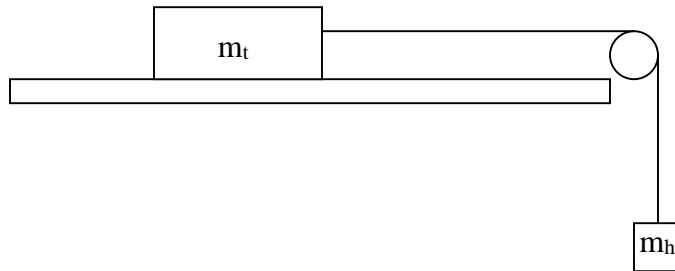Physics Honors

Midterm Review
Free Response Problems

1. A 40 kg mass is pulled across a frictionless table by a string which goes over the pulley and is connected to a 20 kg mass.

   a. Draw a free body diagram, indicating <u>all forces</u> in approximate scale, for the mass on the table. Show the direction of its acceleration next to the free body diagram.

   b. Draw a free body diagram, indicating <u>all forces</u> in approximate scale, for the mass that is hanging from the string. Show the direction of acceleration next to the free body diagram.

   c. Apply Newton's Second Law to the mass on the table to write an equation for the **TENSION**.

   d. Apply Newton's Second Law to the hanging mass to write an equation for the **TENSION** of the hanging mass.

   e. Combine your equations from c and d to solve for the acceleration.

   f. Solve for the tension in the string.

M₁   M₂   F
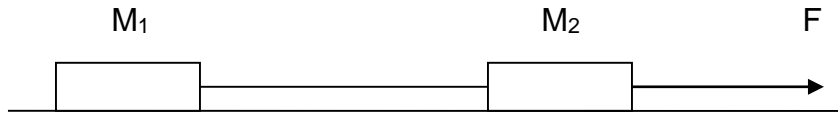
2. Two blocks, with masses $M_1 = 0.25$ kg and $M_2 = 0.35$ kg, are connected by a string and lie on a frictionless tabletop. A force $F = 3.6$ N is applied to block M_2.

   a. Draw free-body diagram, indicating <u>all forces</u> in approximate scale, for M_1.

   b. Draw free-body diagram, indicating <u>all forces</u> in approximate scale, for M_2.

   c. Use Newton's Second Law to write an equation for M_1

   d. Use Newton's Second Law to write an equation for M_2.

   e. Use equations from c and d to find the acceleration of each of the blocks.

   f. Use equations from c and d to find the tension force in the string.

3. A 100 kg object begins at rest on a frictionless surface.
   It then experiences a 10 N force for 6.0 s.

   a. What is its acceleration during that 6.0s?

   b. How far does it travel during that 6.0s?

   c. What is its velocity after that 6.0s?

The force is then turned off for the next 10s (no force acts on the object during this time).

   d. What is its velocity after that 10s time interval has elapsed?

   e. How far does the object travel during that 10s?

 An opposing force 3.6 N is then used to stop the object over a distance of 5m.

   f. What acceleration does the object experience while it travels that 5m?

   g. How much work is done by that force as the object travels its last 5m?

4. A 250 kg object begins at rest on a frictionless surface.
   It then experiences a 35.5 N force for 12.0 s.

   a. What is its acceleration during that 12.0s?

   b. How far does it travel during that 12.0s?

   c. What is its velocity after that 12.0s?

The force is then turned off for the next 10s (no force acts on the object during this time).

   d. What is its velocity after that 10s time interval has elapsed?

   e. How far does the object travel during that 10s?

An opposing force of 72.6 N is then used to stop the object over a distance of 5m.

   f. What acceleration does the object experience while it travels that 5m?

   g. How much work is done by that force as the object travels its last 5m?
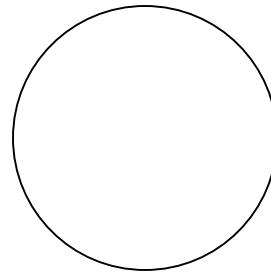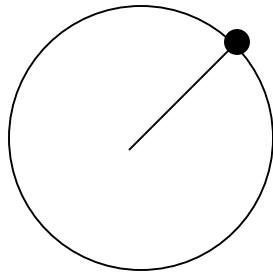
5. A 5.0 kg object is attached to the end of a string. It is swung in a vertical circle whose radius is 2.0m. At the top of the circle (its highest point) its velocity is 3.0 m/s.

    a. On the diagram indicate the velocity and acceleration of the object at its lowest point. (use the circle on the left)

    b. On the diagram indicate the velocity and acceleration of the object at its highest point. (use the circle on the left)

    c. Draw a free body diagram, indicating <u>all forces</u> in approximate scale, for the object at its <u>highest point</u>. Show the direction of its acceleration next to the free body diagram. (use the circle on the right)

    d. Draw a free body diagram, indicating <u>all forces</u> in approximate scale, for the object at its <u>lowest point</u>. Show the direction of its acceleration next to the free body diagram. (use the circle on the right)

    e. Use Newton's Second Law to write an equation for the tension in the string when the object is at its_highest point.

    f. Use conservation of energy to determine the velocity of the object at its lowest point.
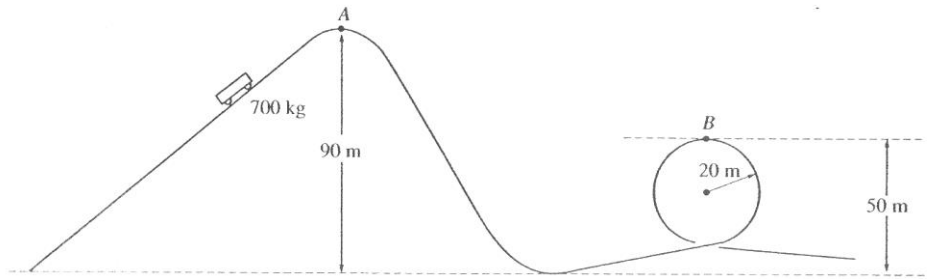
6. A roller coaster ride at an amusement park lifts a car of mass 700 kg to point A at a height of 90 m above the lowest point on the track, as shown above. The car starts from rest at point A, rolls with negligible friction down the incline and follows the track around a loop of radius of 20 m. Point B, the highest point on the loop, is at a height of 50 m above the lowest point on the track.

    a. Indicate on the figure the point P at which the maximum speed of the car is attained.

    b. Use conservation of energy to calculate the maximum speed of the car at this point P.

    c. Use conservation of energy to calculate the speed of the car at point B.

    d. Draw free-body diagram, indicating all forces in approximate scale, for the car at point B. (the roller coaster car follows the inner side of the loop).

    e. Use Newton's Second Law to determine the Normal Force applied on the car at point B.

    f. Now suppose that friction is not negligible. How does it change the speed of the car at point B?

0.50 kg

$v_0 = 1.5$ m/s

A

$r = 0.95$ m

2.0 m

1.9 m
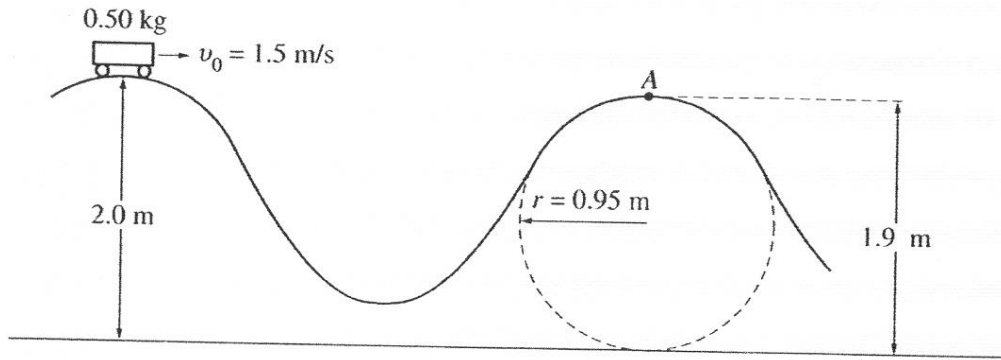
7. A designer is working on a new roller coaster, and she begins by making a scale model. On this model, a car of a total mass 0.5 kg moves with negligible friction along the track show above. The car is given an initial speed $v_0 = 1.5$ m/s at the top of the first hill of height 2.0 m. Point A is located at a height of 1.9 m at the top of the second hill, the upper part of which is a circular arc of radius 0.95 m.

   a. Calculate the initial kinetic energy of the car at the top of the first hill.

   b. Calculate the potential energy of the car at the top of the first hill.

   c. Calculate the potential energy of the car at the top of the second hill.

   d. Use conservation of energy to find the kinetic energy of the car at the top of the second hill.

   e. Calculate the speed of the car at the top of the second hill.

   f. Draw free-body diagram, indicating all forces in approximate scale, for the car at the top of the second hill.

   g. Use Newton's Second Law to find the normal force of track on the car at the top of the second hill.

   h. Now suppose that friction force is not negligible. How does it change the speed of the car at the top of the second hill?
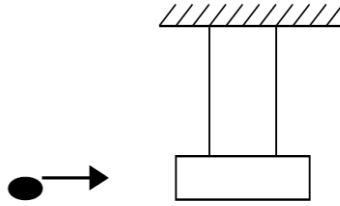
8. The diagram above shows a ballistic pendulum. A 0.020 kg bullet is fired into the suspended 2.5 kg block of wood and remains embedded inside it (a perfectly inelastic collision). After the impact of the bullet, the block swings up to a maximum height h. If the initial speed of the bullet was 40 m/s:

    a. What was the momentum of the bullet before the collision?

    b. What was the kinetic energy of the bullet before the collision?

    c. What was the velocity of the bullet-block system just after the collision?

    d. What was the total kinetic energy of the bullet-block system after the collision?

    e. What is the maximum possible potential energy of the bullet-block system when it reaches its maximum height?

    f. What is the maximum possible height of the bullet-block system?
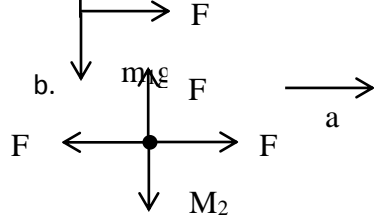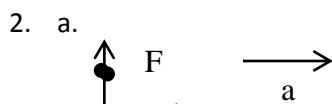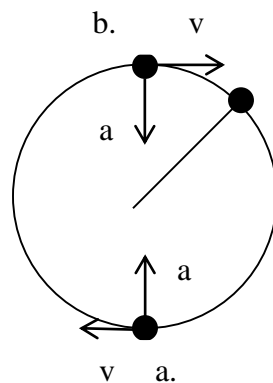
Physics Honors FR Midterm Review Answers

1. a.

   b.
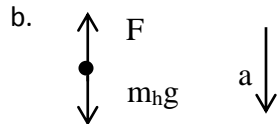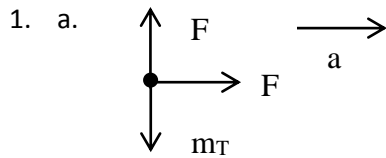
   c. $F_T = m_t a$
   d. $F_T - m_h g = m_h a$
   e. $a = 3.3 \text{ m/s}^2$
   f. $F_T = 130.7 \text{ N}$

   c. $F_T = m_1 a$
   d. $F - F_T = m_2 a$
   e. $a = 6 \text{ m/s}^2$
   f. $F_T = 1.5 \text{ N}$

3. a. $a = .1 \text{ m/s}^2$
   b. $x = 1.8 \text{ m}$
   c. $v = .6 \text{ m/s}$
   d. $v = .6 \text{ m/s}$
   e. $x = 6 \text{ m}$
   f. $a = -0.036 \text{ m/s}^2$
   g. $W = -18 \text{ J}$

2. a.

   b.

4. a. $a = 0.142 \text{ m/s}^2$
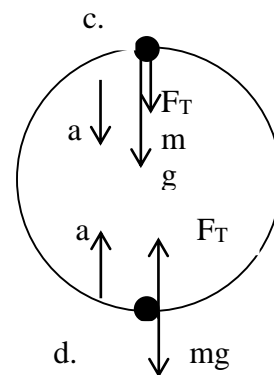   b. $x = 10.2 \text{ m}$
   c. $v = 1.7 \text{ m/s}$
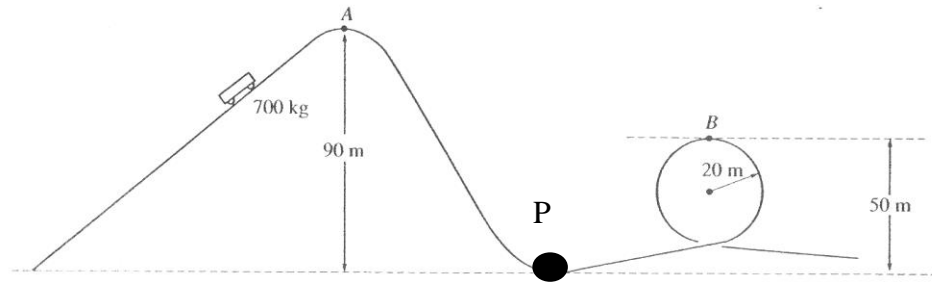   d. $v = 1.7 \text{ m/s}$
   e. $x = 17 \text{ m}$
   f. $a = -0.29 \text{ m/s}^2$
   g. $W = -363 \text{ J}$

5.

e. $F_T + mg = mv^2/r$
f. $v_L = 9.3 \text{ m/s}$

6. a. At the bottom of the slope.

b. v = 42 m/s
c. v = 28 m/s
d.

e. F_N = 20, 580 N
f. Friction would decrease the speed at point B.

7. a. KE = 0.56 J
    b. GPE = 9.8 J
    c. GPE_F = 9.3 J
    d. KE_F = $_1$.06 J
    e. v = 2.06 m/s
    f.

g. F_N = 2.7 N
k. Friction would decrease the speed at point A.

8. a. p = .8 kgm/s
    b. KE_O = 16 J
    c. v' = .32 m/s
    d. KE_F = .13 J
    e. E_F = .13 J
    f. h = 0.005 m