PHYS 111.01 PRACTICE MIDTERM EXAM 2 SOLUTIONS

A. MULTIPLE-CHOICE QUESTIONS. **CIRCLE THE BEST ANSWER** (6 Pts. each):

1. An object of mass 1.0 kg on a frictionless table is attached to a spring of spring constant 16 N/m. The object is pulled 0.50 m from equilibrium and released. What is the maximum kinetic energy of the object?

a) 0.5 J
b) 1.0 J
c) 2.0 J
d) 4.0 J
e) 8.0 J
f) 16.0 J

$$\frac{1}{2}mV_{MAX}^2 = E = \frac{1}{2}kA^2$$
$$= \frac{1}{2}(16N/m)(0.50m)^2 = 2.0\,J$$

2. Which one of the following statements is true concerning an object in simple harmonic motion?

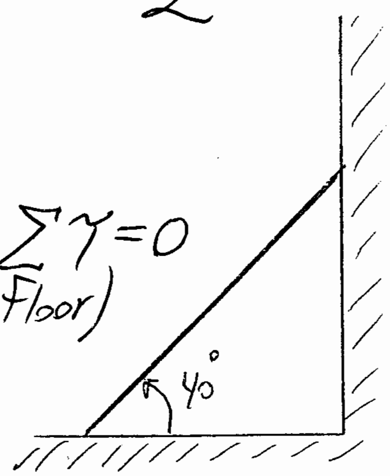
a) Its velocity is never zero
b) Its velocity and acceleration are simultaneously zero
c) Its acceleration is never zero
d) Its velocity is zero when its acceleration is maximum.
e) Its maximum acceleration is equal to its maximum velocity

3. A spinning ice skater draws in her outstretched arms to reduce her moment of inertia by a factor of two. Determine the ratio of final kinetic energy to her initial kinetic energy.

a) 0.25
b) 0.50
c) 1.00
d) 2.00
e) 4.00
f) 16.0

$$I_i\omega_i = I_F\omega_F \Rightarrow \omega_F = \left(\frac{I_i}{I_F}\right)\omega_i = 2\omega_i$$
$$\frac{K_{Rot\,F}}{K_{Rot\,i}} = \frac{\frac{1}{2}(I_i/2)(2\omega_i)^2}{\frac{1}{2}I_i\omega_i^2} = 2$$

4. A ladder of weight 30 N has one end resting on a rough floor and the other end leaning against a frictionless wall as shown. The ladder makes an angle of 40° with the floor. What is the magnitude of the force which the wall exerts on the ladder?



a) 12.6 N
b) 15.0 N
c) 17.9 N
d) 25.5 N
e) 35.8 N

Let L = length of ladder, Need $\sum \tau = 0$ (Axis @ Floor)

$$F_W L \sin\theta - mg\left(\frac{L}{2}\right)\cos\theta = 0$$
$$F_W = \frac{(30N)\cos(40°)}{2\sin(40°)} = 17.9\,N$$

5. A cube of material of density 2.0 x 10^3 kg/m^3 is suspended in water with its top 3.0 meters below the surface of the water (density 1.0 x 10^3 kg/m^3). The cube measures 0.1 m on each side. What is the buoyant force on it?

a) 1.0 x 10^4 N
b) 2.0 x 10^4 N
c) 9.8 N
d) 20 N
e) 30 N
f) 60 N

$$F_B = \rho_F gV$$
$$= (10^3 kg/m^3)(9.8\frac{N}{kg})(0.1m)^3 = 9.8N$$

m_A $\qquad$ V_{Ai} $\qquad$ m_B

6. A particle of mass 5.0 kg moving at a speed of 10.0 m/s in the positive x-direction strikes a 9.0 kg particle initially at rest. The 5.0 kg particle bounces off with a speed of 5.0 m/s in the negative x-direction. No net external forces act. What is the velocity of the 9.0 kg particle after the collision?

a) 5.0 m/s in positive x-direction
b) 5.0 m/s in the negative x-direction
c) 8.3 m/s in the positive x direction
d) 8.3 m/s in the negative x-direction
e) 10 m/s in the positive x-direction
f) 10 m/s in the negative x-direction

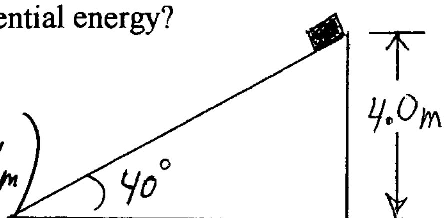
$$P_F = P_i$$
$$m_A V_{AF} + m_B V_{BF} = m_A V_{Ai}$$
$$V_{BF} = \frac{m_A V_{Ai} - m_A V_{AF}}{m_B} = \frac{(5kg)(10\frac{m}{s}) - (5kg)(-5\frac{m}{s})}{9kg} = 8.3\ m/s$$

7. Which one of the following statements about an inelastic collision with no net external force is always true:

a) The change in momentum is less than the total impulse
b) Total linear momentum is not conserved
c) Total kinetic energy is not conserved
d) The final velocity of each particle is less than its initial velocity
e) The final velocity of each particle is greater than its initial velocity

8. A box of mass 3.0 kg slides down a frictionless inclined plane of angle 40°, starting at rest at height 4.0 m and ending at height 0. What is the **change** in the box's gravitational potential energy?

a) -76J
b) -90J
c)-118 J
d)118J
e)90J



$$\Delta U_{grav} = mg\Delta h = (3.0kg)(9.8\tfrac{N}{kg})(-4m) = -118\ J$$

9. What is the speed of the above box when it reaches the bottom of the inclined plane? (**Assume ΔU_{grav}= - 80J.)**

a) 10.3 m/s
b) 7.3 m/s
c) 5.2 m/s
d) 3.65 m/s
e) 0

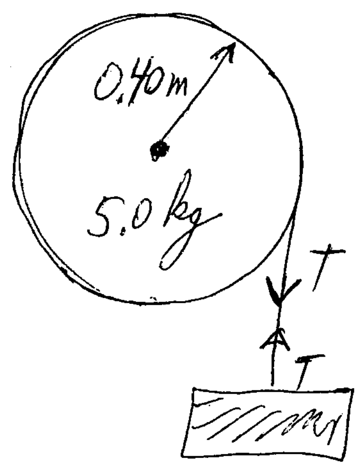
Conservation of energy

$$\Delta E = 0 \Rightarrow \tfrac{1}{2} m V_F^2 = -\Delta U_{grav} = -(-80J)$$
$$V_F = \sqrt{\frac{2(80J)}{3kg}} = 7.3\frac{m}{s}$$

PROBLEMS. BE SURE TO **SHOW YOUR METHOD CLEARLY**. (6 points for each problem part.)

1. A string attached to a block of mass 2.0 kg is wrapped around a wheel of radius 0.4 m and mass 5.0 kg as shown. The block hangs straight down, while the wheel can turn around an axis through its center. The block is released at time t=0 with the wheel and the block at rest. The tension in the string between the block and the wheel is found to be 11 N.

a) What is the torque on the wheel?



$$\tau = T r_\perp = -(11N)(0.4m)$$

$$\boxed{-4.4\ Nm}$$

b) The rotational inertia of the wheel is given by $I = 0.5MR^2$. What is the angular acceleration of the wheel, assuming the net torque on it is 10 N•m (numerical value, please)?

$$\tau = I\alpha$$

$$\alpha = \frac{\tau}{I} = \frac{10\ Nm}{(0.5)(5\ kg)(0.4\ m)^2} = 25\ rad/s^2$$

$$\boxed{25\ rad/s^2}$$

For parts (c) below, assume the angular acceleration of the wheel is 5.0 rad/s².

c) If the wheel starts at rest, how long will it take to turn through 20 radians?

$$\theta = \cancel{\theta_0} + \cancel{\omega_0 t} + \tfrac{1}{2}\alpha t^2$$

$$20 = \tfrac{1}{2}(5\ rad/s^2)t^2$$

$$t^2 = 8\ s^2$$

$$t = 2.8\ s$$

$$\boxed{2.8\ s}$$

d) How much string will unwrap from the wheel while it turns through 20 radians?

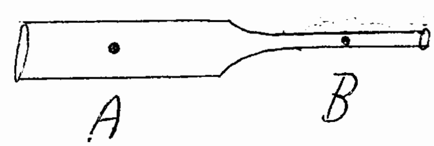
$$S = R\theta$$

$$= (0.4\ m)(20\ rad) = 8\ m$$

$$\boxed{8.0\ m}$$

2. Water (density 1.0×10^3 kg/m^3) flows at a speed of 9 m/s through a tube of cross-sectional area 0.30 m^2, as shown at point A. The pressure at A is 1.5×10^5 Pa.

a) The tube narrows down to a smaller cross-sectional area as shown at point B. If the speed of the fluid at B is 12 m/s, what is cross-sectional area of the tube there?



Continuity $A_A V_A = A_B V_B$

$$A_B = \left(\frac{V_A}{V_B}\right)A_A = \left(\frac{9\ m/s}{12\ m/s}\right)(.30\ m^2)$$

$$= 0.23\ m^2$$

b) What is the pressure at point B? Bernoulli Eqn.

$$P_A + \frac{1}{2}\rho V_A^2 = P_B + \frac{1}{2}\rho V_B^2$$

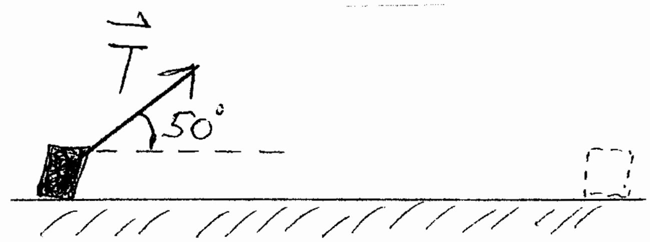
$$P_B = P_A + \frac{1}{2}\rho V_A^2 - \frac{1}{2}\rho V_B^2$$

$$= 150\ kPa + \frac{1}{2}(10^3\ kg/m^3)\left[(9\tfrac{m}{s})^2 - (12\tfrac{m}{s})^2\right]$$

$$= \underline{119\ kPa}$$

3. A person pulls with a force of 20N on a rope attached to a box of mass 3.0 kg. The rope makes a 50° angle with the horizontal, as shown. The box starts at rest, moves a distance 15 m along the rough floor, and has a speed of 4.0 m/s at the end of the motion.

(a) What work did the rope tension do on the box during this motion?



$$W_T = F\Delta X \cos\theta$$

$$= (20N)(15\ m)\cos(50^\circ) = 193\ J$$

$$\boxed{193\ J}$$

(b) What work was done by friction during the motion?

$$W_{NC} = \Delta E = W_T + W_F$$

$$W_F = \Delta E - W_T = \frac{1}{2}mV_f^2 - 193J$$

$$= \frac{1}{2}(3kg)(4\tfrac{m}{s})^2 - 193J = 24J - 193J$$

$$= -169J$$

$$\boxed{-169\ J}$$

(c) If the motion took 8.0 s, what power was delivered to the box by the rope?

$$P = \frac{W_T}{\Delta t} = \frac{193J}{8s} = 24W$$

$$\boxed{24W}$$