The exam is closed book and closed notes.

**Part I: There are 12 multiple choice questions, 1 point each.**
The answers for the multiple choice questions are to be placed on the SCANTRON form. Make sure you put your name, section, and ID number on the SCANTRON form.

**Part II: One work-out problem, 8 points.** Show ALL your work. Correct answers with unsubstantiated work on the problem will receive ZERO CREDIT.

Use a Number 2 pencil to fill in answers on the SCANTRON form.

\[ w = mg \]

**Use:** \( g = 10 \text{ m/s}^2 \)

1 hour = 60 min = 3600 sec

\[ A = A_x i + A_y j \]

\[ \Phi = \tan^{-1}(A_y/A_x) \]

\[ A + B = (A_x + B_x)i + (A_y + B_y)j \]

\[ A \cdot B = A_x B_x + A_y B_y + A_z B_z = |A||B| \cos(\mathbf{A},\mathbf{B}) \]

linear motion \( v = v_0 + at \)

\[ x - x_0 = v_0 t + \frac{1}{2} at^2 \]

\[ 2a(x - x_0) = v^2 - v_0^2 \]

\[ x - x_0 = \frac{1}{2} (v + v_0)t \]

projectile motion \( v_x = v_{x0} = |v_0| \cos \theta_0 \]

\( v_y = |v_0| \sin \theta_0 \)

\( v_y = v_0 \sin \theta_0 \cdot gt \)

\( x = v_0 \cos \theta_0 t \)

\( y = v_0 \sin \theta_0 t - \frac{1}{2} gt^2 \)

\( (x - x_0) = \frac{v_0^2 \sin(2\theta)}{2g} \)

circular motion \( a_r = v^2/r \)

\( a_r = r(2\pi/T)^2 \)

\( T = 1/f \)

\( F_r = m \frac{v^2}{r} \)

Newton laws: \( F_{\text{net}} = \Sigma F = ma \)

\( \Sigma F_x = ma_x \)

\( \Sigma F_y = ma_y \)

\( w = mg \)

\( F_{\text{sm}} = \mu_s N \)

\( F_k = \mu_k N \)

Hook's Law \( \mathbf{F} = -k \mathbf{x} \)

Work \( W = \mathbf{F} \cdot \mathbf{d} = |F||d| \cos(\mathbf{F},\mathbf{d}) = F_x d_x + F_y d_y \)

\( W_s = -\frac{1}{2}kx^2 \)

\( W_{\text{net}} = (\Sigma_{\text{all}})F_i \cdot d_i \)

Energy \( K = \frac{1}{2} mv^2 \)

\( U_g = mgy \)

\( U_k = \frac{1}{2}kx^2 \)

\( \Delta K = K_f - K_i = W_{\text{net}} \)

\( \Delta U = -W \)

\( E = K + U \)

\( W_{\text{net}} = \Delta K \)

Power \( P = dW/dt = \mathbf{F} \cdot \mathbf{v} = |\mathbf{F}||\mathbf{v}| \cos(\mathbf{F},\mathbf{v}) \)

\( P_{\text{avg}} = \frac{\Delta W}{\Delta t} \)

\( U_{gi} + U_{ai} + K_i + W_{nc} = U_{gf} + U_{af} + K_f \)

**Part I** (12 pts) Put the answers to these 12 questions on your SCANTRON sheet. Your answer should be **CLOSEST TO THE GIVEN ANSWERS**. The given answers assume a value of \( g = 10 \text{ m/s}^2 \).
1. A car with a mass of 5 T and with good tires can decelerate on a rainy day at about 2.5 m/s\(^2\) when braking with its wheels locked. If the car is initially traveling at 90 km/h, and then stops after braking, what is the work done on it by the friction force?
(A) 90 J  
(B) 1.25 \(\times\) 10\(^2\) J  
(C) \(-\) 2800 J  
(D) \(-\) 1.7 \(\times\) 10\(^6\) J  
(E) none of the above.

2. Using the information in Pr. 1, find the coefficient of kinetic friction between the road and the car during the rain:
(A) 0.15  
(B) 1.2  
(C) 0.25  
(D) 0.6  
(E) \(-\) 0.6

3. A mass of block A is 6 kg and a mass of block B is 4 kg. The two blocks are pushed by a force \(F = 15\) N over a distance 2 m along a frictionless surface as shown. The work done by the block A on block B is closest to
(A) 15 J  
(B) 12 J  
(C) \(-\) 9 J  
(D) 6 J  
(E) \(-\) 3 J

4. In Question 3, the work done by block B on block A is closest to
(A) \(-\) 30 J  
(B) 18 J  
(C) 0  
(D) \(-\) 12 J  
(E) None of the above

5. In question 3, the dot product of the two normal forces applied to block A is closest to
(A) 0  
(B) 600 N\(^2\)  
(C) \(-600\) N\(^2\)  
(D) 225 N\(^2\)  
(E) Wrong question – there is only one normal force acting on a block
6. A 10-kg lamp is suspended by a string from the ceiling inside an elevator moving down with decreasing speed. If the magnitude of the elevator’s acceleration is $2 \text{ m/s}^2$, what is the work done by the string tension force in slowing the lamp from 10 m/s down to the full stop?

(A) $-3000 \text{ J}$
(B) $-2050 \text{ J}$
(C) $-1050 \text{ J}$
(D) 0
(E) $2120 \text{ J}$

7. A 150-kg crate sits on the flat surface of a flatbed truck and does not slide as the truck, moving to the left, slows down with acceleration $a = 5 \text{ m/s}^2$. The work done by the static friction force in slowing down from 72 km/hr to the full stop is

(A) $750 \text{ J}$
(B) 0
(C) $-3 \times 10^4 \text{ J}$
(D) $4.5 \times 10^{-3} \text{ J}$
(E) None of the above

8. As a civil engineer, you have to evaluate the banking angle in a road construction. The bank is designed to keep traffic running at a typical speed 72 km/h on a turn on a rainy day, when friction is not a reliable factor. So neglect friction and determine the ramp angle (that is, the banking angle) necessary to support the traffic at the above-indicated speed on the turn with radius 80 m.

(A) 0
(B) $10^\circ$
(C) $20^\circ$
(D) $30^\circ$
(E) $40^\circ$

9. A certain type of a laundry centrifuge for drying wet clothes is essentially a vertical hollow cylinder with perforated walls, which is rotated rapidly around its central axis. At a sufficiently rapid rotation the clothes are pinned to the wall and the water is being thrown off them through perforations. Suppose that the coefficient of static friction $\mu_s$ between the wet clothing and the cylinder’s wall is 0.35, and the cylinder’s radius $R$ is 35 cm. What minimum speed must the cylinder’s wall have in order for the clothing not to slide down the wall?

(A) 0.5 m/s
(B) 1.3 m/s
(C) 2.0 m/s
(D) 2.6 m/s
(E) 3.16 m/s
10. A car with its engine off costs along a straight highway, which goes uphill. How far along the highway will the car go before it stops, if its initial speed was 80 km/h, and the slope is 15°?
(A) 68 m
(B) 100 m
(C) 196 m
(D) 294 m
(E) 55 m

A 25-kg block is pulled on a horizontal floor with a force of $T = 160 \text{ N}$ in the direction $\theta = 30^\circ$ above the horizontal. The coefficient of kinetic friction between the block and the floor is $\mu_k = 0.2$

11. What is the work done on the block by the kinetic friction force over a distance $x = 30 \text{ m}$?
(A) $-210 \text{ J}$
(B) $-630 \text{ J}$
(C) $-745 \text{ J}$
(D) $-870 \text{ J}$
(E) $-1020 \text{ J}$

12. What is the velocity of the block at $x = 30 \text{ m}$ if it started from rest?
(A) 10.2 m/s
(B) 12.2 m/s
(C) 15.5 m/s
(D) 20.9 m/s
(E) 30.2 m/s
Part 2.
Work-out problem (8 p.)
A bicyclist in a loop-the-loop starts rolling freely from a point P, 16 m above the ground. Radius of the loop is $R = 3.6$ m. The mass of the bicyclist together with the bike is 80 kg. Find the normal force on the bike
a. at the top of the loop (point A)
b. at the bottom of the loop (point B)
c. at the midpoint between the top and the bottom (point C).
d. Neglecting friction, find the *minimal* height $H$, from which you could start sliding and complete the whole performance safely (that is, complete full circle in the loop without falling down).