1 **(a)** Fig. 2.1 shows an aeroplane flying in a horizontal circle at constant speed. The weight of the aeroplane is *W* and *L* is the lift force acting at right angles to the wings.

Fig. 2.1

(i) Explain how the lift force *L* maintains the aeroplane flying in a **horizontal** circle.

.....

.....

.....

..... **[2]**

(ii) The aeroplane of mass 1.2×10^5 kg is flying in a horizontal circle of radius 2.0 km.

The centripetal force acting on the aeroplane is 1.8×10^6 N. Calculate the speed of the aeroplane.

speed = ... $m\,s^{-1}$ **[2]**

(b) Fig. 2.2 shows a satellite orbiting the Earth at a constant speed *v*. The radius of the orbit is *r*.

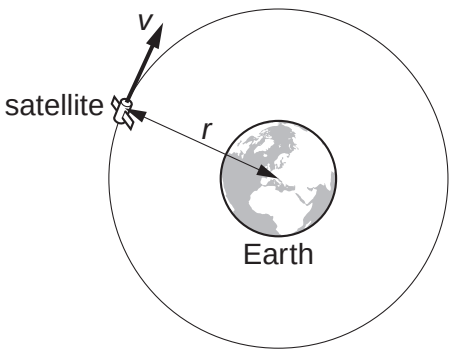

Fig. 2.2

Show that the orbital period T of the satellite is given by the equation

$$T^2 = \frac{4\pi^2 r^3}{GM}$$

where M is the mass of the Earth and G is the gravitational constant.

[3]

(c) The satellites used in television communication systems are usually placed in geostationary orbits.

In your answer, you should use appropriate technical words spelled correctly.

(i) State two features of geostationary orbits.

1. .....

.....

2. .....

..... **[2]**

(ii) Calculate the radius of orbit of a geostationary satellite.

The mass of the Earth is 6.0×10^{24} kg.

radius = ... m **[3]**

[Total: 12]

2 A satellite orbits the Earth in a circular path 800 km above the Earth's **surface**. At the orbit of the satellite the gravitational field strength is 7.7 N kg^{-1}. The radius of the Earth is 6400 km.

(a) Calculate

(i) the orbital speed of the satellite

orbital speed = ... m s^{-1} **[3]**

(ii) the period of the orbit of the satellite.

period = ... s **[2]**

(b) The orbit of the satellite passes over the Earth's poles.

(i) Show that the satellite makes about 14 orbits around the Earth in 24 hours.

[1]

(ii) The cameras on board the satellite continually photograph a strip of the Earth's surface, of width 3000 km, directly below the satellite. Determine, with an appropriate calculation, whether the satellite can photograph the whole of the Earth's surface in 24 hours. State your conclusion.

.....

.....

..... **[3]**

(c) Suggest a practical use of such a satellite.

.....

..... **[1]**

[Total: 10]

3 **(a)** State, in words, Newton's law of gravitation.

.....

.....

..... **[1]**

(b) Fig. 3.1 shows the circular orbits of two of Jupiter's moons: Adrastea, **A**, and Megaclite, **M**.

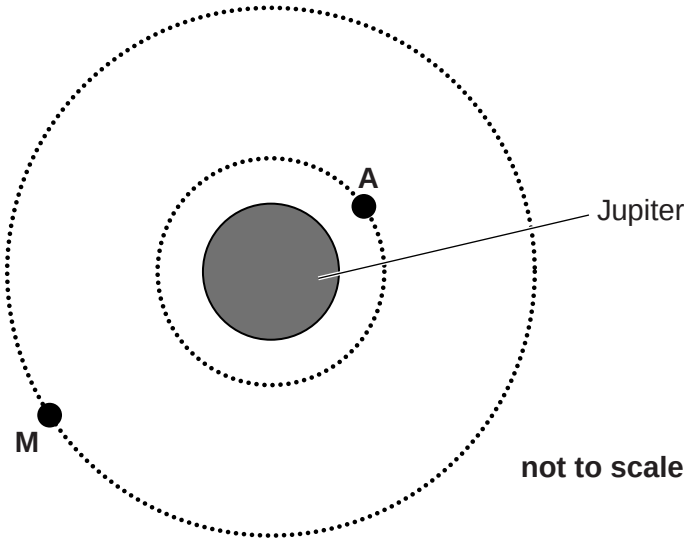

Fig. 3.1

Use the following data in the calculations below.

orbital radius of **A** = 1.3×10^8 m
orbital period of **A** = 7.2 hours
gravitational field strength at orbit of **A** = $7.5\,\text{N}\,\text{kg}^{-1}$
orbital radius of **M** = 2.4×10^{10} m

Calculate

(i) the mass of Jupiter

mass = ... kg **[3]**

(ii) the gravitational field strength at the orbit of **M**

gravitational field strength = ... $N\,kg^{-1}$ **[2]**

(iii) the orbital period of **M**.

orbital period = ... hours **[3]**

[Total: 9]

4 **(a)** **(i)** State the name given to satellites that orbit the Earth, with a period of 1 day, above the equator.

You should use the appropriate technical term spelled correctly.

..... **[1]**

(ii) Explain why these satellites orbit above the equator.

.....

..... **[1]**

(iii) For companies who provide a satellite TV service, suggest the main advantage of using this type of satellite.

.....

..... **[1]**

(iv) The mass of the Earth is 6.0×10^{24} kg. Show that the radius of the orbit of a satellite with an orbital period of 1 day is about 4×10^{7} m.

[3]

(b) **(i)** State Kepler's third law.

.....

..... **[1]**

(ii) The Moon orbits the Earth with a period of 27.3 days. Use the information given in **(a)(iv)** to calculate the following ratio:

$$\frac{\text{distance of the Moon from the Earth's centre}}{\text{distance of the satellite from the Earth's centre}}$$

ratio = ... **[2]**

5 **(a)** **(i)** State, in terms of force, the conditions necessary for an object to move in a circular path at constant speed.

.....

..... **[1]**

(ii) Explain why this object is accelerating. State the direction of the acceleration.

.....

..... **[2]**

(b) A satellite moves in a circular orbit around the Earth at a constant speed of $3700\,m\,s^{-1}$.

The mass M of the Earth is $6.0 \times 10^{24}\,kg$.

Calculate the radius of this orbit.

radius = ... m **[4]**

(c) In order to move the satellite in **(b)** into a new smaller orbit, a decelerating force is applied for a brief period of time.

(i) Suggest how the decelerating force could be applied.

.....

..... **[1]**

(ii) The radius of this new orbit is $2.0 \times 10^{7}\,m$. Calculate the speed of the satellite in this orbit.

speed = ... $m\,s^{-1}$ **[2]**