Name: _____

PHYS 1110-02 Exam 2

You may use an 8.5"×11" note sheet written on both sides and a calculator. Please write your answers in the boxes provided. Show your work outside the boxes. If you need to change the answer you wrote in a box, erase it and write your intended answer. This is easiest if you write in pencil. You have 110 minutes.

1. A race car driver practicing cornering drives a car on a flat and level track at a speed of 15.0 meters per second in a circle with a radius of 50.0 meters.

   A. How long does it take the car to make one complete revolution around the circle?

   B. What is the car's angular speed, in radians per second?

   C. What is the direction of the car's acceleration? Select the one best answer by filling its circle.

   ○ a. The car is not accelerating.

   ○ b. The car is accelerating outward from the center of the circular path.

   ○ c. The car is accelerating inward toward the center of the circular path.

   ○ d. The car is accelerating forward.

   ○ e. The car is accelerating backward.

   D. The car's tires have a coefficient of static friction $\mu_s = 0.70$ against the track. What is the smallest radius that the circular path can have so that when the car is traveling at 15.0 meters per second, its tires maintain traction with the road? Traction cannot exceed the maximum magnitude of static friction, $\mu_s mg$.

2. We have learned two operations that multiply vectors together: dot product and cross product. The following questions concern these operations.

   A. How does the dot product of two vectors depend on the magnitudes of the vectors? Choose the one best answer by filling its circle.

      ○ a. The dot product is proportional to the sum of the magnitudes.

      ○ a. The dot product is proportional to the sum of the squares of the magnitudes.

      ○ c. The dot product is directly proportional to the product of the magnitudes.

      ○ d. The dot product is inversely proportional to the product of the magnitudes.

      ○ e. The magnitudes of the vectors do not affect their dot product.

   B. How does the cross product of two vectors depend on the magnitudes of the vectors? Choose the one best answer by filling its circle.

      ○ a. The cross product is proportional to the sum of the magnitudes.

      ○ b. The cross product is proportional to the sum of the squares of the magnitudes.

      ○ c. The cross product is directly proportional to the product of the magnitudes.

      ○ d. The cross product is inversely proportional to the product of the magnitudes.

      ○ e. The magnitudes of the vectors do not affect their cross product.

   C. What kind of quantity is a dot product? Choose the one best answer by filling its circle.

      ○ a. A dot product is a vector.

      ○ b. A dot product is a scalar.

   D. What kind of quantity is a cross product? Choose the one best answer by filling its circle.

      ○ a. A cross product is a vector.

      ○ b. A cross product is a scalar.

   E. How does the dot product of two vectors depend on the angle between the vectors? Choose the one best answer by filling its circle.

      ○ a. The angle between the vectors does not affect their dot product.

      ○ b. The dot product of two vectors is proportional to the sine of the angle between them.

      ○ c. The dot product of two vectors is proportional to the cosine of the angle between them.

F. How does the cross product of two vectors depend on the angle between the vectors? Choose the one best answer by filling its circle.

○ a. The angle between the vectors does not affect their cross product.

○ b. The cross product of two vectors is proportional to the sine of the angle between them.

○ c. The cross product of two vectors is proportional to the cosine of the angle between them.

3. Barbara pulls her little sister Annie up a snow-covered hill on her sled. It takes them 200 seconds, a little over three minutes, to reach the top of the hill. Annie and the sled together have a mass 35.0 kg; the hill is 40.0 meters long, and the top of the hill is 4.0 meters higher than the bottom. The force of kinetic friction between the snow and the sled has a magnitude of 2.00 newtons. Annie reaches the top of the hill at rest.

A. How much work was done on Annie and her sled along her ascent by the force of gravity?

B. How much work was done on Annie and her sled along her ascent by the normal force?

C. How much work was done on Annie and her sled along her ascent by friction?

D. How much work was done on Annie and her sled along her ascent by Barbara's pull?

E. What is Barbara's average power as she pulls the sled up the hill?

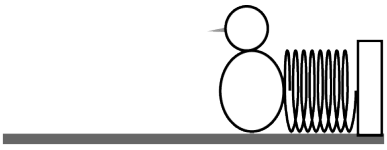
Barbara gives the sled a gentle nudge, sending Annie to ride the sled back down the hill.

F. What is the total (net) work done on Annie and her sled by all forces (friction, normal force, gravity) as she rides the sled back down the hill?

G. What is Annie's (including her sled) kinetic energy when she reaches the bottom of the hill?

H. What is Annie's speed when she reaches the bottom of the hill?

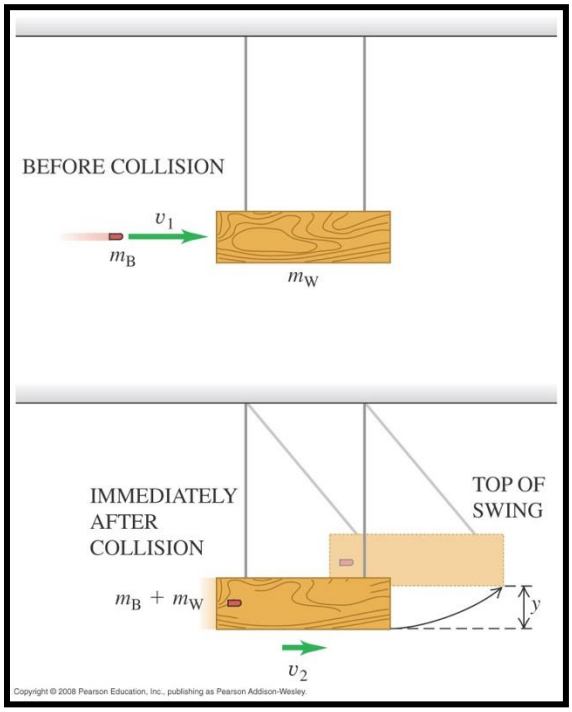
4. A snowman is pressed with a force of 600. newtons against a spring with a spring constant of 1500 newtons per meter, compressing the spring.



A. How far does the spring compress?

B. What is the potential energy in the compressed spring?

5. A m_B = 10.0-g rifle bullet is fired with a speed of v_1 = 400 m/s into a wood block pendulum with mass m_w = 5.00 kg, suspended from two cords 70.0 cm long. The bullet embeds in the block, and the block swings upward after impact.



A. What kind of collision is this?

B. Find the speed v_2 of the bullet and pendulum immediately after the bullet becomes embedded in the pendulum.

C. Find the kinetic energy of the (bullet + pendulum) immediately after the bullet becomes embedded in the pendulum.

D. Find the gravitational potential energy of the (bullet + pendulum) at the top of the swing. Define the gravitational potential energy as zero at the bottom of the swing.

E. Find the vertical height y through which the pendulum rises (at the top of its swing).

6. A 1.00-kilogram cart initially traveling at 1.20 meters per second in the $+x$ direction on a linear track collides elastically with a 1.50-kilogram cart traveling at 0.300 meters per second in the $-x$ direction. Both carts remain on the track during and after the collision.

   A. What is the total momentum of the two carts before the collision?

   B. What is the total momentum of the two carts after the collision?

C. (0.5 point) What is the velocity of the 1.00-kilogram cart after the collision? Be careful of the sign.

D. (0.5 point) What is the velocity of the 1.50-kilogram cart after the collision? Be careful of the sign.

E. What is the momentum change of the 1.00-kilogram cart? Be careful of the sign.

F. If the two carts were in contact for 0.50 seconds, what was the average magnitude of the force on the 1.00-kilogram cart?

7. A bicycle with wheels 0.36 meters in radius coasts down a hill. The bicycle's initial speed is 3.00 meters per second, and its speed increases at the rate of 0.10 meters per second per second.

   A. What is the initial angular speed of a wheel of the bicycle, in radians per second?

   B. What is the angular acceleration of a wheel of the bicycle, in radians per second per second?

   C. What is the centripetal (radial) component of the acceleration of a point on the rim of a wheel of the bicycle, in meters per second per second?

   D. What is the tangential component of the acceleration of a point on the rim of a wheel of the bicycle, in meters per second per second?