Bull's Eye

Effects of Rotation

Rotational Motion of the Ball

- Most, but not all, the potential energy is transferred to kinetic energy
- Some of the PE also goes into rotational energy

$$PE_{lost} = KE_{translational} + KE_{rotational}$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

Expressing Rotational Energy in Terms of Translational

- For solid sphere, $I=2/5mr^2$ and for tangential speed on ball's surface, $v=\omega r$

$$\omega = \frac{v}{r}$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{5}mr^2\right)\left(\frac{v}{r}\right)^2$$

Simplification

- 71% of ball's potential energy is converted to translational kinetic energy, and 29% is converted to rotational energy

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{5}mr^2\right)\left(\frac{v}{r}\right)^2$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{5}mr^2\frac{v^2}{r^2}$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}mv^2$$

$$mgh = \frac{7}{10}mv^2$$

Effect on Speed of Ball

- Compare the speed of a rotating ball with the speed of a non-rotating ball
- Rotating ball is about 15% slower than a non-rotating ball
- Thus, range of rotating ball is also about 15% less than range of non-rotating ball

$$\frac{1}{2}mv_R^2 = \frac{5}{7}\left(\frac{1}{2}mv_{NR}^2\right)$$

$$v_R^2 = \frac{5}{7}v_{NR}^2$$

$$v_R \approx 0.85 v_{NR}$$