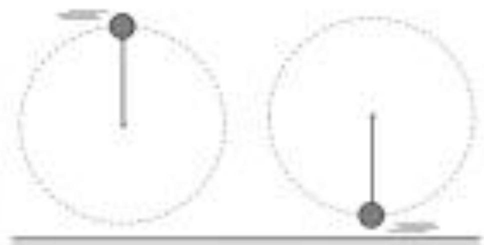
NAME ______________________ DATE ____________

Scenario

A ball whose weight is 2 N is attached to the end of a cord of length 2 m as shown. The ball is whirled in a vertical circle clockwise. The tension in the cord at the top of the circle is 7 N, and the tension at the bottom is 15 N. Two students discuss the net force on the ball at the top of the circle.



Dominique: "~~The net force on the ball at the top position is 7 N since the net force is the same as the tension.~~"

Carlos: "No, the net force on the ball includes ~~the centripetal force~~, tension, and weight. The tension and the weight are acting downward and have to be added. ~~Then you need to figure out the centripetal force $\left(\frac{mv^2}{r}\right)$ and include it in the net force.~~"

Analyze Data

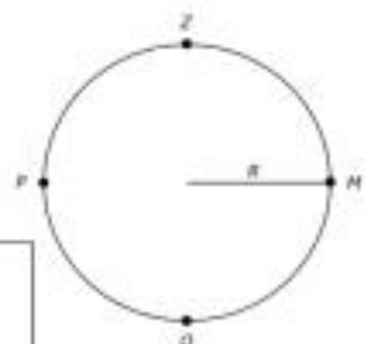
PART A: Cross out the incorrect statements for each student's argument.

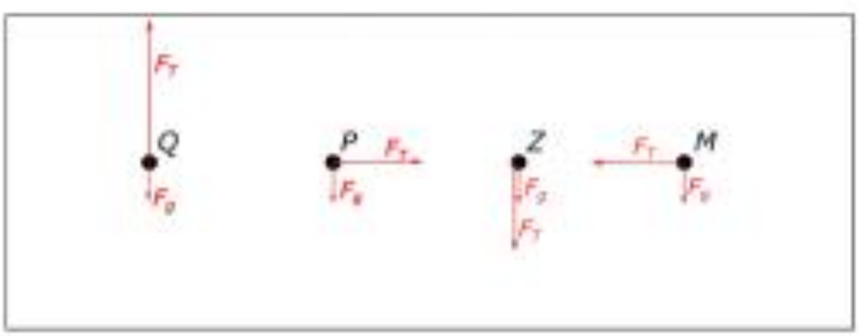
PART B: In a few short sentences, state the net force on the ball at the top of the circle and support your claim with evidence.

Carlos is correct that the net force includes the weight and the tension force and they both point down so that they will be added together. Therefore, the net force on the ball at the top of the circle is 7 N + 2 N = 9 N. These two forces together add to be the centripetal force.

Using Representations

PART C: The diagram at right shows the circular path of the ball from Part A. The dots below represent the ball at the marked locations on the circular path. Draw free-body diagrams showing and labeling the forces (not components) exerted on the ball at each point. Draw the relative lengths of all vectors to reflect the relative magnitudes of all the forces.





Quantitative Analysis

PART D: Derive an expression for the minimum speed the ball can have at point Z without leaving the circular path. For each line in the derivation, explain what was done mathematically. The first line is completed for you as an example.

$\sum F = ma_c$	The sum of the force is equal to *ma*, and since the ball is in circular motion, *a* is the centripetal acceleration.
$\Sigma F_c = \frac{mv^2}{r}$	Centripetal acceleration can be represented by the velocity squared over radius.
$F_t - F_g = \frac{mv^2}{r}$	The two forces on the ball at the top of the circle (Point Z) are the force of tension and the gravitational force, both of which are exerted downward.
$mg = \frac{mv^2}{r}$	At the minimum speed, the tension goes to zero.
$v = \sqrt{gr}$	The masses cancel in the equation and the equation is rearranged to solve for velocity.

PART E: Suppose the ball breaks at point P. Describe the motion of the ball after the string breaks. (When describing the motion of an object, you need to discuss what is happening to the position, velocity, and the acceleration of the object.) Tell the story of the motion of the ball from the time the string breaks until the ball reaches the ground.

Position:

The ball travels straight up to a maximum height and then comes straight back down.

Velocity:

The speed of the ball decreases until it reaches the maximum height at which point the ball turns around and speeds back up until it hits the ground.

Acceleration:

The acceleration of the ball is always 9.8 m/s^2 down after the string is cut.