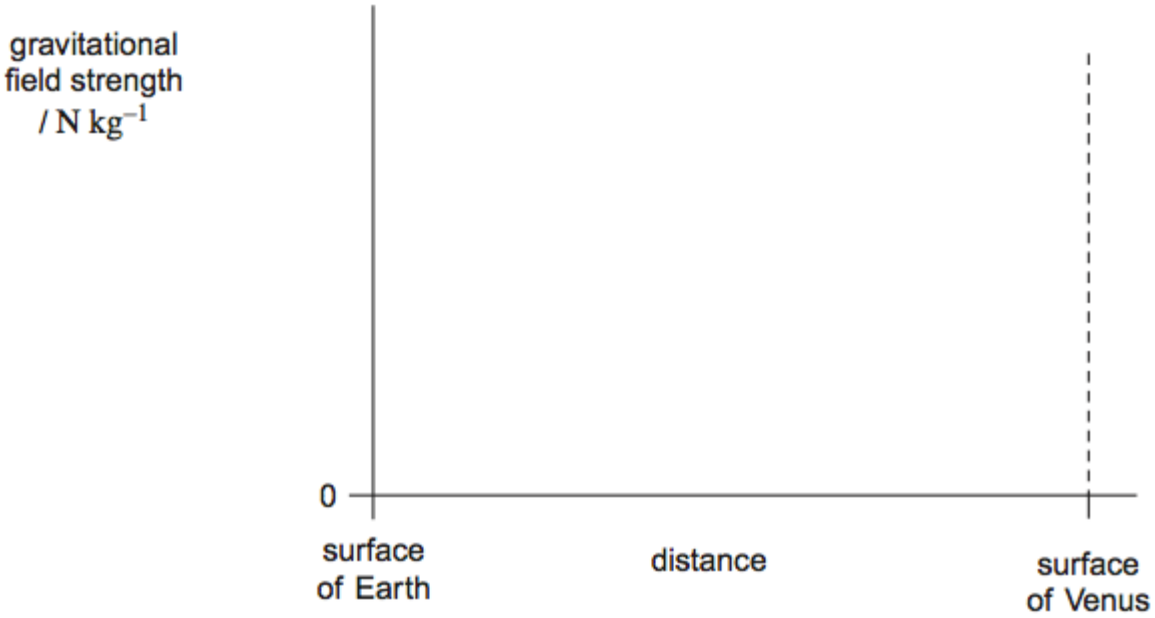
(ii) Calculate the radius of Venus.

Give your answer to an appropriate number of significant figures.

radius = _____ m

(3)

(b) At a certain time, the positions of Earth and Venus are aligned so that the distance between them is a minimum.
Sketch a graph on the axes below to show how the magnitude of the gravitational field strength g varies with distance along the shortest straight line between their surfaces.
Consider only the contributions to the field produced by Earth and Venus.
Mark values on the vertical axis of your graph.



(3)
(Total 8 marks)