Physics 10154 - Exam #3B

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. (30 pts) Mass A is 2.00 times more massive than mass B. Mass A slides across a frictionless surface with a speed of 7.70 m/s in the +x direction, then strikes mass B, which is initially at rest. After the collision, mass A moves away at a speed of 4.88 m/s at an angle of 25.0° above the +x axis.

   What is the magnitude and direction of the velocity of mass B after the collision?

$m_1 = 2m \qquad V_{1i,x} = 7.70\ m/s \qquad V_{2i,x} = 0$

$m_2 = m \qquad V_{1i,y} = 0 \qquad V_{2i,y} = 0$

$V_{1f,x} = 4.88 \cos 25° = 4.423\ m/s$

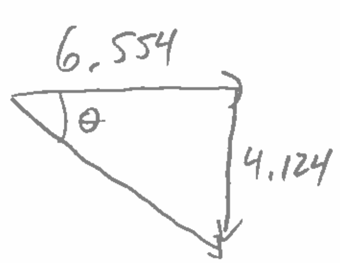
$V_{1f,y} = 4.88 \sin 25° = 2.062\ m/s$

$x:\ 2m(7.70) + m(0) = 2m(4.423) + m(V_{2f,x})$

$V_{2f,x} = 2(7.70) - 2(4.423) = 6.554\ m/s$

$y:\ 2m(0) + m(0) = 2m(2.062) + m(V_{2f,y})$

$V_{2f,y} = 2(2.062) = -4.124$



$V_{2f} = \sqrt{6.554^2 + 4.124^2} = \boxed{7.74\ m/s}$

$\theta = \tan^{-1}\left(\frac{4.124}{6.554}\right) = \boxed{32.2° \text{ below } +x}$

2. (20 pts) A thin ring with radius 2.50 cm rolls without slipping across a horizontal distance of 1.75 meters at a constant angular speed of 4.80 rev/sec. Keeping the same angular speed while in the air, the ring rolls off the edge of the table and falls through a vertical distance of 93.2 cm before hitting the ground. What is the total number of revolutions made by the ring during this entire motion (horizontal motion + free fall)?

On table, $t = \frac{\Delta s}{v} = \frac{1.75\ m}{r\omega}$

$\omega = 4.80 \frac{rev}{sec} \cdot \frac{2\pi\ rad}{1\ rev} = 30.16\ rad/s$

$v = r\omega = 0.754\ m/s \Rightarrow t = \frac{1.75}{.754} = 2.32\ s$

In air: $\Delta y = .932\ m$ $\quad .932 = 0 + \frac{1}{2}(9.8)t^2$

$v_{oy} = 0$ $\quad t^2 = 0.190$

$a_y = 9.8\ m/s^2$ $\quad t = 0.436\ s$

$t_{total} = 2.32 + .436 = 2.756\ s$

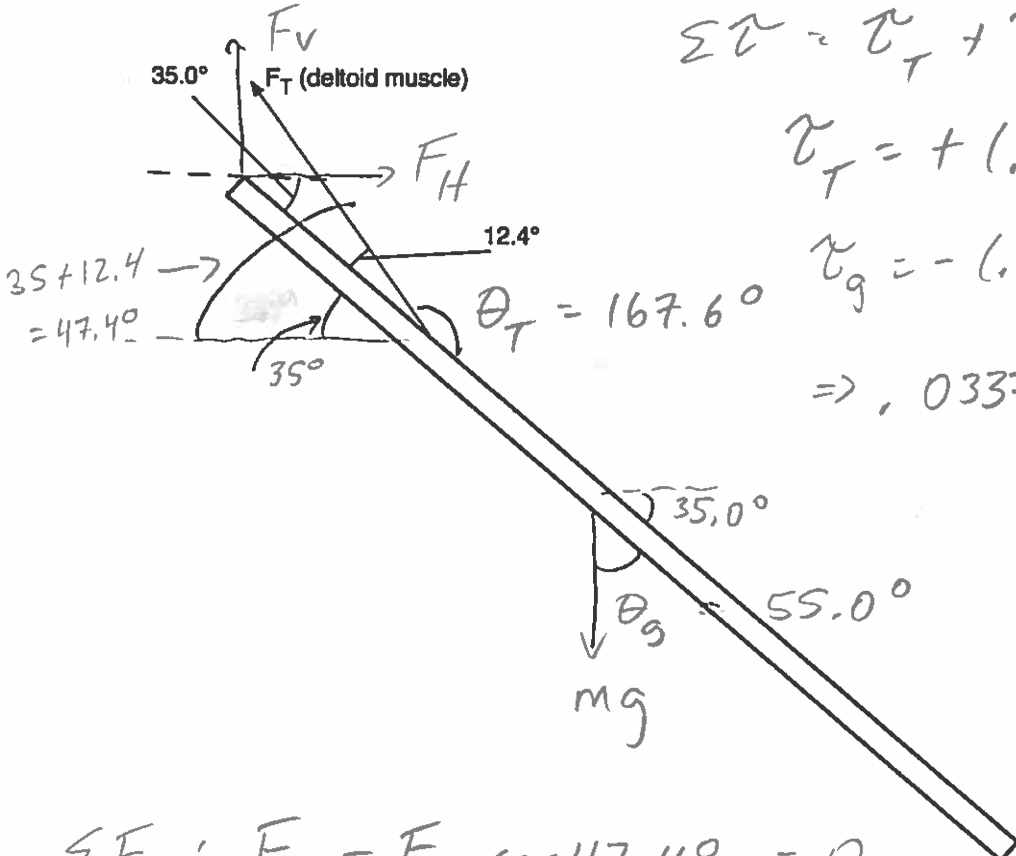
$\Delta\theta = \omega t$

$= 4.80 \frac{rev}{sec} \cdot 2.756\ s$

$= \boxed{13.2\ rev}$

3. (30 points) A human arm can be approximated as a uniform thin rod with a length of 74.0 cm and mass 13.8 kg. In the figure below, the arms makes an angle of 35.0° below the horizontal. At the top end of the arm, it is attached to the shoulder, and the shoulder exerts a horizontal and vertical reaction force on the arm. Also, the deltoid muscle attaches to the arm 15.7 cm from the shoulder, making an angle of 12.4° with the arm.

Find (a) [→ magnitude + direction] the tension in the deltoid muscle, (b) the horizontal component and (c) the vertical component of the shoulder's reaction force.



$$\Sigma\tau = \tau_T + \tau_{grav} = 0$$

$$\tau_T = +(.157) F_T \sin 167.6°$$

$$\tau_g = -(.370)(13.8)(9.8)\sin 55°$$

$$\Rightarrow .0337 F_T - 40.99 = 0$$

$$\boxed{F_T = 1220\,N}$$

$$\Sigma F_x : F_H - F_T \cos 47.4° = 0$$

$$F_H = F_T \cos 47.4° = \boxed{823\,N \;\rightarrow}$$

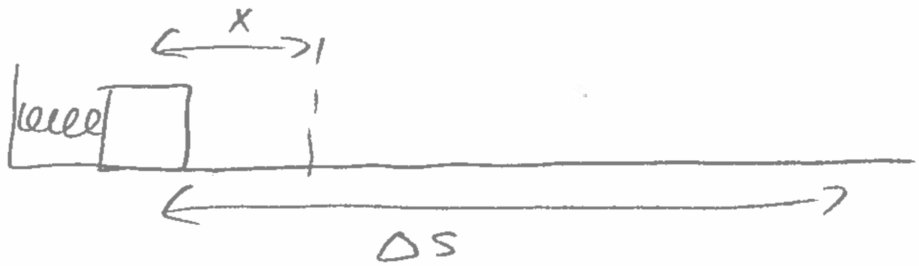
$$\Sigma F_y : F_V + F_T \sin 47.4° - mg = 0$$

$$F_V = (13.8)(9.8) - 1220 \sin 47.4 = -763\,N$$

so $\boxed{F_V = 763\,N \;\downarrow}$

4. A spring (k = 1520 N/m) has its left end attached to a wall, and a 4.30-kg mass attached to its right end. The right end of the spring is compressed by 12.4 cm and the mass is then released from rest to slide horizontally across a rough surface with coefficient of kinetic friction 0.185.

Measuring from the point the mass is first released until it comes to rest, how far does the mass slide?



$$\Sigma W_F = W_{spr} + W_{KF} = \Delta K$$

$$W_{spr} = +\tfrac{1}{2}k_s x^2 = \tfrac{1}{2}(1520)(.124)^2$$

$$W_{KF} = -\mu_k F_N \Delta s$$

$$= -\mu_k mg\Delta s = -(.185)(4.30)(9.8)\Delta s$$

$$\Delta K = 0 - 0$$

$$11.68 - 7.796\,\Delta s = 0$$

$$\Delta s = \frac{11.68}{7.796} = \boxed{1.50\ m}$$