Part I

1. The speed of Halley's comet, while traveling in its elliptical orbit around the sun,

   (a) increases as it nears the sun.
   (b) is constant.
   (c) is zero at two points in the orbit.
   (d) is zero at four points in the orbit.

   Answer: (a) This is Kepler's law of areas

2. If the Earth had four times its present mass, what would be its new period of revolution around the sun, compared to its present orbital period?

   (a) four times as much
   (b) two times as much
   (c) the same
   (d) one-half as much

   Answer: (c) The period depends on the mass of the sun, but not the mass of the planet.

3. The following statements refer to man-made, artificial satellites in orbit around Earth. Which is an accurate statement?

   (a) The velocity required to keep a satellite in a given orbit depends on the mass of the satellite.
   (b) Only circular orbits are possible for artificial satellites.
   (c) The period of revolution of a satellite moving about the Earth is independent of the size of the orbit it travels.
   (d) A satellite in a large diameter circular orbit will always have a longer period of revolution about the Earth than will a satellite in a smaller circular orbit.

   Answer: (d)

Part II

1. Answer Hobson Ch 5, Ex 6,15,20,26 and Problems 3,4,6,7,8,9

2. You travel to a distant planet, and as part of your survey you want to discover its mass. In this question you will see how to use the motion of the spaceship around the planet to estimate this. Here are some details that may be helpful. The mass of the spaceship is 6.8×10^5 kg, and it orbits the planet with a period of 26 hours and an orbital radius of 16×10^6 m.

   (a) (i) Use the radius and period to find the velocity of the spaceship in m/s.
   $$v = \frac{2\pi r}{T} = \frac{2\pi \times 16 \times 10^6}{26 \times 60 \times 60} = 1070 \text{ m/s}$$

(ii) Based on your answer above, find the centripetal acceleration of the spaceship.

For centripetal acceleration $a = \dfrac{v^2}{r} = \dfrac{1070^2}{16 \times 10^6} = 0.072 \text{ m/s}^2$

(iii) Using Newton's second law and the Universal Law of Gravitation, find the mass of the planet.

The acceleration can be related to the mass of the planet through Newton's 2nd Law. $F_{\text{net}} = ma \implies \dfrac{GmM}{r^2} = ma \implies M = \dfrac{ar^2}{G} = 2.76 \times 10^{23} \text{ kg}$

(b) (i) What forces if any act on the astronauts inside the spaceship?

The only force acting on the astronauts is the their weight – ie the force of gravity acting on them.

(ii) Explain why the astronauts feel weightless.

The astronauts feel weightless because they are in 'freefall'. That is, they are accelerating toward the planet at a rate equal to the acceleration of gravity at that point. (Note: The sensation of weight is actually the normal force of a surface acting on your body in order to limit your acceleration. When acceleration is zero the normal force must equal your actual weight. When your acceleration is equal to the acceleration of gravity the normal force is zero and you feel weightless.)

(c) The spaceship decreases its orbital radius to get a closer view of the planet. In this lower orbit will its speed be greater or smaller? Explain.

The speed is higher, since lower down the force is greater and the centripetal acceleration needs to be larger.