1. A dumbbell is made of two equal masses, $m$, connected by a massless rod of length $r$. If $I_1$ is the moment of inertia with respect to an axis passing through the center of the rod and perpendicular to it and $I_2$ is the moment of inertia with respect to an axis passing through one of the masses we can say that

(A) $I_1 = I_2$  
(B) $I_1 < I_2$  
(C) $I_1 > I_2$  
(D) needs more info

Treat masses as point masses

$I_2$ about axis at one end $I_2 = m(r)^2 + mL^2 = mL^2$

2. Consider a solid sphere of radius $R$ and mass $M$ rolling without slipping. Which form of kinetic energy is larger, translational ($K_T$) or rotational ($K_R$)? (For a sphere rotating around its axis, $I = \frac{2}{5} MR^2$)

(A) $K_R$  
(B) $K_T$  
(C) They are equal  
(D) Depends on the linear speed

Solid sphere $I_c = \frac{2}{5} MR^2$  
$K_{Rot} = \frac{1}{2} I_c \omega^2 = \frac{1}{2} \left( \frac{2}{5} MR^2 \right) \omega^2$

No slip: $v_c = R\omega \rightarrow \omega = \frac{v_c}{R} \rightarrow K_{Rot} = \frac{1}{2} \frac{M}{R^2} v_c^2$

But $K_{Trans} = \frac{1}{2} \frac{M}{R^2} v_c^2 \rightarrow K_{Rot}/K_{Trans} = \frac{2}{5}$

3. Two balls, one of radius $R$ and mass $M$, the other of radius $2R$ and mass $8M$, roll down an incline. They start together from rest at the top. Which one will reach the bottom first? (I is given in question 2)

(A) The small one  
(B) The bigger one  
(C) They arrive at the same time

Small ball: $K_{Total} = \frac{7}{10} M v^2$, $U_g = Mg h \rightarrow v = \frac{\sqrt{10g}}{7} h$

Big ball: $K_{Total} = \frac{28}{5} M v^2$, $U_g = 8Mg h \rightarrow v = \frac{\sqrt{10g}}{5} h$

4. Two points are on a disk that rotates about an axis perpendicular to the plane of the disk at its center. Point B is 3 times as far from the axis as point A. If the linear speed of point B is $V$, the linear speed of point A is:

(A) $9V$  
(B) $3V$  
(C) $V$  
(D) $V/3$  
(E) $V/9$

$v = r\omega$, same $\omega$ at any point on object

$v_A = r_A \omega$, $v_B = r_B \omega$  
If $r_B = 3r_A \rightarrow v_B = 3r_A \omega = 3v_A$

$v_A = v_B/3$

5. For the two points A and B in the previous question, if the angular speed of point B is $\omega$, then the angular speed of point A is:

(a) $9\omega$  
(b) $3\omega$  
(c) $\omega$  
(d) $\omega/3$  
(e) $\omega/9$

Angular speed $\omega$ is the same for all points
1. A disk starts from rest and has a constant angular acceleration. If it takes a time $t$ to make its 1$^{st}$ revolution, in time $2t$ (starting from rest) the disk will make

(A) $\sqrt{2}$ revolutions (B) 2 revolutions (C) 4 revolutions (D) 8 revolutions

$$\Theta - \Theta_0 = \omega_0 t + \frac{1}{2} \alpha t^2$$

but $\omega_0 = 0$ so

$$\Theta - \Theta_0 = \frac{1}{2} \alpha t^2$$

Thus it takes double the time, the $\Theta - \Theta_0$ is 4 times larger.

2. Consider a hollow sphere of radius $R$ and mass $M$ rolling without slipping. Which form of kinetic energy is larger, translational ($K_T$) or rotational ($K_R$)? (For a hollow sphere rotating around its axis, I=2/3 $MR^2$)

(A) $K_R$ (B) $K_T$ (C) They are equal (D) Depends on the linear speed

Similar to $z$ of $\frac{8A}{3}$ except now $I_{cm} = \frac{2}{3} MR^2$

Obtain $K_{Rot} = \frac{1}{2} M v_{cm}^2$ \hspace{1cm} $K_{Rot} = \frac{1}{2} M \frac{V_{Rot}}{L_{Trans}} = \frac{1}{2} \frac{1}{2} = \frac{1}{3}$

3. Two hollow balls, one of radius $R$ and mass $M$, the other of radius $2R$ and mass $6M$, roll down an incline. They start together from rest at the top. Which one will reach the bottom first? (I is given in question 2)

(A) The small one (B) The bigger one (C) They arrive at the same time

Small hollow ball: $K_{Total} = \frac{3}{2} M v^2$, $U_g = Mgh \rightarrow v^2 = \frac{6}{3} g h$

Big hollow ball: $K_{Total} = 2M v^2$, $U_g = 6Mgh \rightarrow v^2 = \frac{6}{5} g h$

4. Two points are on a disk that rotates about an axis perpendicular to the plane of the disk at its center. Point B is 2 times as far from the axis as point A. If the linear speed of point B is $V$, the linear speed of point A is:

(A) 4$V$ (B) 2$V$ (C) $V$ (D) $V/2$ (E) $V/4$

$v = r \omega$, same $\omega$ at any point on object

$v_A = r_A \omega$, $v_B = r_B \omega$, \hspace{1cm} $r_B = 2r_A \rightarrow v_B = 2v_A$

$v_A = v_B / 2$

5. A wheel of radius 0.5 m is spinning with constant angular velocity of 2 rad/sec. What is the centripetal acceleration of a point on the rim of the wheel?

(A) 0.5 m/s$^2$ (B) 1.0 m/s$^2$ (C) 2.0 m/s$^2$ (D) 0.25 m/s$^2$ (E) 4.0 m/s$^2$

$$a_c = \frac{v_{tangential}^2}{R} = \frac{(R \omega)^2}{R} = R \omega^2$$

$$a_c = 0.5 m \left( 2 \text{rad/s} \right)^2 = 2.0 \text{m/s}^2$$