3 A satellite moves about Earth in a circular orbit, as illustrated in Fig. 3.1.

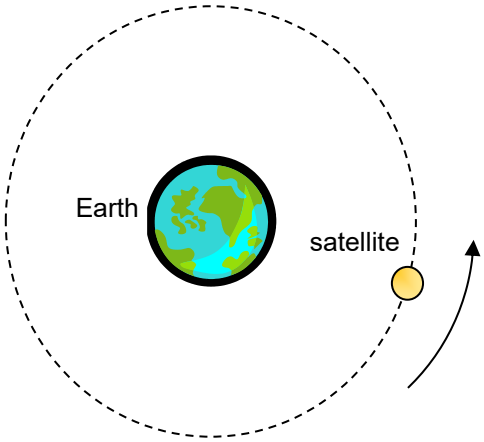

Fig. 3.1

The Earth and the satellite may be considered to be point masses with their masses concentrated at their centres.

(a) In a certain time interval, the satellite moved from position A to position B, as shown in Fig. 3.2, such that the straight line distance between A and B is equal to the radius of orbit.

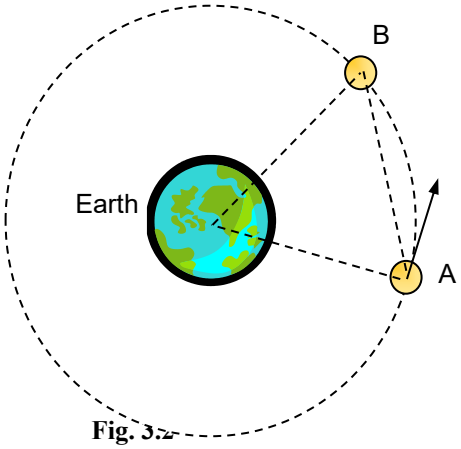

Fig. 3.2

Calculate the angular displacement of the satellite during this time interval.

angular displacement = …… rad [1]

(b) The Moon can also be considered to be a point mass with its mass concentrated at its centre. It makes a circular orbit about the Earth, taking 27.3 days to make one complete orbit.

(i) Calculate the angular velocity of the Moon

angular velocity = ... rad s^{-1} [1]

(ii) At time $t = 0$, the centres of mass of the Earth, the Moon and the satellite align, as shown in Fig. 3.3.

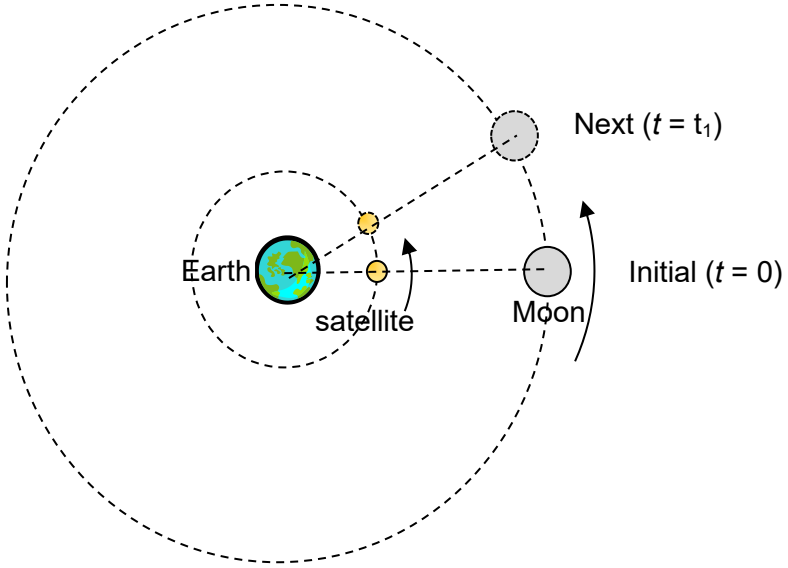

Fig. 3.3

At at later time $t = t_1$, the centre of mass of the three bodies align again, as illustrated in Fig. 3.3. The satellite takes 23.9 hours to make one complete orbit.

Calculate the time t_1.

t_1 = …… hours [2]

(c) **(i)** The period of the satellite and the radius of its orbit are related by the expression:

$$T = k\sqrt{d^3}$$

where T is the period of orbit, d is the radius of orbit, and k is a constant.

Determine the expression for the constant k in terms of gravitational constant, G, and the mass of the Earth, M.

[3]

(ii) An aged satellite orbiting the Earth, due to resistive forces, will gradually spiral down and towards the Earth.

State and explain what happens to the angular velocity of the satellite as it spirals down.

……

……

……

…… [3]