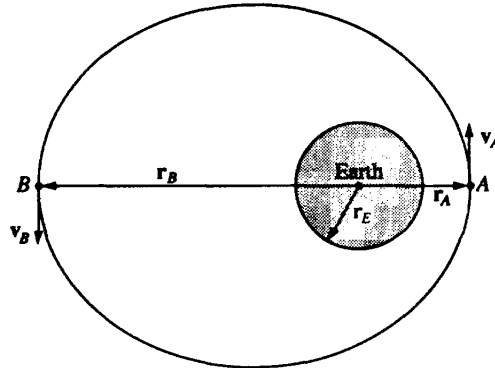


Name _____ Date _____ Period _____



A spacecraft of mass 1,000 kilograms is in an elliptical orbit about the Earth, as shown above. At point A the spacecraft is at a distance $r_A = 1.2 \times 10^7$ meters from the center of the Earth and its velocity, of magnitude $v_A = 7.1 \times 10^3$ meters per second, is perpendicular to the line connecting the center of the Earth to the spacecraft. The mass and radius of the Earth are $M_E = 6.0 \times 10^{24}$ kilograms and $r_E = 6.4 \times 10^6$ meters, respectively.

Determine each of the following for the spacecraft when it is at point A .

- a. The total mechanical energy of the spacecraft, assuming that the gravitational potential energy is zero at an infinite distance from the Earth.

$$E = PE + KE = -\frac{GMm}{R} + \frac{1}{2}mv^2 = -8.1 \times 10^9 \text{ J}$$

- b. The magnitude of the angular momentum of the spacecraft about the center of the Earth.

$$L = mvr = 8.5 \times 10^{13} \text{ kg}\cdot\text{m}^2/\text{s}$$

Later the spacecraft is at point B on the exact opposite side of the orbit at a distance $r_B = 3.6 \times 10^7$ meters from the center of the Earth.

- c. Determine the speed v_B of the spacecraft at point B.

**Angular momentum is conserved so $mv_a r_a = mv_b r_b$
giving $v_b = 2.4 \times 10^3$ m/s**

Suppose that a different spacecraft is at point A, a distance $r_A = 1.2 \times 10^7$ meters from the center of the Earth. Determine each of the following.

- d. The speed of the spacecraft if it is in a circular orbit around the Earth

$$F_g = F_c \text{ gives } \frac{GMm}{R^2} = \frac{mv^2}{R} \text{ and } v = \sqrt{GM/R} = 5.8 \times 10^3 \text{ m/s}$$

- e. The minimum speed of the spacecraft at point A if it is to escape completely from the Earth

Escape occurs when $E = PE + KE = 0$

$$\text{giving } -\frac{GMm}{R} + \frac{1}{2}mv^2 = 0 \text{ and } v_{esc} = \sqrt{2GM/R} = 8.2 \times 10^3 \text{ m/s}$$