Physics 10154 - Exam #3C

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work (or if some parts are incorrect) even if you get the right answer. Clearly indicate your answer with a circle or box and remember to include correct units and significant figures.

1. (35 pts) A 12.0-gram bullet collides with a 375-gram pendulum bob that is initially at rest. After the collision, the bullet rebounds with a speed of 22.0 m/s in the opposite direction of its initial velocity, while the pendulum bob rises to such a height that the 1.50-meter long string it is attached to makes a 38.0° angle with respect to the vertical. What was the initial speed of the bullet before the collision?

Collision: $m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$

$(.012) v_{1i} + 0 = (.012)(-22) + (.375) v_{2f}$

Pendulum: $h = \ell - \ell \cos\theta = 1.50(1 - \cos 38°)$

$= 0.318\ m$

$\Sigma W_F = W_{grav} = \Delta K$

$-mgh = 0 - \frac{1}{2} m v_0^2$

$v_0 = \sqrt{2gh} = 2.496\ m/s$

Use this as v_{2f} for collision.

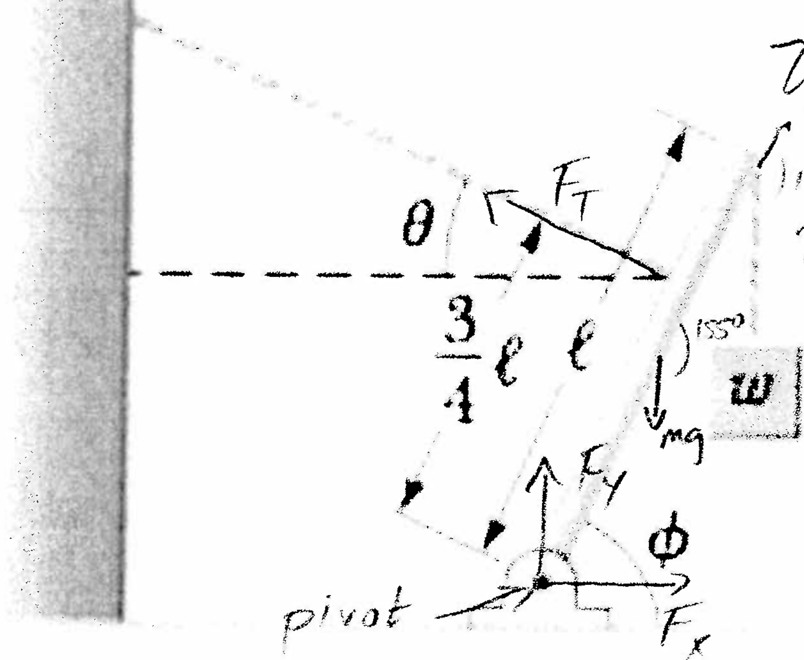
$(.012) v_{1i} = (.012)(-22) + (.375)(2.496)$

$.012 v_{1i} = -0.264 + 0.936$

$\boxed{v_{1i} = 56.0\ m/s}$

2. (35 pts) A 1560-N uniform boom makes an angle $\Phi = 65.0°$ above the horizontal. It is supported by a cable that makes an angle $\theta = 25.0°$ above the horizontal as shown below. An object with a weight $w = 2120$ N hangs from the end of the boom. Find (a) the tension in the support cable and (b) the horizontal and vertical components of the reaction force exerted on the base of the boom.

$$\Sigma\tau = \tau_{boom} + \tau_T + \tau_w = 0$$



$$\tau_{boom} = -\left(\frac{\ell}{2}\right)mg\sin 155°$$

$$\tau_T = +\left(\frac{3\ell}{4}\right)F_T\sin 90°$$

$$\tau_w = -(\ell)w\sin 155°$$

$$\Sigma\tau = -\frac{1}{2}\ell(1560)\sin 155° + \frac{3}{4}\ell F_T\sin 90° - \ell(2120)\sin 155° = 0$$

$$= -329.64 + 0.75F_T - 895.95 = 0$$

$$F_T = \frac{1225.59}{0.75} = 1634 \text{ or } \boxed{1630\ N}$$

$$\Sigma F_x = F_x - F_T\cos 25° = 0 \qquad F_x = 1634\cos 25° = \boxed{1480\ N}$$

$$\Sigma F_y = F_y + F_T\sin 25° - mg - w = 0$$

$$F_y = 1560 + 2120 - (1630)\sin 25° = \boxed{2990\ N}$$

3. (30 pts) A motorized wheel has a radius of 35.0 cm and moment of inertia 24.0 kg-m² starts at rest on a horizontal table. A torque of 18.8 N-m is applied to the wheel, and the wheel begins to roll as a result. It reaches the edge of the table, 7.20 meters away, with some final rotation speed, then flies off the edge in free-fall until hitting the ground 1.70 meters below the edge of the table. While it free fall, it has the same rotation speed as when it left the table.

a) What is the final rotation speed when it leaves the table?
b) How many total revolutions does the wheel make during both parts of the motion?

a) $\Sigma \tau = I\alpha$

$\alpha = \frac{18.8\ N\cdot m}{24.0\ kg\cdot m^2} = 0.783\ rad/s^2$

$\Delta\theta = \frac{\Delta s}{R} = \frac{7.20}{.35} = 20.57\ rad$

$\omega_0 = 0$

$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta = 0^2 + 2(.783)(20.57)$

$\boxed{\omega = 5.68\ rad/s}$

b) $\Delta\theta_1 = 20.57\ rad \cdot \frac{1\ rev}{2\pi\ rad} = 3.27\ rev$

free-fall: $\Delta y = 1.70\ m$ $\quad 1.70 = 0 + (0.5)(9.8)t^2$

$V_{oy} = 0$

$V_y = ?$ $\quad t = 0.589\ s$

$a_y = 9.8\ m/s^2$

$t = ?$

$\Delta\theta_2 = \omega t = (5.68)(.589) = 3.346\ rad = 0.532\ rev$

$\Delta\theta_{TOT} = 3.27 + 0.53 = 3.80\ rev$