Solutions

Each answer shows the steps, then the **result**.

2.1

- rolling without slipping: $v = \omega r$, rearranged:

$$\omega = \frac{v}{r} = \frac{5.0\ \text{m s}^{-1}}{0.25\ \text{m}} = \mathbf{20}\ \text{rad s}^{-1}$$

2.2

- $v = \omega r$ (the centre's speed equals angular speed times radius)

2.3

- the solid cylinder (smaller rotational inertia)

3.1 A

- $v = \omega r$.

3.2 C

- the sum of translational and rotational.

3.3

(a)

$$\omega = \frac{v}{R} = \frac{3.0\ \text{m s}^{-1}}{0.10\ \text{m}} = \mathbf{30}\ \text{rad s}^{-1}$$

(b)

$$I = \tfrac{1}{2}mR^2 = \tfrac{1}{2}(2.0\ \text{kg})(0.10\ \text{m})^2 = 0.010\ \text{kg m}^2$$

$$K = \tfrac{1}{2}mv^2 + \tfrac{1}{2}I\omega^2 = \tfrac{1}{2}(2.0\ \text{kg})(3.0\ \text{m s}^{-1})^2 + \tfrac{1}{2}(0.010\ \text{kg m}^2)(30\ \text{rad s}^{-1})^2$$

- $K = 9.0\ \text{J} + 4.5\ \text{J} = \mathbf{13.5}\ \text{J}$

3.4

(a)

- the lost U_g becomes translational plus rotational KE; with $I = \tfrac{1}{2}mR^2$ and $\omega = v/R$:

$$mgh = \tfrac{1}{2}mv^2 + \tfrac{1}{2}\left(\tfrac{1}{2}mR^2\right)\left(\frac{v}{R}\right)^2 = \tfrac{3}{4}mv^2$$

$$v = \sqrt{\frac{4gh}{3}} = \sqrt{\frac{4(9.8\ \text{m s}^{-2})(0.60\ \text{m})}{3}} = \mathbf{2.80}\ \text{m s}^{-1}$$

(b)

- part of the energy becomes rotational kinetic energy, so less is left for translation
- $mgh = \tfrac{1}{2}mv^2$ gives all of it to translation, so the larger $v = \sqrt{2gh} = 3.43\ \text{m s}^{-1}$