8 **(a)** **(i)** A satellite is orbiting the Earth in a circular orbit with a period of 24 hours. State two circumstances under which this satellite will be a geostationary satellite.

1.....

.....

2.....

.....[2]

(ii) State one advantage and one disadvantage of geostationary satellites.

Advantage:.....

.....

.....

.....

Disadvantage:.....

.....

.....

.....

[2]

(b) Fig. 8.1 shows a pair of stars of equal mass *m* which move in circular orbits around their common centre of mass (C.M.).

In this question consider the stars to be point masses situated at their centres.

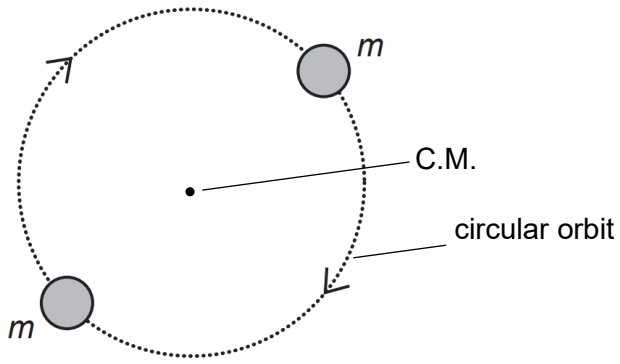

Fig. 8.1

(i) By considering the forces acting on the stars, explain why they must always be diametrically opposite in such an orbit.

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.....[2]

(ii) The centres of the two stars are separated by a distance R of 3.6×10^{10} m. The stars have an orbital period T of 20.5 days.

Calculate the mass m of each star.

m = ... kg [3]

(c) Saturn is a massive planet with a mass of 5.68×10^{26} kg and radius 5.82×10^{4} km.

(i) Calculate the gravitational potential V_S on the surface of Saturn.

V_S = ... [3]

(ii) State a physical meaning to your answer to part **(c)(i)**.

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.....

.....[1]

(d) Titan is the largest moon of Saturn. It has a mass of 1.35×10^{23} kg and a radius of 2.58×10^{3} km . The distance between the centres of Titan and Saturn is 1.22×10^{6} km .

(i) A space probe is at the mid-point between Titan and Saturn, heading directly towards Titan. Explain whether the space probe is gaining or losing gravitational potential energy at this point in time.

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.....[2]

(ii) Point E is the point between the centres of Saturn and Titan where the resultant gravitational field strength is zero. Calculate the distance between point E and the centre of Titan.

distance = ... km [3]

(e) As a result of bombardment of Titan by a meteor, a rock of mass m is ejected with an intial kinetic energy of K_T from Titan's surface.

Let the symbols V_S, V_T and V_E represent the gravitational potential on the surface of Saturn, Titan and at point E respectively.

(i) Using any of the symbols m, K_T, V_S, V_T and V_E, write an inequality that represents the condition for the rock being able to arrive on Saturn.

[1]

(ii) Using any of the symbols m, K_T, V_S, V_T and V_E, write an expression for the kinetic energy K_S of the rock when it arrives on the surface of Saturn.

[1]