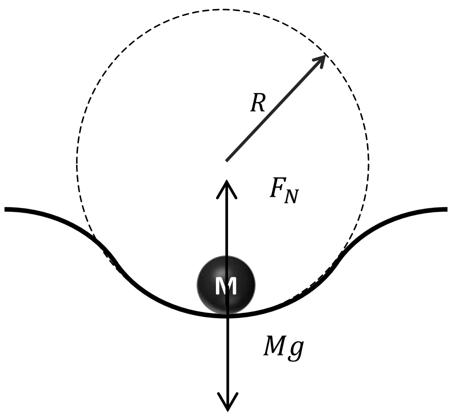
Name: ______________________ DISC: __________ Score: _____ / 20

Instructions:

- Do your own work.
- Answer the questions below in the space provided.
- Make sure you show all your work and any equations that you use.
- Please place a box around your answers.
- Remember to give the correct units with all numerical answers.

Q1	Q2	Q3	Q4
10	10	5	5

1. A bolder rolls down a hill into a valley. Let's approximate the hill-valley combination as part of a circle of radius R as shown in the figure:



M	R
$100\ kg$	$200\ m$

Table 1: Useful Information

Diagram (2pts):

a. On the figure complete the free-body diagram of the bolder at the bottom of the valley.

Explanation (3 pts):

b. As the bolder travels in its path down the hill and back up the other side, it undergoes *uniform circular motion*. For *uniform circular motion* the acceleration of a rotating object is $a = \frac{v^2}{r}$. The bolder moves at a constant *speed*, why is there an acceleration? **(Lecture 8, p. 3)**

While the bolder's speed is constant its direction is changing, so is the velocity. A change in velocity means there is an acceleration.

Acceleration (3 pts):

c. At the bottom of the valley, the normal force on the bolder is measured to be $1010\ N$. What is the acceleration of the bolder? (Use $g = 9.8\frac{m}{s^2}$, and the information in the table.) **(Discussion 6-3)**

$$Ma = F_N - Mg$$

$$(100\ kg)a = 1010N - (100\ kg)\left(9.8\frac{m}{s^2}\right)$$

$$a = \frac{(1010\ N - 980\ N)}{(100\ kg)} = 0.3\ m/s^2$$

Speed (2 pts):

d. What is the speed of the bolder? **(Lecture 8, p. 3)**

$$a = \frac{v^2}{R}$$

$$v = \sqrt{aR} = \sqrt{(0.3\ m/s^2)(200\ m)} = 7.7\ m/s$$

2. You are traveling on a train with a velocity of $\vec{v} = 20\ m/s$ due East. You drop (*not throw*) a baseball out of the window. The window is $2\ m$ from the ground. **(Lecture 7, p. 12)**

   a. You observe the baseball from the window as it travels to the ground. Answer the following questions about the *path you see* as the baseball travels:

v_{East} (2 pt):
Ball position (2 pt):

      i. With what velocity do you see the baseball travel in the eastward direction?
      $v_{East} = 0\ m/s$. The train is not accelerating, so there are no forces acting on the baseball in the direction of motion of the train (or opposite the direction of motion) after it leaves your hand. Therefore, *you* will see the baseball appear to have no velocity in the direction of motion of the train (East).

      ii. When the baseball hits the ground which part of the train is it near (select the correct option from the list):
         1. A window in front of yours
         2. A window behind yours
         3. Your window

         Since $v_{East} = 0\ m/s$, the ball appear to have not moved laterally.

   b. Your friend is on the ground observing the baseball's path. Answer the following questions about the *path your friend sees* the baseball travels:

v_{East} (2 pt):
Ball position (2 pt):
Speed (2 pts):

      i. With what velocity does your friend see the baseball travel in the eastward direction?
      $v_{East} = 20\ m/s$. Since there are no forces acting in the direciton of motion of the train (or opposite the direction of motion), the train and the baseball appear to move at the same rate and in the direction of motion of the train to an observer on the ground.

      ii. When the baseball hits the ground which part of the train is it near (select the correct option from the list):
         1. Your window
         2. A window behind yours
         3. A window in front of yours

         Since $v_{East} \neq 0\ m/s$, the ball appear to have moved laterally at the same rate as the train.

      iii. Find the vertical speed of the baseball when it hits the ground.
      Due to the gravity in the vertical direction, the ball will fall with the acceleration $g = 9.8\ m/s^2$. Since no time information is given, it is better to use $v^2 = v_0^2 + 2\ a\ \Delta y$ to find the speed of the ball just as it hits the ground:
      $v^2 = v_0^2 + 2\ a\ \Delta y = 0 + 2(-9.8\ m/s^2)(-2\ m) = 39.2\ m^2/s^2$. Here Δy is take as negative since the positive-y direction is defined as vertically upward and $\Delta y = y_{final} - y_{initial} = 0\text{ m} - 2\text{ m} = -2\text{m}$. Taking the square root, we get: $v = 6.26\frac{m}{s}$.