PHYS 2311 Ch. 11 HW

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Problem 1.

$$I = mR^2 = (0.210)(1.25)^2 = 0.328\,\text{kg} \cdot \text{m}^2$$

$$\vec{L} = I\vec{\omega} = (0.328)(10.4) = \boxed{3.4112\,\text{kg} \cdot \text{m}^2/\text{s}}$$

Problem 2.

(a)

$$I = \frac{1}{2}mR^2 = \frac{1}{2}(2.8)(0.18)^2 = 0.045\,\text{kg} \cdot \text{m}^2$$

$$1500\,\text{rpm} = \frac{2\pi\,\text{rad}}{60\,\text{s}} = 157.1\,\text{rad/s}$$

$$L = I\omega = (0.045)(157.1) = \boxed{7.0695\,\text{kg} \cdot \text{m}^2/\text{s}}$$

(b)

$$\omega = \omega_0 + \alpha t$$

$$0 = 157.1 + \alpha(6.0)$$

$$\alpha = \frac{-157.1}{6.0} = -26.183\,\text{rad/s}^2$$

$$\tau = I\alpha = (0.045)(26.183) = \boxed{1.178\,\text{Nm}}$$

Problem 3.

$$L_i = L_f$$

$$L_i = I \cdot \omega$$

$$L_f = 2I\omega_f$$

$$I\omega = 2I\omega_f$$

$$\omega_f = \frac{I\omega}{2I}$$

$$\boxed{\omega_f = \frac{1}{2}\omega}$$

Problem 5.

$$\omega_i = 0.67\,\text{rev/s} \quad \omega_f = 2.5\,\text{rev/s}$$

$$\omega_i = 4.19\,\text{rad/s} \quad \omega_f = 15.71\,\text{rad/s}$$
$$I_i = 4.9\,\text{kg}\cdot\text{m/s}^2$$
$$L_i = L_f$$
$$(4.9)(4.19) = I_f(15.71)$$
$$I_f = \boxed{1.317\,\text{kg}\cdot\text{m}^2}$$

The dancer lowers her moment of inertia. The simplest way to do this is by pulling in her arms to decrease her radius.

Problem 9.

$$L_{\text{initial}} = L_{\text{final}}$$

$$L_{\text{initial}} = I_{\text{disk}} \cdot \omega_d$$
$$L_{\text{final}} = (I_{\text{disk}} + I_{\text{rod}}) \cdot \omega_f$$
$$I_{\text{disk}} \cdot \omega_d = (I_{\text{disk}} + I_{\text{rod}}) \cdot \omega_f$$
$$I_{\text{disk}} = \frac{1}{2}MR^2$$
$$I_{\text{rod}} = \frac{1}{3}MR^2$$
$$\left(\frac{1}{2}MR^2\right) \cdot \omega_d = \left(\frac{1}{2}MR^2 + \frac{1}{3}MR^2\right) \cdot \omega_f$$
$$\frac{1}{2}MR^2 \cdot \omega_d = \frac{5}{6}MR^2 \cdot \omega_f$$
$$\frac{1}{2}(4.1) = \frac{5}{6} \cdot \omega_f$$
$$\omega_f = \boxed{2.46\,\text{rev/s}}$$

Problem 36.

$$\vec{L} = \vec{r} \times \vec{p}$$

$$\vec{p} = m\vec{v}$$

$$\vec{r}_O = d\hat{j}$$
$$\vec{L}_O = \vec{r}_O \times \vec{p} = (d\hat{j}) \times (mv\hat{i})$$
$$\boxed{\vec{L}_O = mvd\hat{k}}$$
$$\vec{r}_{O'} = 0$$
$$\vec{L}_{O'} = \vec{r}_{O'} \times \vec{p} = 0$$
$$\vec{L}_O = mvd\hat{k}$$
$$\boxed{\vec{L}_{O'} = 0}$$

Problem 42.

(a)

$$L_{\parallel} = I \cdot \omega$$
$$I = mr^2$$
$$L_{\parallel} = 2 \cdot (mr^2) \cdot \omega = 2 \cdot (0.480 \cdot 0.24^2) \cdot 4.5 = 0.249\,\mathrm{kg} \cdot \mathrm{m}^2/\mathrm{s}$$
$$L_{\perp} = m \cdot v \cdot h$$
$$v = r \cdot \omega$$
$$L_{\perp} = 2 \cdot (m \cdot r \cdot \omega \cdot h) = 2 \cdot (0.480 \cdot 0.24 \cdot 4.5 \cdot 0.42) = 0.435\,\mathrm{kg} \cdot \mathrm{m}^2/\mathrm{s}$$
$$L = \sqrt{L_{\parallel}^2 + L_{\perp}^2} = \sqrt{(0.249)^2 + (0.435)^2} = \boxed{0.502\,\mathrm{kg} \cdot \mathrm{m}^2/\mathrm{s}}$$

(b)

$$\theta = \tan^{-1}\left(\frac{L_{\perp}}{L_{\parallel}}\right) = \boxed{60.26^\circ}$$

Problem 48.

$$\ell = 1.0\,\mathrm{m}, \quad M = 270\,\mathrm{g} = 0.270\,\mathrm{kg}, \quad m_b = 3.5\,\mathrm{g} = 0.0035\,\mathrm{kg}$$
$$v_{\text{in}} = 250\,\mathrm{m/s}, \quad v_{\text{out}} = 140\,\mathrm{m/s}, \quad \ell/4 = 0.25\,\mathrm{m}, \quad L_i = 0$$
$$L_{\text{initial}} = L_{\text{final}}$$
$$L_{\text{initial}} = m_b v_{\text{in}} r$$
$$L_{\text{initial}} = (0.0035)(250)(0.25) = 0.21875\,\mathrm{kg{\cdot}m^2/s}$$
$$L_{\text{bullet}} = m_b v_{\text{out}} r = (0.0035)(140)(0.25) = 0.1225\,\mathrm{kg{\cdot}m^2/s}$$
$$I = \frac{1}{12}ML^2 = \frac{1}{12}(0.270)(1.0)^2 = 0.0225\,\mathrm{kg{\cdot}m^2}$$
$$L_{\text{stick}} = I\omega = (0.0225)\omega$$

$$L_{\text{final}} = L_{\text{bullet}} + L_{\text{stick}} = 0.1225 + 0.0225\omega$$

$$L_{\text{initial}} = L_{\text{final}}$$

$$0.21875 = 0.1225 + 0.0225\omega$$

$$0.0225\omega = 0.21875 - 0.1225 = 0.09625$$

$$\omega = \frac{0.09625}{0.0225} = \boxed{4.28\,\text{rad/s}}$$