PART I: MULTIPLE CHOICE

Each multiple choice question has one best answer -- circle the letter of the best answer. **Partial credit will be given on the multiple choice questions.** If you circle two answers, one of which is correct, you will receive half credit for the question. No credit will be given for more than two answers, even if one of them is correct. Use \( g = 10 \text{ m/s}^2 \) throughout the exam. (4 points each for full credit)

1. A force moves an object in the direction of the force. The graph shows the force versus the object's position. The work done when the object moves from 0.0 to 4.0 m is

   a) 20 J.  
   b) 40 J.  
   c) 60 J.  
   d) 80 J.

2. A lightweight object and a very heavy object are sliding with equal speeds along a level frictionless surface. They both slide up the same frictionless hill. Which rises to a greater height?

   a) The heavy object, because it has greater kinetic energy.  
   b) The lightweight object, because it weighs less.  
   c) They both slide to the same height.  
   d) It cannot be determined from the information given.

3. A golf ball is thrown at, and bounces straight back from, a massive bowling ball that is initially at rest. Assuming an elastic collision, after the collision the bowling ball has

   a) more momentum than the golf ball.  
   b) the same momentum as the golf ball.  
   c) less momentum than the golf ball.  
   d) cannot be determined from the information given.

4. A chunk of clay slams into, and sticks to, another identical chunk of clay that is at rest. The momentum of the chunks stuck together after the collision is the same as the momentum of the moving chunk before collision, but not so with kinetic energy, which is partly turned into heat and other forms of energy. What percentage of the kinetic energy is dissipated?

   a) 10 percent  
   b) 25 percent  
   c) 50 percent  
   d) 75 percent
5. You are using a wrench and trying to loosen a rusty nut. Which of the arrangements shown is most effective in loosening the nut? Choose the list that orders the arrangements in descending efficiency.

a) 1, 2, 4, 3  
b) 2, 1, 3, 4  
c) 2, 4, 3, 1  
d) 2, 1, 4, 3

6. Two solid spheres, starting from rest, roll down a ramp. Sphere 1 has twice the radius of sphere 2 and eight times the mass. Which statement is true when the spheres reach the bottom of the ramp?

a) The velocity of sphere 1 is twice that of sphere 2.  
b) The velocity of sphere 2 is eight times that of sphere 1.  
c) The velocity of sphere 1 is equal to that of sphere 2.  
d) The ratio of velocities depends on the length and angle of the ramp.

7. A heavy seesaw (i.e., not massless) is out of balance. A light girl sits on the end that is tilted downward, and a heavy boy sits on the other side so that the seesaw now balances. If they both move forward so that they are one-half their original distance from the pivot point (the fulcrum), what will happen to the seesaw?

a) The side the boy is sitting on will tilt downward.  
b) The side the girl is sitting on will once again tilt downward.  
c) Nothing; the seesaw will still be balanced.  
d) It is impossible to say without knowing the masses and the distances.

8. A block of wood floats on water while the same size block of steel lies submerged in water. The buoyant force is greatest on the

a) block of steel.  
b) block of wood.  
c) cannot be determined because the block of steel is resting on the bottom  
d) the buoyant force is the same on each
PART II:  FREE RESPONSE  Use g = 10 m/s$^2$ throughout the exam.

9. In trying out two of your new (same mass, but very cheap) billiard balls you notice that after a moving ball (initial $v = 1.2$ m/s) collides with a stationary one, the angle between their final velocities is not 90° as you would expect. Rather, the motion is as shown in the figure. Assume no friction and no rolling (rotational K.E.) in doing this problem.

(a) What are the velocities of the two balls after the collision? [12 pts]

(b) Has any kinetic energy been lost? If yes, how much? [5 pts]
10. A small piece of clay of mass \( m = 1 \text{ kg} \) is dropped from a height \( h = 50 \text{ cm} \) onto a potter's wheel of mass \( M = 20 \text{ kg} \) (see figure), and sticks to it. The radius of the wheel is \( R = 30 \text{ cm} \) and the clay hits the wheel a distance \( r = 20 \text{ cm} \) from the center. You may treat the clay as a particle.

(a) If the wheel is rotating with rotational velocity \( \omega_i \) when the clay is released and the wheel is rotating freely (that is to say, it is not driven by a motor), what is the final rotational velocity \( \omega_f \) of the wheel and the clay? Assume the clay sticks to the wheel upon impact. [14 pts]

(b) Explain briefly (in a sentence or two) the assumptions and/or principles you used to answer part (a). [3 pts]
11. A 20.0 m long uniform beam weighing 600 N is resting on top of two walls, A and B, as shown.

(a) Find the maximum weight a person can be to walk to the extreme end D, without tipping the beam. (Hint: think about the conditions when the beam just starts to tip.) [7 pts]

(b) Find the forces that the walls A and B exert on the beam when the person is standing at C. (Assume the same weight as in part (a); if you can’t do part (a), use W for the person’s weight.) [10 pts]
12. (a) What is the likely identity of a metal (see table) if a sample has a mass of 63.5 g when measured in air and an apparent mass of 56.4 g when submerged in water? [10 pts]

(b) This sample of metal floats when placed in mercury. What fraction will be submerged? [7 pts]

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<tr>
<th>substance</th>
<th>density, $\rho$ (kg/m$^3$)</th>
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<tbody>
<tr>
<td>aluminum</td>
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<tr>
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