Physics 1145 Fall 2023 Test 3 (4 pages)

Name: Solution **November 17, 2023** **Total Score:** 120 **/120**

$\sum F_x = ma_x$ $f_s \le \mu_s N$ $f_k = \mu_k N$ $a_c = \frac{v^2}{R}$ $F_{Sx} = -kx$

$\tau = rF \sin\theta$ $\sum \tau = I\alpha$ $v = \omega r$ $a = \alpha r$ $I = \sum_i m_i r_i^2$ $L = I\omega$

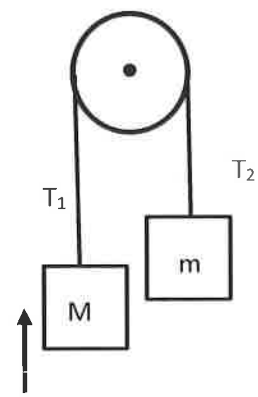
$\vec{p} = m\vec{v}$ $\vec{J} = \vec{F}_{avg}\Delta t$ $\vec{P}_f - \vec{P}_i = \vec{J}_{ext}$ $W = Fd\cos\theta$ $\Delta E = W$

$K = \frac{1}{2}mv^2$ $U_{grav} = mgy$ $U_{spring} = \frac{1}{2}kx^2$ $\Delta E_{th} = f_k \Delta x$ $P = W/\Delta t = Fv$

D 1. (5) 3. A constant force acts on an object perpendicular to the direction in which it is moving. The work done by the force on the object

A) depends on the mass of the object B) depends on the speed of the object

C) depends on the acceleration of the object D) is zero



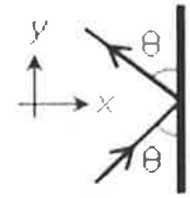
D 2. (5) Two blocks, of masses *m* and *M*, are attached to opposite ends of a massless string that passes over a pulley with moment of inertia *I*. The block of mass *M* is accelerating upward. The string does not slip on the pulley. Which statement about the tensions in the string is true?

A) $T_1 > T_2$ B) $T_1 = T_2$ C) $T_1 = Mg$ D) $T_2 > T_1$

A 3. (5) Which of the following quantities is **not** conserved in an inelastic collision?

A) speed of each object B) y-component of total linear momentum

C) total mass D) magnitude of total linear momentum



B 4. (5) A ball bounces elastically off a wall. The angle of incidence θ equals the angle of reflection. The impulse delivered to the ball by the wall is:

A) in the positive *x*-direction. B) in the negative *x*-direction.

C) zero. D) in the *y*-direction.

C 5. (5) An incline makes an angle θ with the horizontal. A constant pushing force *P* that is directed **parallel to the incline** pushes a block of mass *M* up the incline by a distance *L* along the incline. The work done by the pushing force equals

A) $PL\cos\theta$ B) $PL\sin\theta$ C) PL D) $(P - Mg\sin\theta)L$

25 /25 points for this page

7.(10) You are weighing Frodo the cat by putting him into a light cotton bag and hanging it from a spring scale with a force constant of 600 N/m. The spring stretches by 10cm. Calculate the mass of Frodo (including the bag) and the potential energy stored in the spring.

$F_s = Mg$

$kx = Mg$

$M = \frac{kx}{g} = \frac{600\frac{N}{m} \cdot 0.1m}{9.8\frac{m}{s^2}} = \underline{\underline{6.1kg}}$

He is a big cat!

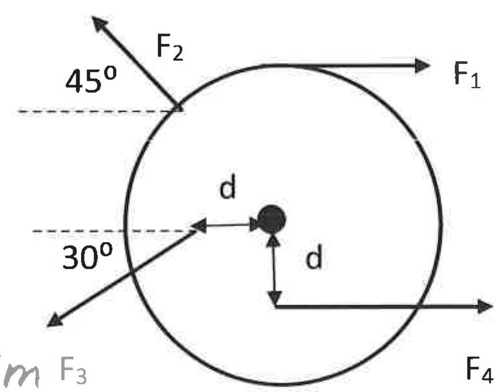
$U = \frac{1}{2}kx^2$

$U = \frac{1}{2} 600\frac{N}{m} (0.1m)^2$

$\boxed{U = 3J}$

8. (30) A uniform disk of mass 4.0 kg and radius 10.0 cm can rotate about an axle through its center. Four forces are acting on it as shown in the figure. Their magnitudes are F_1=8.0N, F_2=6.0N, F_3=5.0 N and F_4=4.0N. d=5.0cm

The moment of inertia of a uniform disk of mass m and radius r about its center of mass is $\frac{1}{2}mr^2$.



a) (20) Calculate the torques due to each of the forces.

$\tau_1 = -F_1 R = -8N \cdot 0.1m = -0.8Nm$

$\tau_2 = 0$

$\tau_3 = F_3 d \sin 30° = 5N \cdot 0.05m \cdot \frac{1}{2} = 0.125Nm$

$\tau_4 = F_4 d = 4N \cdot 0.05m = 0.2Nm$

b) (10) Calculate the angular acceleration of the disk.

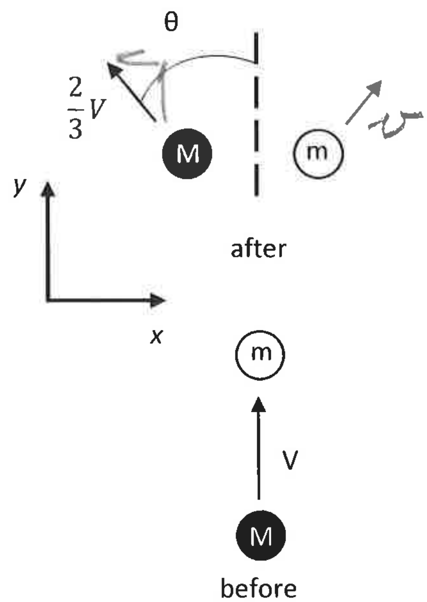
$\tau_{net} = I\alpha$

$I = 0.02 kgm^2$

$\alpha = \frac{\tau_{net}}{I} = \frac{-0.475 Nm}{\frac{1}{2} 4kg (0.1m)^2} = -23.75 s^{-2}$

40/40 points for this page

9.(25) Two pucks are on a frictionless horizontal air hockey table. The white puck of mass *m* is initially at rest. The black puck of mass *M* is moving with a speed *V* in the positive y-direction and collides with the white puck. Immediately after the collision, the black puck is travelling with a speed 2/3 *V* at an angle θ to the left of the positive y-axis, while the white puck is traveling at an unknown speed in an unknown direction.



a) OSE (40 points) Derive expressions for the x- and y-components of the white puck's velocity after the collision, in terms of system parameters.

$$\cancel{\vec{J}_{net\,ext}}^{\,0} = \vec{P}_f - \vec{P}_i$$

$$P_{ix} = P_{fx}$$

$$0 = -M\tfrac{2}{3}V\sin\theta + mv_x$$

$$\boxed{v_x = \frac{2M}{3m}V\sin\theta}$$

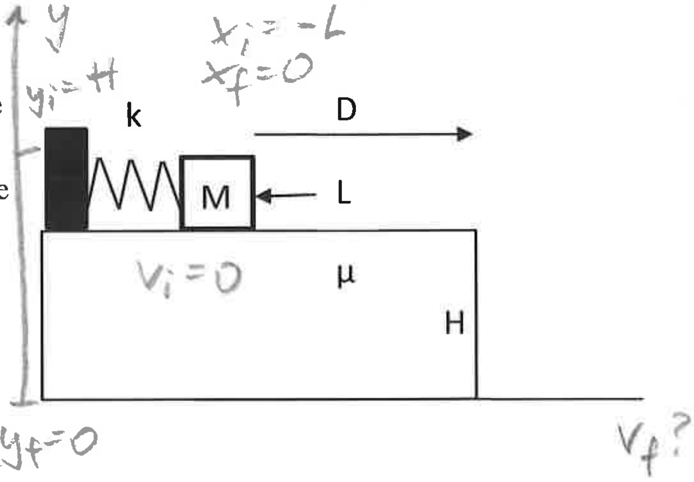
$$P_{iy} = P_{fy}$$

$$MV + 0 = M\tfrac{2}{3}V\cos\theta + mv_y$$

$$\boxed{v_y = \frac{M}{m}V\left(1 - \tfrac{2}{3}\cos\theta\right)}$$

25 /25 points for this page

10. (30) A box of mass M is on a horizontal, rough table next to a spring of force constant k. The table is a height H above the ground. The box is pushed against the spring, compressing it a distance L. The box is now a distance D from the right edge of the table and is launched from rest. The coefficient of kinetic friction between the box and table is μ. The box travels along the table and then flies off the edge.



Derive an expression for the speed V at which the box hits the ground, in terms of system parameters.

$\Delta E = \cancel{W}^{0}$

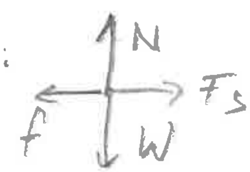
$\Delta E = 0$

$K_f - K_i + U_{Gf} - U_{Gi} + U_{sf} - U_{si} + \Delta E_{th} = 0$

$\frac{1}{2}MV_f^2 - \frac{1}{2}M\cancel{V_i}^{2\,0} + Mg\cancel{y_f}^{0} - Mgy_i + \frac{1}{2}\cancel{kx_f^2}^{0} - \frac{1}{2}kx_i^2 + \Delta E_{th} = 0$

$\frac{1}{2}MV_f^2 - MgH - \frac{1}{2}kL^2 + \mu ND = 0$

Find N:



$\Sigma F_y = N_y + \cancel{f_y}^{0} + \cancel{F_{sy}}^{0} + W_y = M\cancel{a_y}^{0}$

$N - Mg = 0$

$N = Mg$

$$\boxed{V_f = \sqrt{\frac{2}{M}\left[MgH + \frac{1}{2}kL^2 - \mu MgD\right]}}$$

30/30 points for this page