10.3 The radius $r$ of the circular orbit is 100 km greater than the radius of the Earth, so

$$r = 6.37 \times 10^3 \text{ km} + 100 \text{ km} = 6.47 \times 10^6 \text{ m}.$$  

Find the speed of the satellite by applying Newton’s second law to it. The gravitational force of the Earth is the only force acting on the satellite. Since the orbit is circular, the acceleration is the centripetal acceleration. Therefore, using the magnitudes of the vectors, we have

$$F_{total} = ma \implies \frac{GMm}{r^2} = \frac{mv^2}{r} \implies v = \sqrt{\frac{GM}{r}} \implies v = \sqrt{\frac{(6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2/\text{kg}^2)(5.98 \times 10^{24} \text{ kg})}{6.47 \times 10^6 \text{ m}}} \implies v = 7.85 \times 10^3 \text{ m/s}.$$  

The orbital angular momentum of the satellite is

$$\vec{L} = \vec{r} \times \vec{p} = \vec{r} \times m\vec{v}.$$  

For circular motion, and an origin at the center of the circle, the position vector is perpendicular to the velocity. Hence, the magnitude of the orbital angular momentum is

$$L = rmv \sin 90^\circ = mvr = (1000 \text{ kg})(7.85 \times 10^3 \text{ m/s})(6.47 \times 10^6 \text{ m}) = 5.08 \times 10^{13} \text{ kg} \cdot \text{m}^2/\text{s}.$$  

10.4  

a) The momentum of the puck is

$$\vec{p} = m\vec{v} = (0.170 \text{ kg})(40.0 \text{ m/s})\hat{i} = (6.80 \text{ kg} \cdot \text{m/s})\hat{i}.$$  

b) There are no forces acting on the hockey puck in the direction of its momentum. Hence, Newton’s second law implies that the momentum of the puck is conserved (until it hits the net).  

c) The orbital angular momentum of the hockey puck when it is 10 m from the goalie is

$$\vec{L} = \vec{r} \times \vec{p} = \vec{r} \times m\vec{v} = -mvr \hat{k} \implies \vec{L} = -(0.170 \text{ kg})(40.0 \text{ m/s})(0.75 \text{ m})\hat{k} = -(5.1 \text{ kg} \cdot \text{m}^2/\text{s})\hat{k}.$$  

d) When the puck is closest to the goalie, the position vector and the velocity are perpendicular to each other, hence the orbital angular momentum is

$$\vec{L} = \vec{r} \times \vec{p} = \vec{r} \times m\vec{v} = -mvr\hat{k} \implies \vec{L} = -(0.170 \text{ kg})(40.0 \text{ m/s})(0.75 \text{ m})\hat{k} \implies \vec{L} = -(5.1 \text{ kg} \cdot \text{m}^2/\text{s})\hat{k}.$$