Ch8 Q5. If the net force on an object is zero, is the net torque zero? How about vise-versa?

You can easily rotate an object without moving it left or right, so obviously, net torque can be non zero while the net force on an object is not. Moreover, you can move an object without rotating it, so again, the net force can be nonzero while the net torque is zero.

Ch8 Q8. Can the mass of a rigid object be concentrated at its CM for rotational motion? Explain.

Not for rotation about its center of mass. This is because then

$$\begin{aligned} \tau &= I\alpha \\ &= \sum_i m_i r_i^2 \alpha \\ &= \sum_i m_i 0 \alpha \\ &= 0. \end{aligned}$$

since all of the radii are zero if all masses are at the center of mass.

Ch8 Q10. Two inclines have the same height but make different angles wrt the horizontal. The same steel ball rolls with slipping on either slope. On which incline will the speed of the ball be greater? Explain why.

Neither. The work done by gravity only depends on the height through which either ball falls.

Ch8 Q11. Two spheres have the same mass and look identical, but one is hollow and the other is solid. Describe an experiment to determine which is which.

Roll them down the incline, an each will have a different speed at the same time. Note that the hollow one has $I = \frac{2}{3}mr^2$, ball has $I = \frac{2}{5}mr^2$, which are both of the form

$$I = \alpha m r^2,$$

where for the hollow ball, $\alpha = 2/3$ and for the solid ball, $\alpha = 2/5$. Thus, conservation of energy gives

$$\begin{aligned} mgh &= \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2 \\ &= \alpha\frac{1}{2}mv^2 + \frac{1}{2}mv^2 \\ &= (\alpha+1)\frac{1}{2}mv^2 \\ \Rightarrow v &= \sqrt{\frac{2gh}{\alpha+1}}. \end{aligned}$$

Thus, the hollow sphere will have a slower speed at every height, since $2/3 > 2/5$, which makes the hollow sphere's speed slower. Thus, it will reach the bottom last.

Ch8 P26. A person exerts a horizontal force of 42 N on the end of a door 96 cm wide. What is the magnitude of the torque exerted (a) perpendicular and at a 60 degree angle to the face of the door?

Torque is $\tau = F\sin\theta r$, so, for each case,

$$\begin{aligned} 42\text{N}\cdot\sin(90)0.96\text{m} &= 40.\,\text{N}\cdot\text{m}, \\ 42\text{N}\cdot\sin(60)0.96\text{m} &= 35\,\text{N}\cdot\text{m}, \end{aligned}$$

Ch8 P38. A small 350 gram ball on the end of a thin, light rod is rotated in a horizontal circle of radius 1.2m. Calculate (a) the moment of inertia of the ball about the center of the circle, and (b) the torque needed to keep the ball rotating at constant angular velocity if air resistance exerts a force of 0.020 N on the ball. Ignore air resistance on the rod and its moment of inertia.

a) we have that the moment of inertia is

$$\begin{aligned} mr^2 &= .35\,\text{Kg}\cdot(1.2\text{m})^2 \\ &= 0.50\,\text{Kgm}^2. \end{aligned}$$

To keep a constant angular speed, newton's second law is

$$\begin{aligned} I\alpha &= 0 \\ &= \tau - D \\ \Rightarrow \tau &= D \\ &= 0.020\text{N}\times 1.2\text{m} \\ &= 0.024\,\text{Nm}. \end{aligned}$$

Ch8 P45. To get a flat uniform cylindrical satellite spinning at the correct rate, engineers fire four tangential rockets as shown in the figure. Suppose that the satellite has a mass of 3600 Kg and a radius of 4.0 m, and that the rockets each add a mass of 250 kg. What is the steady force required of each rocket if the satellite is to reach 32 rpm in 5.0 min, starting from rest?

We need to have an angular acceleration of

$$\begin{aligned} 32\frac{\text{rev}}{\text{min}}/5.0\,\text{min} &= 6.4\frac{\text{rev}}{\text{min}^2}\frac{2\pi\,\text{rad}}{1\text{ rev}}\frac{1\,\text{min}^2}{(60\text{sec})^2} \\ &= 6.4\left(\frac{2\pi}{3600}\right)\text{rad/s}^2. \\ &= 0.11\,\text{rad/s}^2. \end{aligned}$$

This is the total acceleration. Thus, we have that since

$$\begin{aligned} I &= \frac{1}{2}3600\text{Kg}(4.0\text{m})^2 + 4(250\text{Kg})(4.0\text{m})^2 \\ &= (2800)\times 16\text{kgm}^2 \\ &= 4.5\times 10^4\text{kgm}^2, \end{aligned}$$

we need a torque of

$$\begin{aligned} I\alpha &= 500\text{Nm} \\ \Rightarrow &= 4\tau \\ \Rightarrow \tau &= 125\text{Nm}. \end{aligned}$$

Thus, each must supply 125/4=31N of thrust.

Ch8 P52. A bowling ball of mass 7.25 Kg and radius 10.8 cm rolls without slipping down a lane at 3.10 m/s. Calculate its total kinetic energy.

The kinetic energy is

$$\begin{aligned} \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 &= \frac{1}{2}mv^2 + \frac{1}{2}\frac{2}{5}mr^2\omega^2 \\ &= \left(\frac{1}{2}+\frac{1}{5}\right)mv^2 \\ &= \frac{7}{10}mv^2 \\ &= \frac{7}{10}7.25\,\text{Kg}(3.10)^2 \\ &= 48.8\,\text{J} \end{aligned}$$