1. This exam is closed book, closed notes. You may use one 4” × 6” index card (both sides) as a crib sheet.
2. There are 7 problems and 11 pages including this one. Check now to see that you have all of them before you begin. Note that the last page is intentionally blank to provide you with some additional room for calculations, should you need it. More scratch paper is available up front.
3. Partial credit is possible on all problems except 1 and 2.
4. You may ignore the effects of air resistance in all problems unless it is specifically mentioned otherwise.
5. Remember to box your final answers on problems 3 through 7, so that I know what they are!

List of possibly useful constants, conversions, and quantities:

- mass of Earth $m_E = 6.0 \times 10^{24}$ kg
- radius of Earth $r_E = 6.4 \times 10^6$ m
- gravitational acceleration at Earth's surface:
  \[ g = 9.80 \text{ m/s}^2 \]
- 1 mile = 1.61 km
- 1 inch = 2.54 cm
- 1 meter = 3.28 ft
- $\cos 60^\circ = \sin 30^\circ = 0.50$
- $\sin 60^\circ = \cos 30^\circ = 0.87$
- $\sin 45^\circ = \cos 45^\circ = 0.71$
Problem 1 (5 points each; 20 points total; no partial credit)
Circle TRUE or FALSE for each question.

(a) If the net force on an object is zero, then we can assume that the object is not moving.

    TRUE       FALSE

(b) As you sit taking this test, you are exerting a force on the Earth equal in magnitude to your weight.

    TRUE       FALSE

(c) Two objects having different masses experience the same magnitude of gravitational force near the Earth’s surface.

    TRUE       FALSE

(d) The work done by friction on an object is always negative.

    TRUE       FALSE
Problem 2 (5 points each; 25 points total; no partial credit)
Circle the BEST ANSWER to each question.

(a) If a physical process has doubled the velocity of a moving object, then which of the following must also be true about the object?
   i) The momentum has been doubled.
   ii) The kinetic energy has been doubled.
   iii) No net work has been done on the object.
   iv) None of the above.

(b) If we know that a non-zero net force is acting on an object, which of the following must be true regarding this object?
   i) The object is at rest.
   ii) The object is moving with constant velocity.
   iii) The object is accelerating.
   iv) The object’s kinetic energy is increasing.

(c) If a bowling ball and a tennis ball have the same momentum, then they must also have:
   i) the same velocity.
   ii) the same kinetic energy.
   iii) the same potential energy.
   iv) None of the above choices are valid.

(d) Two objects collide inelastically. There are no net external forces on the objects. Which of the following quantities is conserved in the collision?
   i) Velocity.
   ii) Momentum.
   iii) Kinetic energy.
   iv) None of the above choices are valid.

(e) A very light cart holding a box that weighs 300 N is moved at constant velocity for a distance of 15 m across a level surface. What is the net work done in this process?
   i) 0 J
   ii) 0.050 J
   iii) 20 J
   iv) 2000 J
   v) 4500 J
Problem 3 (12 points)
A 0.12 kg ball is moving at 6.0 m/s when it is hit by a bat, causing it to reverse direction and have a speed of 14 m/s. If the bat was in contact with the ball for 5.0 ms, what was the magnitude of the average force exerted by the bat on the ball? (A complete answer to this problem includes a diagram!)
Problem 4 (15 points)
A sled weighs 100 N. It is held in place on a frictionless 20° slope by a rope attached to a stake at the top; the rope is parallel to the slope.

5 pts (a): Draw a relevant diagram and label it with the appropriate variables. Make a separate free-body diagram for the sled.

10 pts (b): Calculate the tension in the rope.
Problem 5 (25 points)
Brenda applies a constant horizontal force to push a 35 kg crate a distance of 5.0 m across a level floor with an acceleration of 0.40 m/s². The coefficient of kinetic friction is 0.35.

5 pts (a): Draw a relevant diagram and label it with the appropriate variables. Make a separate free-body diagram for the crate.

10 pts (b): What is the magnitude of the pushing force exerted by Brenda?
10 pts (c): What is the net work done on the crate while it is being pushed?
Problem 6 (15 points)

A child riding a sled gets a brief push from the top of a snow-covered hill so that she starts down with an initial speed of 2.5 m/s. At the bottom of the hill, her speed is 6.0 m/s. The child and sled together have a mass of 45 kg and lose 430 J of energy due to friction on the way down the hill.

5 pts (a): Draw a relevant diagram and label it with the appropriate variables.

10 pts (b): Calculate the height of the hill.
Problem 7 (25 pts)
A 60.0 kg skater is moving due west on a frozen pond (assume it to be frictionless) at 1.00 m/s.
While skating, he catches a 7.00 kg medicine ball that had been traveling horizontally and due north at 2.00 m/s.

5 pts (a): Draw a relevant diagram and label it with the appropriate variables.

10 pts (b): What is the skater’s velocity (magnitude and direction) after catching the ball?
10 pts (c): How much kinetic energy is lost in the collision?