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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 provided.

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.

$$\mathbf{w} = mg$$

$$\text{Use: } g = 10 \text{ m/s}^2$$

$$1 \text{ hour} = 60 \text{ min} = 3600 \text{ sec}$$

$$\mathbf{A} = A_x \mathbf{i} + A_y \mathbf{j}$$

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

$$\mathbf{A} + \mathbf{B} = (A_x+B_x)\mathbf{i} + (A_y+B_y)\mathbf{j}$$

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

linear motion       $\mathbf{v} = \mathbf{v}_0 + \mathbf{a}t$

$$x - x_0 = \mathbf{v}_0 t + \frac{1}{2} \mathbf{a}t^2$$

$$2\mathbf{a}(x - x_0) = v^2 - v_0^2$$

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

projectile motion

$$v_x = v_{x0} = |v_0| \cos \theta_0$$

$$v_{y0} = |v_0| \sin \theta_0$$

$$v_y = |v_0| \sin \theta_0 - gt$$

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

$$x = v_0 \cos \theta_0 t$$

$$y - y_0 = v_0 \sin \theta_0 t - \frac{1}{2} gt^2$$

circular motion

$$a_r = v^2/r$$

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

$$T = 1/f$$

$$\mathbf{F}_r = m v^2/r$$

Newton laws:

$$\mathbf{F}_{\text{net}} = \Sigma \mathbf{F} = m\mathbf{a}$$

$$\Sigma \mathbf{F}_x = m\mathbf{a}_x$$

$$\Sigma \mathbf{F}_y = m\mathbf{a}_y$$

$$\mathbf{w} = mg$$

$$\mathbf{F}_{\text{smax}} = \mu_s \mathbf{N}$$

$$\mathbf{F}_k = \mu_k \mathbf{N}$$

Hook's Law

$$\mathbf{F} = -k\mathbf{x}$$

Work

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

$$W_s = -\frac{1}{2} kx^2$$

$$W = \int_{\mathbf{r}_i}^{\mathbf{r}_f} \mathbf{F} \cdot d\mathbf{r}$$

$$W_{\text{net}} = (\Sigma_{\text{all}} \mathbf{F}) \cdot \mathbf{d}$$

Energy

$$K = \frac{1}{2} mv^2$$

$$U_g = mgy$$

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

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

$$\Delta U = -W$$

$$E = K + U$$

$$W_{\text{net}} = \Delta K$$

Power

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

$$P_{\text{avg}} = \Delta W / \Delta t$$

$$U_{gi} + U_{si} + K_i + W_{nc} = U_{gf} + U_{sf} + K_f$$

**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  $g = 10 \text{ m/s}^2$ .

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1. A car with a mass of 5 T and with good tires can decelerate on a rainy day at about  $2.5 \text{ m/s}^2$  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?

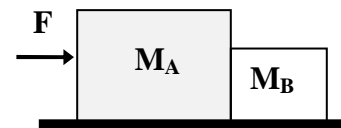
- (A) 90 J
- (B)  $1.25 \times 10^2 \text{ J}$
- (C)  $-2800 \text{ J}$
- (D)  $-1.7 \times 10^6 \text{ J}$
- (E) none of the above.

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  $F = 15 \text{ N}$  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)  $-9 \text{ J}$
- (D) 6 J
- (E)  $-3 \text{ J}$



4. In Question 3, the work done by block B on block A is closest to

- (A)  $-30 \text{ J}$
- (B) 18 J
- (C) 0
- (D)  $-12 \text{ J}$
- (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)  $600 \text{ N}^2$
- (C)  $-600 \text{ N}^2$
- (D)  $225 \text{ N}^2$
- (E) Wrong question – there is only one normal force acting on a block

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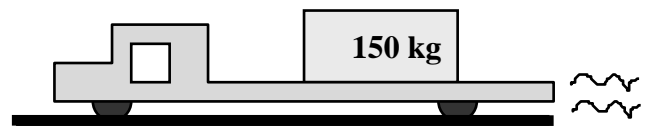
6. A 10-kg lamp is suspended by a string from the ceiling inside an elevator moving down with decreasing speed. If the magnitude of the elevator's acceleration is  $2 \text{ m/s}^2$ , what is the work done by the string tension force in slowing the lamp from  $10 \text{ m/s}$  down to the full stop?

- (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  $72 \text{ km/hr}$  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  $72 \text{ km/h}$  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  $80 \text{ m}$ .

- (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  $35 \text{ cm}$ . What minimum speed must the cylinder's wall have in order for the clothing not to slide down the wall?

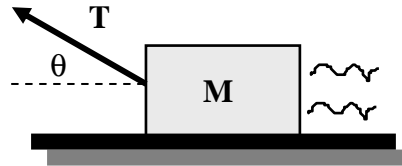
- (A)  $0.5 \text{ m/s}$
- (B)  $1.3 \text{ m/s}$
- (C)  $2.0 \text{ m/s}$
- (D)  $2.6 \text{ m/s}$
- (E)  $3.16 \text{ m/s}$

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10. A car with its engine off coasts 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  $15^\circ$ ?

- (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  $T = 160$  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  $x = 30$  m?

- (A)  $-210$  J
- (B)  $-630$  J
- (C)  $-745$  J
- (D)  $-870$  J
- (E)  $-1020$  J

12. What is the velocity of the block at  $x = 30$  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

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**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

- at the top of the loop (point A)
- at the bottom of the loop (point B)
- at the midpoint between the top and the bottom (point C).
- 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).

