Multiple choice questions [60 points]

Answer all of the following questions. Read each question carefully. **Fill the correct bubble on your scantron sheet**. Each question has exactly one correct answer. All questions are worth the same amount of points.

1. A boy holds a bird in his hand. What is the force that makes a third law pair with the weight of the bird?
   A. The force by the Earth on the bird.
   B. The force by the bird on the Earth.
      The weight is $\vec{W}_{BE}$. The third law pair force should be labeled EB. This is a force by the bird on the Earth.
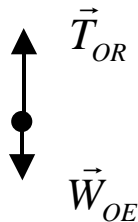   C. The force by the hand on the bird.
   D. The force by the bird on the hand.
   E. The force by the Earth on the hand.

2. A vertical rope is attached to an object that has a mass of 40.0 kg and is at rest. The tension in the rope needed to give the object an upward speed of 3.50 m/s in 0.700 s is
   A. 592 N

$$\vec{T}_{OR} \qquad \vec{T}_{OR} + \vec{W}_{OE} = m\vec{a}$$

$$T_{OR} = mg + ma = 40 \times (9.8 + \frac{3.5}{0.7})$$

$$\vec{W}_{OE}$$

   B. 390 N
   C. 200 N
   D. 980 N
   E. 720 N

(Last)   (First)

3. A net force is exerted on an object toward the north. The object

    A. is moving toward the north.
    B. is moving toward the east.
    C. is moving toward the west.
    D. is moving toward the south.
    E. may be moving in any direction.

      If $\vec{F}$ is toward the north, $\vec{a} = \dfrac{\vec{F}}{m}$ is toward the north. But nothing

    can be said about the direction of the velocity

4. Two groups of five men each are engaged in a tug-of-war, each man pulling with a force of 900 N. If the rope does not move, the tension in it is

    A. 0.9 kN
    B. 9.0 kN
    C. 0 kN
    D. 4.5 kN = 0.9 × 5

             4.5 kN ←——————————→ **4.5 kN**

    E. 1.8 kN

5.   Figure A

Block 1

Surface S

Figure B

Block 1

Block 2

Surface S

Figure C

Block 1   Block 2

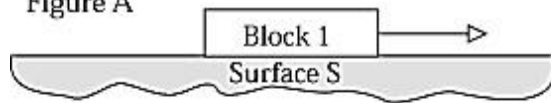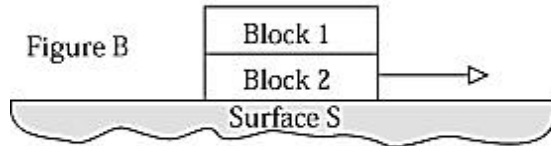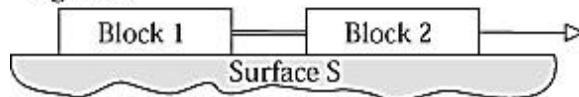Surface S

The blocks shown in the figures have equal masses and are made of the same material. The velocity is the same in each figure. The total frictional force exerted by the surface on the blocks is

A. greater in Figure C than in Figure A or Figure B.
B. the same in Figure C as in Figure A.
C. the same in Figures A, B, and C.
D. the same in Figure A and Figure B.
E. the same in Figure C and Figure B.

Recall that $f = m_k N$

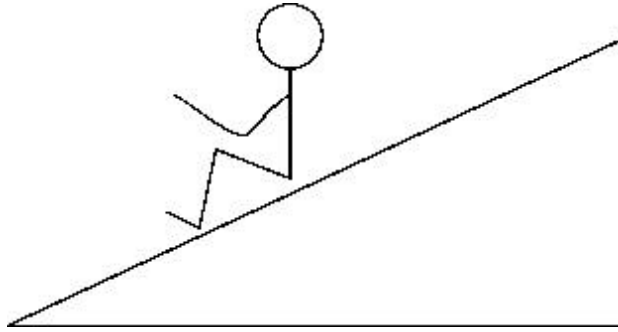Figure B: $m_k (m_1 + m_2) g$

Figure C: $m_k m_1 g + m_k m_2 g$

6.

The free-body diagram that best represents the forces acting on the student sliding down the incline is
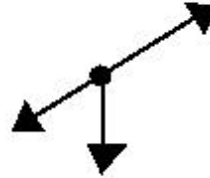
(1)   (2)   (3)   (4)   (5)

A. 1
B. 2
C. 3
D. 4
E. **5**

7. A car experiences both a centripetal and a tangential acceleration. For which of the following would this be true?

A. It is going around a curve at a constant speed.
    It is going around a curve and slowing down.
B. The centripetal component tells us that the car is moving on a curve. The tangential component tells us that the speed of the car is changing.
C. It is going along a straight road at a constant speed.
D. It is going along a straight road and increasing its speed.
E. It is going along a straight road and decreasing its speed.

8.
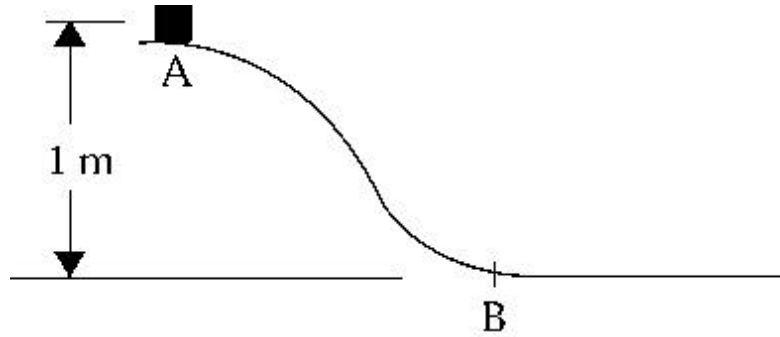
A 6.0-kg block slides from point A down a frictionless curve to point B. After the block passes point B, a friction force opposes the motion of the block so that it comes to a stop 2.5 m from B. Calculate the coefficient of kinetic friction between the block and the surface after position B.

A. **0.15**

B. **0.25**

C. **0.40**

Use the work-energy theorem from A to B (only the weight does work)

$$\frac{1}{2}mv_B^2 - 0 = mgh$$

And from B to the point d=2.5m away from B (only the force of friction does work)

$$0 - \frac{1}{2}mv_B^2 = -f_{BS}d = -m_k N_{BS}d = -m_k mgd \Rightarrow mgh = m_k mgd \Rightarrow m_k = \frac{h}{d}$$

D. **0.52**

E. **0.70**

9. Two skiers start at the same place and finish at the same place. Skier A takes a straight route to the finish whereas Skier B takes a curvy route to the finish. If you assume that friction is negligible, which of the following statements is true?

A. Skier A has the same speed as skier B at the finish.
Since there is no friction, only the weight of the skier does work. Apply the work-energy theorem
$\frac{1}{2}mv^2 - 0 = mgh \Rightarrow v = \sqrt{2gh}$ where h is the difference in height between the start and finish points. v is independent of the length of the path.

B. Skier B has the greater speed at the finish.

C. Skier A has the greater speed at the finish

10.
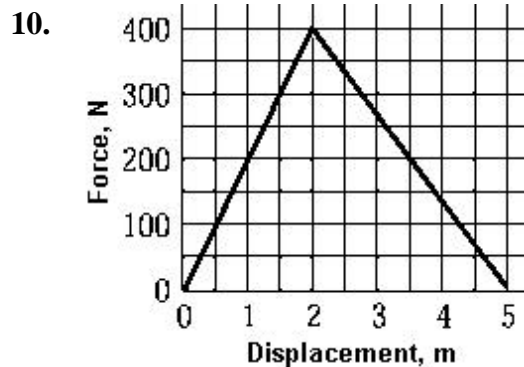
In pushing a load, a woman exerts a force as given by the graph. What is the total work done by the woman?

A. 400 J
B. 200 J
C. 2000 J
D. 1000 J
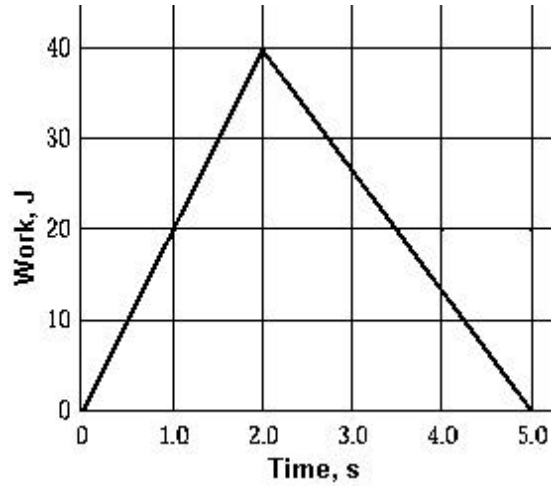$$W = \int F dx = area\ under\ the\ curve = \frac{5 \times 400}{2}$$
E. 500 J

(Last)   (First)

11.

The work done by a crane lifting a boat is plotted on the graph. The power developed by the crane when $t = 1.5$ s is

A. 40 W

B. 20 W

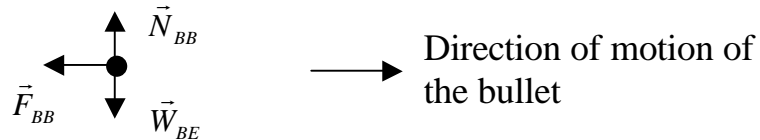$$P = \frac{dW}{dt} = slope = \frac{40 - 0}{2 - 0}$$

C. 10 W

D. 27 W

E. 30 W

12. A bullet with a mass of 10.0 g and an initial speed of 800 m/s penetrates 5.00 cm into a fixed block of wood before stopping. The average force exerted by the block on the bullet was
(apply the work-energy theorem)

A. 160 N

B. 1.3 × 10⁵ N

C. 1.3 × 10³ N

D. 6.4 × 10⁴ N

$\vec{N}_{BB}$

$\vec{F}_{BB}$ $\vec{W}_{BE}$

Direction of motion of the bullet

Only the force on the bullet by the block, $\vec{F}_{BB}$, does work.

$$0 - \frac{1}{2}mv^2 = -F_{BB}d \Rightarrow F_{BB} = \frac{mv^2}{2d} = \frac{0.01 \times 800^2}{2 \times 0.05}$$

E. 6.4 × 10⁵ N

(Last)   (First)

PROBLEM [40 points]

A woman is practicing bungee jumping from a bridge. She jumps off a bridge (with 0 m/s initial velocity) attached to a rope. The rope that acts as a spring stops her fall.

The spring constant of the bungee rope is k=100 N/m. When the rope is not stretched, its length is l=20 m. The mass of the woman is 50 kg. Take g=10 m/s^2. Take as the origin the point where the rope is not stretched.

k=100 N/m

m=50 kg

-20 m

0 m

y
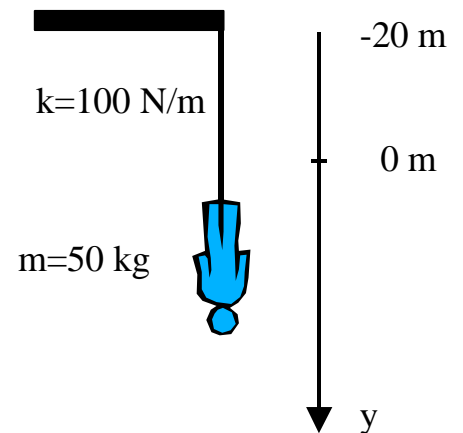
1). [10 pts] What is the velocity of the woman when the rope is just starting to stretch (at y=0)?

Use the work-energy theorem:

$$\frac{1}{2}mv^2 - 0 = mgl \Rightarrow v = \sqrt{2gl} = 20 \; m/s$$

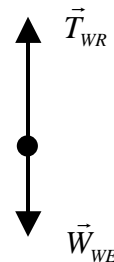2). [10 pts] How far below the bridge does the woman fall?

The lowest point y_{max} is where the velocity of the woman is 0. Apply the work energy theorem between y=0 and y=y_{max}

$$0 - \frac{1}{2}mv^2 = W_{\vec{W}_{WE}} + W_{\vec{T}_{WR}} = mgy_{max} - \frac{1}{2}ky^2_{max}$$

$$\Rightarrow$$

$$\frac{k}{m}y^2_{max} - 2gy_{max} - v^2 = 0$$

$$y_{max} = 20 \; m \quad or \quad -10m$$

$\vec{T}_{WR}$

$\vec{W}_{WE}$

Take the positive solution. The woman falls **40 m** under the bridge.

3). [10 pts] How much work does the rope do on the woman from the bridge to the lowest point of the fall (Make sure that you get the sign right)?

From –20 m to 0 m, the rope does no work (the rope can't be compressed). From 0 m to 20 m, the work done by the rope is

$$W = -\frac{1}{2}ky_{max}^2 = -20\ kJ$$

4). [10 pts] What is the maximum magnitude of the acceleration of the woman?

From –20m to 0m the acceleration is 10m/s^2

For y between 0 m to y_{max}=20m, the acceleration is given by

$$\vec{T}_{WR} + \vec{W}_{WE} = m\vec{a} \quad \Rightarrow \quad a = -\frac{k}{m}y + g$$

The magnitude of a is maximum at y_{max}

$$a = -2\times20 + 10 = -30\ m/s^2$$

Overall between –20 m and +20 m, the magnitude of the acceleration is maximum at +20 m and equal to **30 m/s^2**