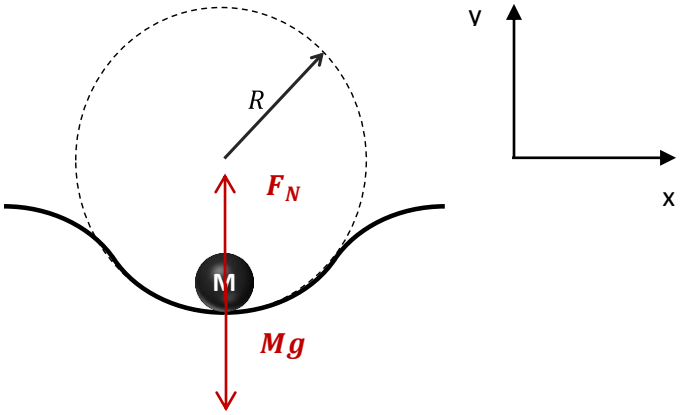
Name: _____ DISC: _____ Score: _____ / 20

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 in to a valley. Let's approximate the hill-valley combination as the arc of a circle of radius R as shown in the figure:



M	R
$500\ kg$	$200\ m$

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 <u>*uniform circular motion*</u>. For *uniform circular motion* the acceleration of a rotating object is $a = v^2/r$. 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, causing the acceleration.

Acceleration (3 pts):

c. At the bottom of the valley, the bolder rolls across a scale. The scale reads $5200\ N$. What is the <u>*magnitude*</u> and <u>*direction*</u> of the acceleration of the bolder? (Use $g = 9.8\ m/s^2$, and the information in the table.) **(Discussion 6-3)**

$$F_N - Mg = Ma$$

$$5200\ N - (500\ kg)\left(9.8\frac{m}{s^2}\right) = (500\ kg)a$$

$$\frac{(5200\ N - 4900\ N)}{(500\ kg)} = a = 0.6\ m/s^2$$

a is directed upward along the radius of the arc, so retains a positive sign.

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

Speed (2 pts):

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

$$\sqrt{aR} = v = \sqrt{(0.6\ m/s^2)(200\ m)} = 10.95\ m/s$$

For this problem my group either understood/remembered how to do the problem (straight from lecture/discussion) :

a) This part went uniformly well.

b) Students either understood why the speed can be constant yet there can be an acceleration or not. I gave *2 points partial credit if the student made a clear reference to circular motion*. Otherwise my students in general either got this part, or did not.

c) For the acceleration:

- **a. -1 pt for missing the direction**
- **b. -0.5 pts for missing the unit**
- **c. -2 pts for not setting up the force equation correctly**

d) This part went generally well—either students knew how to do this, or did not. Propagate any error from part c) to part d) for full credit if done otherwise correctly.

2. You are traveling on a train with a velocity of $\vec{v} = 35\ m/s$ due East. You drop a baseball out of the window. The window is $3\ m$ from the ground. **(Lecture 7, p. 12)**

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

   i. With what velocity does the baseball travel in the eastward direction?

v_{East} (2 pt):

Ball position (2 pt):

Speed (2 pts):

$v_{East} = 35\ m/s$ To an observer on the ground, the train and the baseball appear to move at the same rate and in the direction of motion of the train, if there are no forces acting in the direciton of motion of the train (or opposite the direction of motion).

   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

   iii. Using one or both of these expressions, find the vertical speed of the baseball when it hits the ground: $v^2 = v_0^2 + 2\,a\,\Delta y$ and/or $v = v_0 + at$

Because the vertical direction experiences the force of gravity, we know we have the acceleration $g = 9.8\ m/s^2$ acting on the ball.
We don't know anything about how long it takes the ball to hit the ground, so we must use:

$$v^2 = v_0^2 + 2\,a\,\Delta y$$

to find the speed of the ball just as it hits the ground:

$$v^2 = v_0^2 + 2\,a\,\Delta y = 0 + 2(-9.8\ m/s^2)(-3\ m) = 58.8\ m^2/s^2$$

You'll notice I chose Δy to be negative. I have defined the positive direction to be vertically upward. Taking the square –root we get:

$$v = 7.67\frac{m}{s}.$$

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

   i. With what velocity does the baseball travel in the eastward direction?

v_{East} (2 pt):

Ball position (2 pt):

$v_{East} = 0\ m/s$ Because the train is not accelerating and 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, *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

This problem was one where students either understood relative velocity, or completely didn't understand it (at least in my group):

- **a) Friend's POV**
  - **a. This was an all-or-nothing kind of problem. The most common wrong answer was 0 m/s (-2 pts).**
  - **b. Again, they got this or didn't.**
  - **c. For this problem the most common error was using the 35 m/s as v_{y0} (-1 pt)**
- **b) Your POV**
  - **a. Again, this was pretty much all-or-nothing.**
  - **b. This problem was also all-or-nothing. Some students did get this part right and the previous (same) question wrong and vice-versa.**