Name: ______________________
Group #: _____________________
Date: _______________________

(Hands-on) Introduction to Rotation

Rotational motion is a common sight in our lives. It occurs in everything that twists and spins: you can see it in car wheels, washing machines, CDs, merry-go-rounds, blenders, spinning tops, hinges, screwdrivers, pulleys, toilet paper, figures staking, a see-saw, the motion of the Earth, and the list goes on. However, if you have not given it much thought, rotational motion can be less intuitive. Nonetheless, through careful observation of these motions, we can build some key conceptual understanding of rotational motion. In this lab, you will rotate (no pun intended) through a number of different stations, each with a hands-on mini-experiment to demonstrate particular aspects of rotational motion. At each station, perform the experiment and answer the discussion questions given below.

(With the higher than usual movement within the classroom, please keep your masks on and sanitize your hands often.)

Station 0 – Life (complete this section during any downtime)

Equipment: life experience

1. Come up with at least 5 examples of rotational motion that you have observed in your life that is not one of the examples given above.

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Station 1 – Tipping a Block
Equipment: exam divider block

1. Put the block with the largest face down on the table and overhang the block on the table edge. How much overhang is needed before the block starts to tip over and fall?

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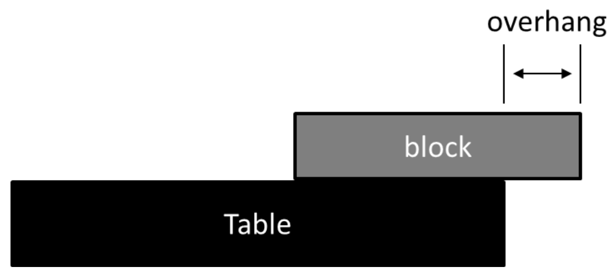

2. Draw a free-body diagram of the block as it just begins to tip over. At what point is the normal force from the table acting on the block? At what point is the gravitation force acting on the block? Explain briefly why the block starts to rotate.

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3. Put the block on the table, flat on one of the faces. Push on the middle of one of the other faces to try to tip it over. In which orientation is the block easiest to tip? In which orientation is the block hardest to tip, if at all? Sketch the block and the direction of the force for the two cases.

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4. For the case where the block is easiest to tip, push it by just a little so that it would return to standing up straight. Then, push over more until the block would continue tipping over by itself. What is special about the angle past which the block will continue to tip over by itself? Sketch the free body diagram of the block at this angle.

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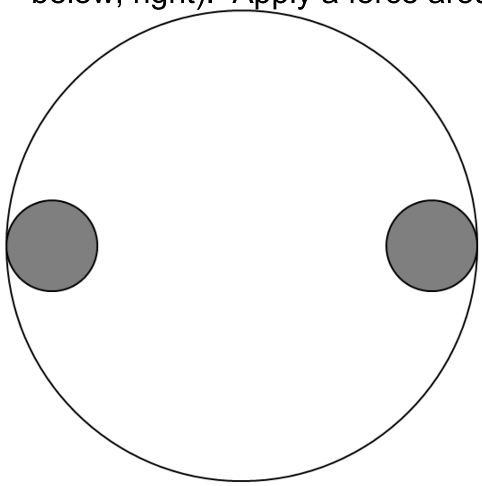
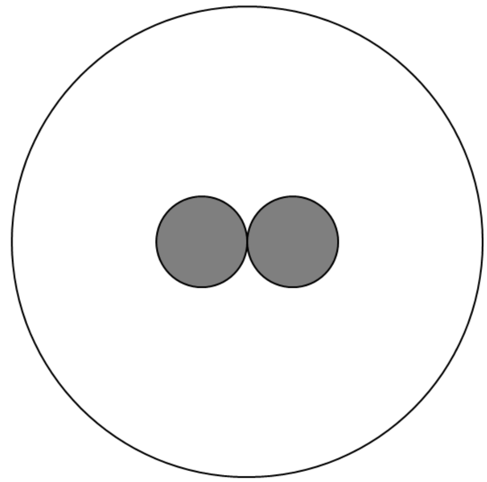
Station 2 – Mass Distribution on a Lazy Susan

Equipment: 2 wooden lazy susan rotating plate, 4 1-kg masses

1. With the lazy susan not moving, place the two 1kg masses near the edges, approximately opposite so the lazy susan is roughly balanced (see diagram below, left). Apply a force around the edge to spin the lazy susan.
2. Stop the lazy susan. Move the two 1kg masses to near the center (see diagram below, right). Apply a force around the edge to spin it.



Masses near the edges



Masses close to the center

3. Describe if the two cases feel different to your hand. If you were to use words to describe both cases, what words would you use? Note that both cases have the same amount of mass on the lazy susan.

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4. Now, instead of speeding up, try slowing the lazy susan down. Which case is easier to slow down the spinning?

/1

5. Based on your observations, if you have 2 more 1kg masses, how would you place all 4 masses to make it the most difficult to set lazy susan into rotational motion? Please keep the lazy susan balanced to avoid frictional effects.

/2

Station 3 – Center of mass

Equipment: 5 styrofoam pieces of different shapes, a pole

1. Spin each of the styrofoam pieces as they lie flat on the desk. It should look like the styrofoam piece is spinning around a particular point. Draw each shape and mark the point about which it spins.

/5

2. Does this point change if you move the styrofoam piece sideway while spinning it?
/1 YES NO

3. Does this point change if you throw the styrofoam piece in the air while spinning it?
/1 YES NO

4. What is special about this point? (hint: try supporting the styrofoam at only that point with the pole.)
/2

Station 4 – Twisting a wheel

Equipment: A bike wheel, fidget spinners

1. Hold a fidget spinner in your hand and make it spin horizontally. Once the spinner is spinning quickly, try to flip the spinner upside-down to change the direction of the rotation. What do you feel?

/3

2. Hold two fidget spinners by stacking them up in one hand. Then, spin the two spinners in opposite directions with roughly the same speed. Again, flip the spinner upside-down. What do you feel?

/1

3. Repeat step 1 with the bike wheel. Try to flip the bike wheel upside-down with it spinning and without it spinning. Compare and comment.

/2

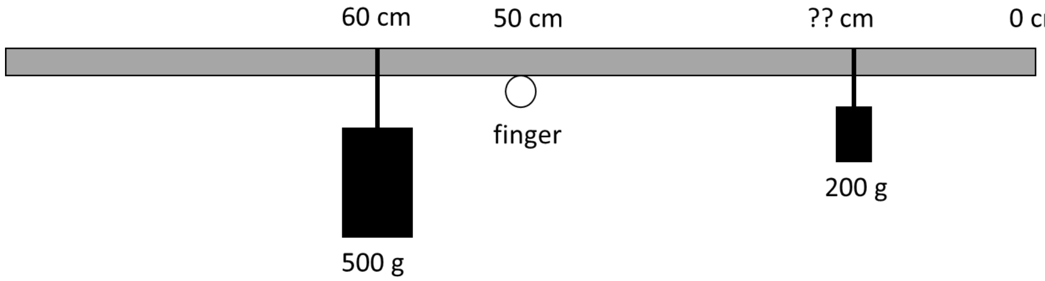
4. Based on what you observed, it seems like once an object is rotating, it tends to continue rotating in the same direction. You notice that the feeling increases with a larger wheel spinning at a faster rate. What could we call this, as a physical quantity? Is it a vector (does direction matter?)?

/2

Station 5 – Meter stick lever

Equipment: A wooden meter stick, loops made with string, masses, a mass scale

1. Put your finger under the 50cm mark on the meter stick - the meter stick should be balanced. Hang a 500g mass at the 60cm mark: where do you have to hang the 200g mass to have the meter stick balanced again?



2. How far is each of the masses from your finger? Do you notice any relationship between the masses and the distance they are from your finger?

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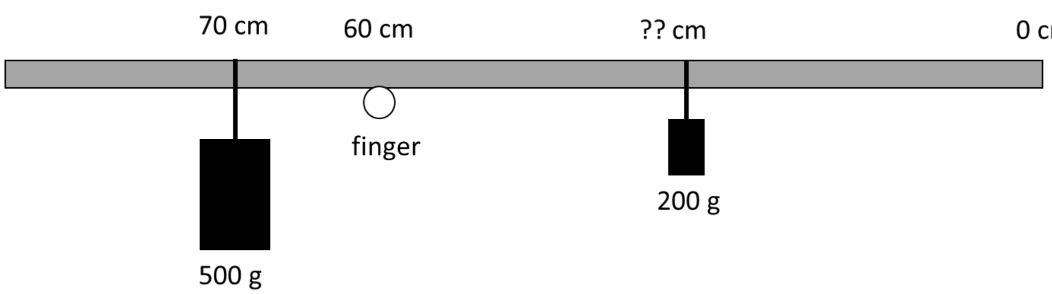
3. This time, put your finger under the 60cm mark on the meter stick. Hang the 500g mass at the 70cm mark" where do you have to hang the 200g mass to have the meter stick balanced?



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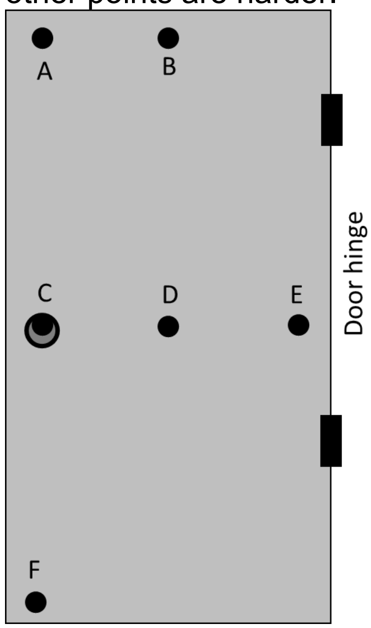
4. How can you use the above information to calculate the mass of the meter stick? What do you calculate the mass of the meter stick to be? Verify the mass by measuring the mass using the mass scale.

/4

Station 6 – Door on a hinge

Equipment: A wooden meter stick with padding on the end, a door, a step stool

1. Since the door is spring-loaded to close, use the meter stick to push on the door at each of the points as drawn below to try to hold it still. Push straight along the meter stick. Use the step stool if you need help reaching up high.
2. At which point(s) is the easiest hold the door? Provide an explanation why each of the other points are harder.



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3. At the easiest point, try to push with different angles by orienting the meter stick. Which direction do you have to push to get the door to stop most easily?

/3

Station 7 – Angular and linear velocity

Equipment: A wooden lazy susan rotating plate with two points marked on it, a stopwatch, ruler

1. Make the wheel spin at a steady speed. Do all the points complete the same number of rotations in a set time period (angular velocity)?

/1

2. When the disk spins steadily, do all the points move in the same direction?

/1

3. When the disk spins steadily, do all the points move at the same speed? Same velocity?

/1

4. Spin the disk and time 5 cycles to estimate the speed of point A and of point B. What are the drawbacks of this method of estimating the speed?

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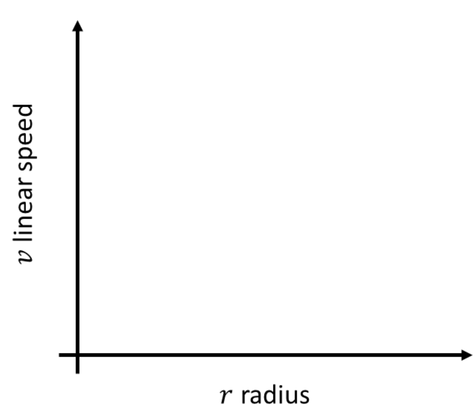
5. Imagine if you were to graph between the linear speed and the radius of different points on the rotating plate. Sketch what you think the graph will look like below:



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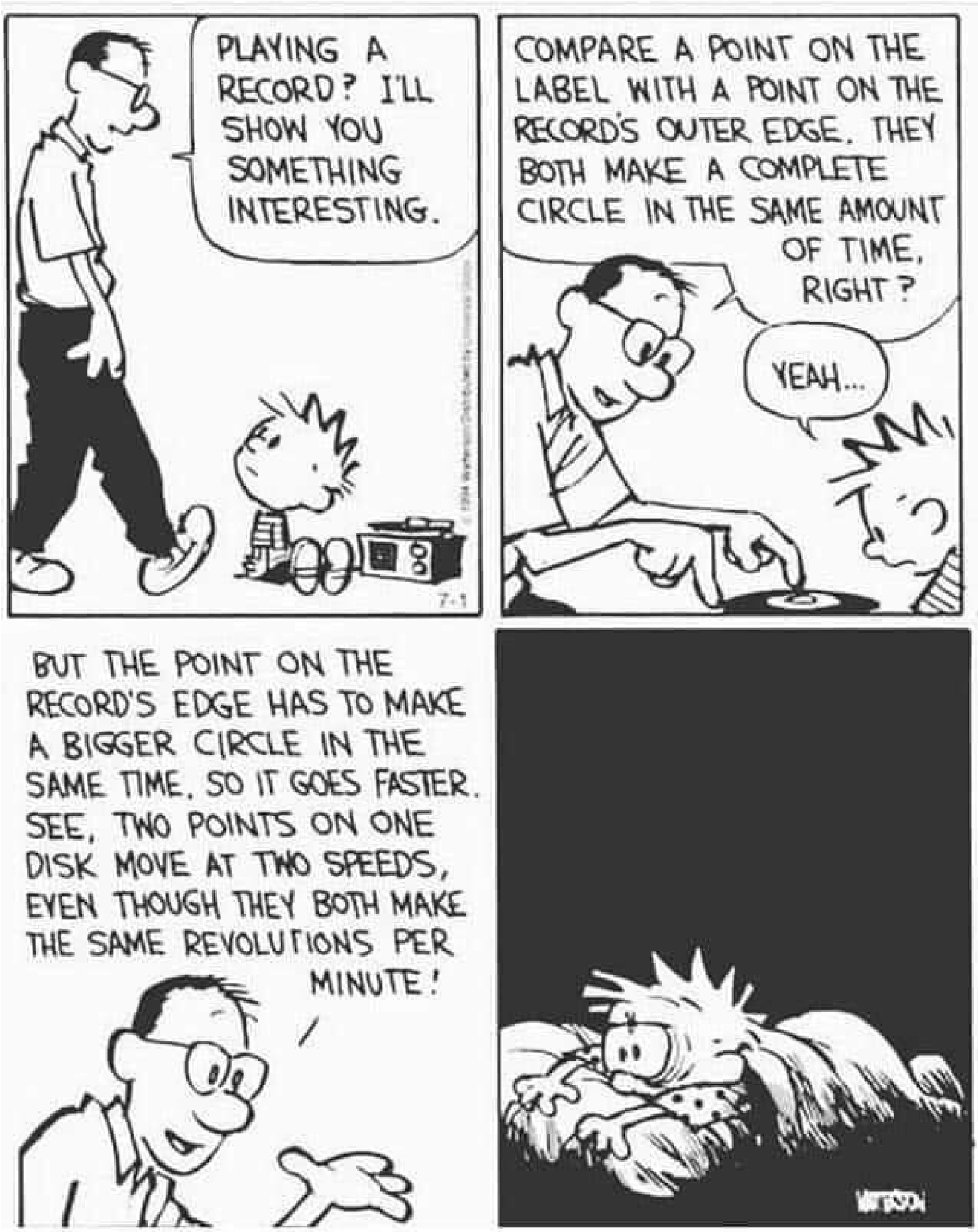
PLAYING A RECORD? I'LL SHOW YOU SOMETHING INTERESTING.
COMPARE A POINT ON THE LABEL WITH A POINT ON THE RECORD'S OUTER EDGE. THEY BOTH MAKE A COMPLETE CIRCLE IN THE SAME AMOUNT OF TIME, RIGHT?
YEAH...
BUT THE POINT ON THE RECORD'S EDGE HAS TO MAKE A BIGGER CIRCLE IN THE SAME TIME. SO IT GOES FASTER. SEE, TWO POINTS ON ONE DISK MOVE AT TWO SPEEDS, EVEN THOUGH THEY BOTH MAKE THE SAME REVOLUTIONS PER MINUTE!
WATTERSON