Physics 271 - Practice Midterm II

1. A stretched spring pulls a block of wood of mass $m = 0.1$ kg up a ramp of angle $\theta = 30^\circ$. The kinetic friction coefficient between the block and the ramp is $\mu_k = \frac{1}{\sqrt{3}}$ and the spring constant is $k = 10$ N/m. The elastic force from the spring is parallel to the ramp. Find the acceleration of the block when the spring is stretched a distance $\Delta l = 0.1$ m from its relaxed position.

   (a) 0.2 m/s$^2$
   (b) 0.4 m/s$^2$
   (c) 1.6 m/s$^2$
   (d) 2.1 m/s$^2$
   (e) 0.8 m/s$^2$

   For this problem note that

   $\sin(30^\circ) = \frac{1}{2}$  \hspace{2cm} $\cos(30^\circ) = \frac{\sqrt{3}}{2}$.

2. A block of mass $m = 0.1$ kg is tied at the end of an ideal cord wrapped around an ideal pulley as shown below. The other end of the cord is tied to a fixed spring of constant $k = 2$ N/m. The spring is initially relaxed, the cord is taut and the block is released with zero initial velocity. How far will the block fall before it bounces back?

   (a) 1.23 m
   (b) 0.67 m
3. In problem 2, what is the speed of the block when it has dropped a distance \( d = 0.49 \text{m} \)?

(a) 0.59 m/s  
(b) 2.19 m/s  
(c) 2.87 m/s  
(d) 1.36 m/s  
(e) 2.49 m/s  

4. A ball hangs at the end of an ideal cord of length \( l = 1 \text{m} \), and the other end of the cord is fixed. The ball is given a horizontal initial velocity of magnitude \( v \). What is the minimum value of \( v \) such that the ball moves on a circular trajectory of radius \( l \) in the vertical plane.

(a) 7 m/s  
(b) 4 m/s  
(c) 5.6 m/s  
(d) 6 m/s  
(e) 3.2 m/s  

5. A block of mass \( m = 0.2 \text{kg} \) is tied at the end of a spring of constant \( k = 20 \text{ N/m} \) as shown below. The other end of the spring is held fixed. The spring is initially compressed a distance \( \Delta l = 0.1 \text{m} \) and the surface of the table is rough. The block is given a horizontal initial velocity of magnitude \( v_0 = 4 \text{ m/s} \). The velocity of the block when the spring is relaxed is \( v_1 = 3 \text{ m/s} \). Find the work done by kinetic friction during this part of the motion.
6. In the set-up of problem 5 suppose the kinetic friction coefficient between the block and the horizontal surface is $\mu_k = 0.2$. What is the horizontal component of the acceleration of the block immediately after it starts moving?
   (a) $4.16 \text{m/s}^2$
   (b) $2.88 \text{m/s}^2$
   (c) $-2.56 \text{m/s}^2$
   (d) $-3.96 \text{m/s}^2$
   (e) $1.74 \text{m/s}^2$

7. A ball of mass $m = 0.1 \text{kg}$ is dropped from a height $h = 11 \text{m}$ above the surface of a triangular block of mass $M = 1 \text{kg}$ as shown below. The triangular block is at rest on a frictionless table and the kinetic energy is conserved during the collision. Suppose the ball moves horizontally immediately after it hits the block. Find the speed of the block after collision.
(a) 0.5m/s  
(b) 0.1m/s  
(c) 1m/s  
(d) 1.2m/s  
(e) 1.4m/s

8. A triangular plate of angle $\theta = 30^\circ$ is glued to the surface of a horizontal table. A ball moving with speed $v_0 = 10\, \text{m/s}$ hits the plate sideways as shown below. The picture shows the collision seen from above such that the $(x, y)$ plane is horizontal. There is no friction between the ball and the plate and no friction between the ball and the table. Suppose the ball slides along the face of the plate after collision. Find the final speed of the ball.

For this problem note that

$$\sin(30^\circ) = \frac{1}{2} \quad \cos(30^\circ) = \frac{\sqrt{3}}{2}.$$
9. In problem 8 suppose the mass of the ball is \( m = (\sqrt{3}/10) \) kg. Compute the magnitude of the impulse of the normal force acting on the ball during the collision.

(a) 1 kg \cdot m/s
(b) 1.5 kg \cdot m/s
(c) 0.5 kg \cdot m/s
(d) 0.7 kg \cdot m/s
(e) 1.7 kg \cdot m/s

10. Suppose the kinetic energy is conserved during the collision in problem 8. Find the velocity vector \( \vec{v} \) of the ball after collision.

(a) \( \vec{v} = -(10\sqrt{3}/s)\hat{i} \)
(b) \( \vec{v} = -(5m/s)(\hat{i} - \sqrt{3}\hat{j}) \)
(c) \( \vec{v} = (5m/s)(\hat{i} + \sqrt{3}\hat{j}) \)
(d) \( \vec{v} = (10m/s)(\sqrt{3}\hat{i} - \hat{j}) \)
(e) \( \vec{v} = (5m/s)(\sqrt{3}\hat{i} + \hat{j}) \)