Name: _____

# PHYS 1210-02 Exam 2

Standards 14–27, excluding 16

Calculators of any type are permitted. You may bring your own 8 ½" × 11"notes sheet, which may contain information on both sides.

Enter your answer inside the box provided by each question. Include units with all quantitative answers. Do not make stray marks in the box, and do not write your answer outside the box. It is a good idea to write your answers in pencil. If the question asks for a selection from provided options, fill the circle (○)by the most correct answer.

1. Jean-Jacques, a red panda at the Paris Zoo, rests peacefully on a tree branch. Jean-Jacques weighs 180 newtons. Fill in the blanks in the sentences below to correctly describe the situation.

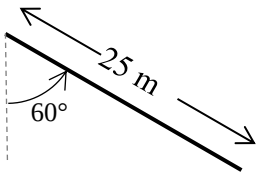
   _____ exerts a downward force of 180 N on Jean-Jacques.
   (object)

   Jean-Jacques exerts a downward force of 180 N on _____.
   (object)

   _____ exerts an upward force of 180 N on Jean-Jacques.
   (object)

   Jean-Jacques exerts an upward force of 180 N on _____.
   (object)

2. A carnival slide is 25 meters long and slopes at an angle of 60 degrees from vertical. A child sitting on a burlap sack slides down the slide. The force of gravity $\vec{F}$ acting on the child is straight downward with a magnitude of 250 newtons.




   A. What is the dot product $\vec{F} \cdot \vec{d}$ of the force and the child's displacement $\vec{d}$? Show your work.

   B. What is the work done by the force of gravity acting on the child? Show your work.

3. A laboratory projectile launcher launches a 70-gram steel ball at a speed of 5.40 m/s. What is the kinetic energy of the ball at launch?

4. An Italian farmer rolls a 1.00-kg ball on a level, grassy field at an initial speed of 5.0 meters per second. After rolling 12.0 meters, the ball's speed is 2.0 meters per second. How much work was done on the ball by the force of friction?

5. A pendulum at a science museum consists of a 100-kilogram metal ball suspended by a steel wire that is 5.50 meters long. A worker displaces the ball sideways by 4.40 meters, always keeping the wire taut.

   A. How much does the ball's height increase when the worker pushes it sideways?

   B. What is the change in the ball's gravitational potential energy?

   C. How much work does gravity do on the ball as the worker displaces the ball?

   D. How much work does the tension in the wire do on the ball as the worker displaces the ball?

   E. How much work does the worker do on the ball?

6. Consider a very simple model of an automobile bumper as a Hooke's law spring. When the bumper hits an immobile barrier, the spring compresses, stopping the car. An engineer is designing a bumper to stop a 1250-kilogram car moving at a speed of 2.24 meters per second as the spring compresses by 10.0 cm. What must be the spring constant of the spring?

7. The spring of a pogo stick shortens 18 centimeters when a compressional force of 980 newtons is applied to it.

   A. What is the spring constant of the spring?

   B. How much work is required to compress the spring 18 centimeters?

9. A bowler throws a bowling ball toward the pins at the end of a bowling lane. The ball travels through the air for a short distance before landing on the wooden surface of the lane. The lane absorbs the impact of the ball so that the ball does not bounce. Kinetic friction slows the ball until it rolls without slipping down the lane. Consider several forces that act on the ball during this process: the throw from the bowler, gravity, the normal force from the lane, and kinetic friction.

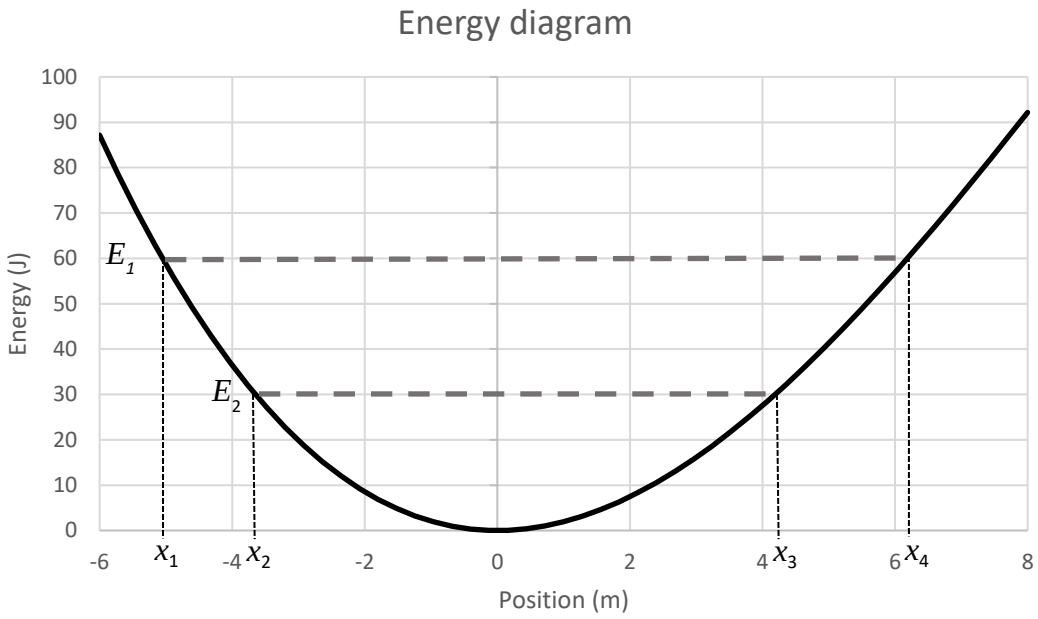
   A. First, tell me if the work done on the ball by each force is positive, negative, or zero.

| Force | positive | negative | zero |
|---|---|---|---|
| throw from the bowler | ○ | ○ | ○ |
| gravity | ○ | ○ | ○ |
| normal force | ○ | ○ | ○ |
| kinetic friction | ○ | ○ | ○ |

   B. Next, classify each force as conservative or non-conservative.

| Force | conservative | non-conservative |
|---|---|---|
| throw from the bowler | ○ | ○ |
| gravity | ○ | ○ |
| normal force | ○ | ○ |
| kinetic friction | ○ | ○ |

9. The graph below shows the potential energy of a particle confined to a line. The horizontal axis is the position of the particle on the line, and the vertical axis is energy. The solid curve shows the potential energy of the particle at each position.




A. If the total mechanical energy of the particle is $E_1 = 60$ J, what is the particle's kinetic energy when it is located at $x = 0$?

B. If the total mechanical energy of the particle is $E_1 = 60$ J, what is the particle's kinetic energy when it is located at at $x = x_2$?

C. If the total mechanical energy of the particle is $E_2 = 30$ J, what is the particle's kinetic energy when it is located at $x = x_3$?

10. Two gliders equipped with magnetic bumpers glide on a frictionless air track. Glider A, with mass 0.500 kg, initially moves in the +*x* direction with a speed of 1.60 m/s. Glider B, with mass 0.250 kg, initially moves in the +*x* direction with a speed of 0.40 m/s. Glider A overtakes Glider B from behind and collides with it elastically.

A. Before the collision, what is the momentum of Glider A?

B. Before the collision, what is the momentum of Glider B?

C. Before the collision, what is the total momentum of the system of Gliders A and B?

D. Before the collision, what is $\vec{v}_{cm}$, the velocity of the center of mass of the system of Gliders A and B?

E. Before the collision, what is $\vec{v}_A - \vec{v}_{cm}$, the difference between the velocity of Glider A and the velocity of the center of mass?

F. Before the collision, what is $\vec{v}_B - \vec{v}_{cm}$, the difference between the velocity of Glider B and the velocity of the center of mass?

G. After the collision, what is the velocity of the center of mass of the system of Gliders A and B?

H. After the collision, what is $\vec{v}_A - \vec{v}_{cm}$, the difference between the velocity of Glider A and the velocity of the center of mass?

I. After the collision, what is $\vec{v}_B - \vec{v}_{cm}$, the difference between the velocity of Glider B and the velocity of the center of mass?

J. If the collision between the gliders had been totally inelastic so that the gliders stuck together after the collision, what would their velocity be after the collision?

11. Three identical point masses, each with mass *m*, are placed at the vertices of an equilateral triangle with sides of length 1.00 meter. One vertex is located at the origin (0, 0), another vertex is located on the *x* axis at (1 m, 0), and the third vertex is above the *x* axis.

A. What are the (*x*, *y*) coordinates of the third vertex?

B. What are the (*x*, *y*) coordinates of the center of mass of the system of the three masses?