**Video Analysis of 2D Motion**

Our goal in this lab is to get a better understanding of the relationships between the position, displacement, velocity, and acceleration vectors in two dimensional motion. You will use prerecorded videos of a thrown object, an object moving in a circle at constant speed, and an object moving in a circle while slowing down, and analyze the motion graphically.

Prelab

**Doing the Tracking**

We’ll be using two of the videos provided by [Vernier Video Analysis](https://videoanalysis.app/?key=4020e622e6bf436db560eca482f462fb-86ac98513bde5c09cf97fbdc4193ace1-0aa757b14dd396b9d5335332eac63844-d665c75f31e7d685fb4718404e004ev2) to analyze motion in today’s lab. Review the [Intro to Vernier Video Analysis](https://docs.google.com/document/d/1yCQoJgxqxyi478nd-_buhzqEVaDlkOo6D2WPECXsgNw/edit?usp=sharing) lab if you don’t remember how this works.

**Video 1: Basketball Shot**

Open the “Basketball shot” video and complete tracking of the basketball. Remember a few things as you do this:

1. Omit any points where the man’s hand is touching the basketball, and any points after the basketball has landed.
2. Choose one point on the basketball (e.g. the top) to follow.
3. Advance by a single frame for this video. The default fps (about 30) is correct.
4. Note there is a meter stick on the ground that can be used to establish a scale.
5. It will be most convenient to place the origin at the lower-left of the screen.
6. Save your work in a place you will be able to find it again.

**Prelab GradeScope Q1. Take a screen capture of your tracking points (the picture, not the graph) (or use File/Export), and place it in your GradeScope document.**

**Video 2: Turntable@16RPM, Constant speed.**

Restart [Vernier Video Analysis](https://videoanalysis.app/?key=4020e622e6bf436db560eca482f462fb-86ac98513bde5c09cf97fbdc4193ace1-0aa757b14dd396b9d5335332eac63844-d665c75f31e7d685fb4718404e004ev2), open the “Turntable@16RPM” video and complete tracking of the red dot in the video for a SINGLE CIRCLE ONLY, STARTING AT FRAME 80 and advancing 5 frames per point. You do NOT want to place any points after the circle has been completed.

Remember a few things as you do this:

1. Choose one point on the dot (e.g. the top) to follow.
2. The default fps (about 30) is correct.
3. Note there is a meter stick on the bottom to establish a scale.
4. Place the origin at the center of the turntable.
5. Save your work in a place you will be able to find it again.

**Prelab GradeScope Q2. Take a screen capture of your tracking points (the picture, not the graph) (or use File/Export), and place it in your GradeScope document.**

**Video 3: Bike Wheel Slowing Down**

Restart [Vernier Video Analysis](https://videoanalysis.app/?key=4020e622e6bf436db560eca482f462fb-86ac98513bde5c09cf97fbdc4193ace1-0aa757b14dd396b9d5335332eac63844-d665c75f31e7d685fb4718404e004ev2) and open [this movie](https://smccd.instructure.com/files/4898686/download?download_frd=1) of a bike wheel slowing down as it spins (also available in Files/Lab Materials). Complete tracking for the white piece of paper starting at frame 112 and running to frame 202, advancing 5 frames per point.

Remember a few things as you do this:

1. Choose one point on the paper to follow.
2. The tire has a diameter of 0.70 m.
3. Place the origin at the center of the tire.
4. Save your work in a place you will be able to find it again.

**Prelab GradeScope Q3.** Take a screen capture of your tracking points (the picture, not the graph) (or use File/Export), and place it in your GradeScope document.

Live Lab

Do this in the live (synchronous) session while working with your classmates, unless otherwise instructor by your teacher.

**Video 1: Basketball Shot**

**Graphical Analysis**

We'll now use your video analysis, along with Google Slides, to do some graphical vector analysis of the motion. *Note: for students that cannot use Google slides, Powerpoint works as well. See you instructor for help.* Start by identifying three evenly spaced points in the projectile's motion as it is moving upwards. If you only have a few points on the way up, choose three consecutive points. If you have many points that are close together you may wish to choose points spaced further apart (for example the 2nd, 4th, and 6th points in the motion). Try and avoid using points that are outliers.

Follow these instructions on how to do vector analysis on these three points: [Instructions on vector analysis.](https://youtu.be/9t8Ak5v-ufk)

Be very careful as you place the vectors: accuracy is vital here!

**GradeScope Q1. Oops- error: skip this problem!**

**GradeScope Q2. You first drew a vector that connected the first and second points. What physical quantity (displacement, average velocity, instantaneous velocity, average or instantaneous acceleration, etc.) does this vector literally represent? What other physical quantity is this vector proportional to?**

**GradeScope Q3. What physical quantity (displacement, average velocity, instantaneous velocity, average or instantaneous acceleration, etc.)  is the red vector proportional to?**

Repeat the steps above with a second set of three points spanning the top of the projectile's motion (so that one point is before the top, a second is near the top, and a third is on its way down). Skip the same number of points between the points you chose as before (for example if you used points 2, 4, and 6 in your first analysis, you might use use points 10, 12, and 14, but not 11, 12, and 13 in your second analysis).

Finally, repeat the analysis again with a third set of points that occur during the downward motion.

**GradeScope Q4. Zoom out so that the results of the three vector analyses are visible and take a screen capture and upload it here.**

**GradeScope Q5. Compare your red vectors. What does this tell you about the acceleration of the ball as it flies through the air?**

**Analysis from Graphs**

Load your basketball shot tracking and first examine the x-motion by displaying graphs of x-position and x-velocity simultaneously. Be sure to pay attention to the scales on your graphs, as autoscaling can sometimes give misleading graphs.

For any quantities that appear linear (but not flat), do a linear fit. As always, be sure to exclude the first three and last three points from your analyses.

**GradeScope Q6. Use the export function or a screen capture to place images of your x position and x-velocity graphs in your GradeScope document. Be sure any linear fits are visible.**

**GradeScope Q7. Compare your results to those of the other students in your group. Are there any substantial differences? If so, explain what might have caused the differences.**

**GradeScope Q8. What quantity(s), if any (position, velocity, and/or acceleration) could be described as constant in the x-motion of the basketball? Are there any quantities that are close to constant but not quite constant? Explain your answer.**

Now examine the y-motion by displaying graphs of y-position and y-velocity simultaneously. Be sure to pay attention to the scales on your graphs, as autoscaling can sometimes give misleading graphs.

For any quantities that appear linear (but not flat), do a linear fit. As always, be sure to exclude the first three and last three points from your analyses.

**GradeScope Q9. Use the export function or a screen capture to place images of your y position and y-velocity graphs in your GradeScope document. Be sure any linear fits are visible.**

**GradeScope Q10. Compare your results to those of the other students in your group. Are there any substantial differences? If so, explain what might have caused the differences.**

**GradeScope Q11. What quantity(s), if any (position, velocity, and/or acceleration) could be described as constant in the y-motion of the basketball? Are there any quantities that are close to constant but not quite constant? Explain your answer.**

**GradeScope Q12. Are your results from looking at the graphs consistent with the results from the graphical vector analysis? Explain.**

**Video 2: Turntable@16RPM, Constant speed**

**Graphical Analysis**

Conduct video analysis of your turntable video. Choose three sets of three points, which should fall in different portions of the motion.

**GradeScope Q13. Take a screen capture of your results (showing all three sets of three points) and place it in your GradeScope document**

**GradeScope Q14. What patterns do you notice about the resulting acceleration vectors?**

**GradeScope Q15. Compare your results to those of the other students in your group. Are there any substantial differences? If so, explain what might have caused the differences.**

**Video 3: Bike Wheel Slowing Down**

**Graphical Analysis**

Conduct video analysis of your bike wheel video. Choose three sets of three points, which should fall in different portions of the motion.

**GradeScope Q16. Take a screen capture of your results (showing all three sets of three points) and place it in your GradeScope document**

**GradeScope Q17. What patterns do you notice about the resulting acceleration vectors?**

**GradeScope Q18. Compare your results to those of the other students in your group. Are there any substantial differences? If so, explain what might have caused the differences.**

**GradeScope Q19. Compare and contrast your acceleration vectors from the turntable and the bike wheel. What accounts for any differences? Use the phrase “tangential acceleration” in your answer.**