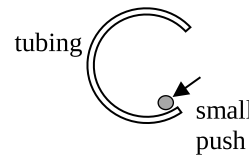
Name______________________________ period_____
Partner_________________________ ***Going in Circles*** lab # _____

In this lab, you will study *uniform circular motion*. This occurs when an object moves in a circle at constant speed. Is this motion accelerated? If so, in what direction?

I. Going Tubing.

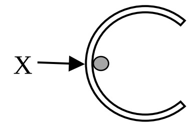
TOP VIEW:



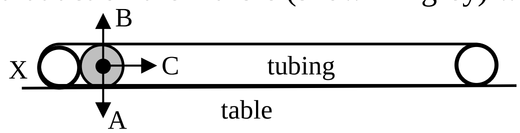
A. Get a piece of tubing and a marble. Lay the tubing on the table as shown:
1. Gently roll the marble CW (clockwise) around the tubing.
2. On the diagram, draw the path of the marble *after it leaves the tubing*.
3. The new diagram at right shows the tubing with a random point X selected.

Look at the forces that act on the marble (shown in grey) when it reached X:

TOP VIEW:



SIDE VIEW:



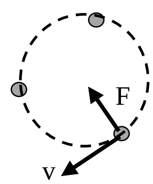
4. Force A is gravity. Force B is a normal force from the table pushing up on the marble. Force C is a normal force that the surface of the tube exerts ***inward*** on the marble. At point X, force C points to the right.

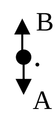
Which 2 of these forces shown in the diagram are balanced?

Which one of the 3 forces is not balanced?

5. As the marble moves along the tube, this unbalanced net force F_{net} always points inward towards the center of the circle. It is a ***centripetal*** force. Centripetal means "toward center."

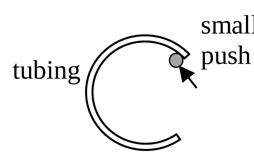
The diagram at right shows a dashed-line path of the marble at 3 positions as it moves around the tube. The velocity ***v*** is always *tangent* to the path. The net force *F* is **centripetal** (towards center). Draw and label *v* and *F* for the other 2 marble positions.



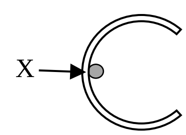
6. When the marble reaches the tube end, force C is no longer there. You only have: . What is F_{net} then?

7. What is the shape of the path of the marble when this occurs?

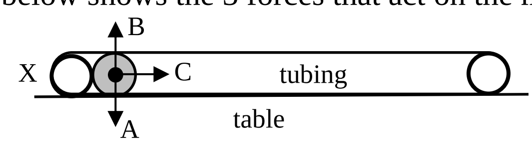
8. Push the marble CCW (counterclockwise) around the tube. On the diagram, draw and label the path of the marble *after it leaves the tubing.*



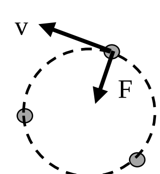
9. Again at right is a diagram of the marble when it reached the same point X.
The SIDE VIEW below shows the 3 forces that act on the marble (in grey) at point X.



SIDE VIEW:



10. Is this side-view diagram any different from the diagram in Step 3?
What is the direction of the net force acting on the marble in this case?
Is this direction different from when the marble was moving CW?



11. On the diagram at right, *v* and *F* are shown at 1 marble position.
Draw and label *v* and *F* at the other 2 positions.

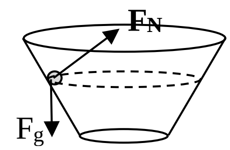
12. Compare diagrams in Steps 5 and 11 above.
A) How do the directions of *v* compare?
B) How do the directions of *F* compare?

13. The *speed* of the marble is almost constant. Why do we say that the velocity changing?

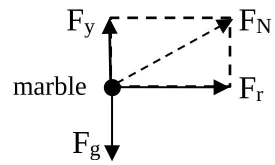
14. The acceleration of the marble is in the same direction as the net force. What direction is that?

II. Climbing the Walls.

1. Get a plastic cup and a marble.



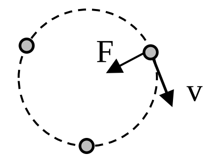
2. Put the marble in the cup and spin it CW (as seen from above) so that it spins around the walls of the cup in a circle at constant height. Then spin it CCW. The 2 forces acting on the marble are shown: F_g (weight) and F_N (normal).



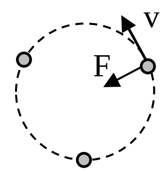
3. Look at the diagram at right. It no longer shows the cup. And the normal force F_N has been resolved into 2 components F_y and F_r. F_y is upwards. $F_\mathbf{r}$ is directed along a **r**adius towards the circle's center.

A) Which one of these two components, F_y or $F_\mathbf{r}$, balances the weight?

B) Which one of these is an unbalanced **centripetal** F_{net}?



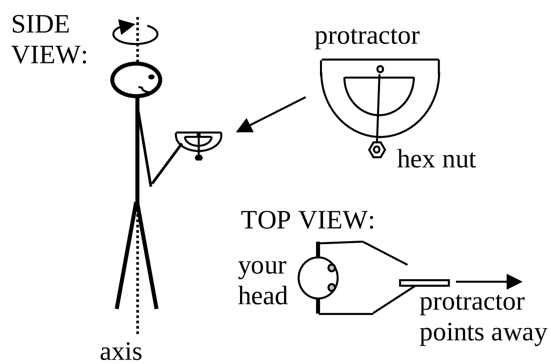
4. The diagram at right shows a top view of the marble going CW in 3 places.
The *v* and *F* are shown at 1 hex nut position.
Draw and label *v* and *F* at the other 2 positions.



5. This new diagram shows the marble going CCW.
The *v* and *F* are shown at 1 hex nut position.
Draw and label *v* and *F* at the other 2 positions.

6. A) Which arrows change direction when you change CW to CCW?
B) The acceleration is in the same direction as the net force. What direction is that?

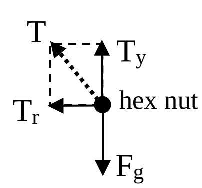
III. Spin Doctor.



1. Get a protractor. Use a thread to attach a hex nut as shown:
2. Look at both views of how to hold the protractor in front of you. Center it and point it directly away from you. Keep it that way.
3. You are going to spin slowly around the dotted axis shown in the diagram. Try to spin at a constant rate.

A) Spin clockwise as seen from above. What happens to the hex nut?

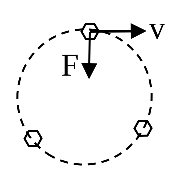
B) Spin counterclockwise. What happens to the hex nut?



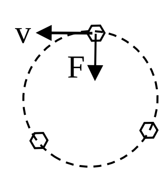
4. Here is a side-view diagram of the forces that act on the hex nut as you spin. It is shown at the instant you are pointing in the direction shown by the stick figure above. The tension T is the pull of the thread. T is resolved into components: T_y and T_r. *Ignore the dotted T arrow*. It has been replaced by T_y and T_r. T_y is the *up* component of T. T_r is the component of T that points ***inward*** towards you along a radius.

Which two forces shown in this diagram are balanced (ignore T)?

Which force is unbalanced and so provides the **centripetal** F_{net}?



5. This diagram shows the hex nut as seen from above as you spin CW.
The *v* and *F* are shown at 1 hex nut position.
Draw and label *v* and *F* at the other 2 positions.



6. This diagram shows the hex nut as seen from above as you spin CCW.
The *v* and *F* are shown at 1 hex nut position.
Draw and label *v* and *F* at the other 2 positions.

7. *Circle the answers:*

When you change from CW to CCW, the (velocity/force) arrows change directions.

The (velocity/force) arrows are tangential. The (velocity/force) arrows are centripetal.

Because acceleration has the same direction as net force, it is also (tangential/centripetal).