

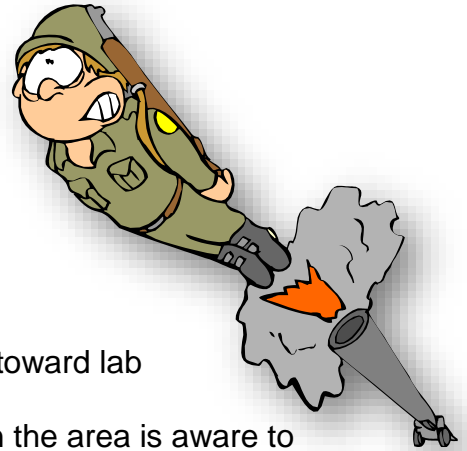
The Amazing Human Cannonball!!!

OBJECTIVES

- ★ Analyze the effectiveness of predicting the range of a horizontally-launched projectile by using physics principles.¹
- ★ Analyze how launch angle relates to range

SAFETY

- ★ Be sure not to release the projectile toward a person or toward lab equipment.
- ★ When launching your projectile, be sure that everyone in the area is aware to stand at a safe location. Anyone near the landing zone must wear goggles.
- ★ Be sure someone stops the projectile from rolling away and becoming lost after landing.



Your group will be at one of six stations. Do only the procedure that matches your station. You may need to scroll to a different page.

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¹ In other words, how accurately did your calculations predict where the ball would land? Does this mean the physics principles were correct?

PASCO SYSTEM with WOOD BLOCK LAUNCHER

MATERIALS

- ★ Wood block projectile launcher with ball bearing (a.k.a. your human cannonball) and table clamp
- ★ PASCO setup: Photogate with extension arm, ring stand, clamp, and Capstone software

PROCEDURE

1. Mount the photogate to the ring stand by attaching the photogate to the extension arm. Then connect the extension arm to the ring stand clamp.
2. Mount the projectile launcher to the table with the table clamp. Then adjust the launcher so that it is perfectly horizontal. Be sure to loosen/tighten the adjustment nut carefully and use the attached protractor to guide you. Do not overtighten the nut or loosen the attachment.
3. Align the photogate so that when the ball bearing leaves the projectile it will pass through the laser beam on the photogate.
4. Start Capstone software on your computer.
5. Plug in the photogate via the USB connection cable. Capstone will automatically connect to the photogate.
6. On the right side of your screen under “Displays” locate the “Table” option. Click and drag “Table” onto the center of your screen. A two-column data table will appear. We will only use the first column.
7. In the first column, click on “Select Measurement” and select “Velocity between Gates (m/s).”
8. You are about to start launching your ball. Before you do so, identify one partner to catch the ball and a second partner to watch the ball in case the catcher misses. **You may not lose your ball.**
9. Start recording data and do not stop recording until you are done with this step. Launch the ball past the eye of the photogate to check alignment. You may need to adjust the location of the photogate. Once you have the alignment perfected, you should stop the recording.
10. Now you are ready to measure the launch velocity for the ball bearing. Start recording again and don't stop recording until you are done with this step. Launch the ball through the photogate five times and examine the data as it appears in the second column. The values should all be similar to each other. If they are not, keep trying until you have five similar trials. Pro-tip: Right now you are only measuring launch velocity. At this point you have no need to mark or measure where the ball lands. However, remember that **you may not lose your ball.**
11. Find the median velocity from the five launches. Using this as the initial horizontal launch velocity, predict mathematically where the projectile will land (horizontal displacement.) Pro-tip: There is one more measurement you will need to make before you can complete your calculations. **You will need to show these measurements and calculations in your lab report, so be sure to keep track of your scratch work.**

12. Hold your meterstick perfectly vertically up against the edge of your table so that you can find the spot on the floor that's directly below the launcher's edge. Put a light pencil mark on the floor there. In front of the mark measure the distance you found to be the "horizontal distance" and place the center of your landing pad at this location. Be sure when you do this to place the landing pad so that it is directly lined up laterally (i.e., left-to-right) with the path the ball bearing takes from the launch ramp.
13. Launch your human cannonball (i.e., ball bearing)! Watch carefully where it actually lands and mark the spot. Measure this horizontal displacement from the table and record the value. **BE SURE TO ASSIGN SOMEONE TO KEEP TRACK OF THE BALL.**
14. Calculate the percent error between your predicted horizontal displacement and the actual horizontal displacement. You will show these calculations in your lab report, so keep track of them.
15. Now you are done with calculations and computerized data collection. **HOWEVER**, you are not done with the lab. 😊 It's time to look at objective two!
16. Remove the photogate system and put it away carefully. Wrap the cords loosely (not tightly) while putting it away. Place the wood block launcher on the floor with its back to a wall or cabinet. Ensure that no one kicks or steps on the wood block launcher.
17. Assign two partners to watch where the cannonball lands. One partner will then mark where the projectile lands while the other will chase the projectile to retrieve it. **You may not lose the projectile.**
18. Raise the angle of the projectile launcher by 10° increments from 20° through 70° and launch the projectile from the floor to the floor. Record the horizontal displacement for each of these in a data table. Create a scatter plot in Excel of the horizontal displacement versus launch angle data.

DATA TABLES AND GRAPHS

- ★ Horizontal launch:
 - ★ Median velocity of the ball through the photogate
 - ★ Vertical displacement
 - ★ Horizontal launch: Actual landing position (horizontal displacement from table)
- ★ Angled launches:
 - ★ The horizontal displacement data for each angled launch in a nifty data table
 - ★ Angled launches: the scatter plot

CALCULATIONS

In your lab report, please be sure to include:

- ★ All calculations you used to find the predicted landing position for the horizontal launch. **CLEARLY IDENTIFY THE EXPECTED HORIZONTAL LAUNCH VALUE THAT YOU CALCULATED.**
- ★ The percent difference between your predicted landing position and the actual landing position from step ten.

PASCO SYSTEM with PASCO LAUNCHER

MATERIALS

- ★ PASCO projectile launcher with ball (a.k.a. your human cannonball) and table clamp
- ★ PASCO setup: Photogate and Capstone software

PROCEDURE

1. Mount the photogate to the projectile launcher.
2. Mount the projectile launcher to the table with the table clamp. Then adjust the launcher so that it is perfectly horizontal. Be sure to loosen/tighten the adjustment nut carefully and use the attached protractor to guide you. Do not overtighten the nut or loosen the attachment.
3. Start Capstone software on your computer.
4. Plug in the photogate via the USB connection cable. Capstone will automatically connect to the photogate.
5. On the right side of your screen under “Displays” locate the “Table” option. Click and drag “Table” onto the center of your screen. A two-column data table will appear. We will only use the first column.
6. In the first column, click on “Select Measurement” and select “Velocity between Gates (m/s).”
7. You are about to start launching your ball. Before you do so, identify one partner to catch the ball and a second partner to watch the ball in case the catcher misses.
You may not lose your ball.
8. Now you are ready to measure the launch velocity for the ball bearing. Start recording again and don't stop recording until you are done with this step. Launch the ball through the photogate five times and examine the data as it appears in the second column. The values should all be similar to each other. If they are not, keep trying until you have five similar trials. Pro-tip: Right now you are only measuring launch velocity. At this point you have no need to mark or measure where the ball lands. However, remember that **you may not lose your ball.**
9. Find the median velocity from the five launches. Using this as the initial horizontal launch velocity, predict mathematically where the projectile will land (horizontal displacement.) Pro-tip: There is one more measurement you will need to make before you can complete your calculations. **You will need to show these measurements and calculations in your lab report, so be sure to keep track of your scratch work.**
10. Hold your meterstick perfectly vertically up against the edge of your table so that you can find the spot on the floor that's directly below the launcher's edge. Put a light pencil mark on the floor there. In front of the mark measure the distance you found to be the “horizontal distance” and place the center of your landing pad at this location. Be sure when you do this to place the landing pad so that it is directly lined up laterally (i.e., left-to-right) with the path the ball bearing takes from the launch ramp.
11. Launch your human cannonball (i.e., ball bearing)! Watch carefully where it actually lands and mark the spot. Measure this horizontal displacement from the table and

record the value. BE SURE TO ASSIGN SOMEONE TO KEEP TRACK OF THE BALL.

12. Calculate the percent error between your predicted horizontal displacement and the actual horizontal displacement. You will show these calculations in your lab report, so keep track of them.
13. Now you are done with calculations and computerized data collection. HOWEVER, you are not done with the lab. 😊 It's time to look at objective two!
14. Remove the photogate system and put it away carefully. Wrap the cords loosely (not tightly) while putting it away. Place the PASCO launcher on the floor with its back to a wall or cabinet. Ensure that no one kicks or steps on the launcher.
15. Assign two partners to watch where the cannonball lands. One partner will then mark where the projectile lands while the other will chase the projectile to retrieve it. **You may not lose the projectile.**
16. Raise the angle of the projectile launcher by 10° increments from 20° through 70° and launch the projectile. Record the horizontal displacement for each of these in a data table. Create a scatter plot in Excel of the horizontal displacement versus launch angle data.

DATA TABLES AND GRAPHS

- ★ Horizontal launch:
 - ★ Median velocity of the ball through the photogate
 - ★ Vertical displacement
 - ★ Horizontal launch: Actual landing position (horizontal displacement from table)
- ★ Angled launches:
 - ★ The horizontal displacement data for each angled launch in a nifty data table
 - ★ Angled launches: the scatter plot

CALCULATIONS

In your lab report, please be sure to include:

- ★ All calculations you used to find the predicted landing position for the horizontal launch. CLEARLY IDENTIFY THE EXPECTED HORIZONTAL LAUNCH VALUE THAT YOU CALCULATED.
- ★ The percent difference between your predicted landing position and the actual landing position from step ten.

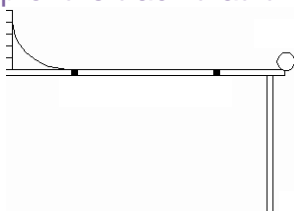
METAL RAMP SYSTEM or HOT WHEELS SYSTEM

MATERIALS

- ★ Metal ramp, ring stand, metal ramp OR Hot Wheels track with ramp attachment, ring stand, tape, marble
- ★ Cell phone with video or stopwatch

PROCEDURE

1. Use the tape to mount the track on a ring stand so that it creates a ramp. Place the ramp so that there is at least 0.3 m (approximately) between the bottom of the ramp and the end of the table. If you're unsure of what this should look like, ask your teacher. Be sure to use enough tape to make the ramp stable but also be sure not to put so much tape on the top of the track that it will deflect the marble.



2. Record the distance between the end of the ramp and the edge of the table.
3. You are about to start launching your ball. Before you do so, identify one partner to catch the ball and a second partner to watch the ball in case the catcher misses.
You may not lose your ball.
4. Set a cell phone on video mode along the edge of the table so that it can record the ball's entire motion across the table after leaving the ramp.
5. Release your ball down the ramp and be sure that one partner catches it. As it rolls record its motion along the table.
6. Use the video to measure the time it took the ball to travel from the end of the ramp to the edge of the table. Record this value.
7. Repeat four more times, recording all measurements.
8. Select the median as the time to use for future calculations.
9. Calculate the velocity of the ball as it moves along the table. **You will need to show these measurements and calculations in your lab report, so be sure to keep track of your scratch work.**
10. Using this as the initial horizontal launch velocity, predict mathematically where the projectile will land (horizontal displacement.) Pro-tip: There is one more measurement you will need to make before you can complete your calculations.
Again, be sure to keep track of the calculations you do, because you will need to put them in your lab report.
11. Hold your meterstick perfectly vertically up against the edge of your table so that you can find the spot on the floor that's directly below the launcher's edge. Put a light pencil mark on the floor there. In front of the mark measure the distance you found to be the "horizontal distance" and place the center of your landing pad at this location. Be sure when you do this to place the landing pad so that it is directly lined up laterally (i.e., left-to-right) with the path the ball bearing takes from the launch ramp.

12. Launch your human cannonball (i.e., ball bearing)! Watch carefully where it actually lands and mark the spot. Measure this horizontal displacement from the table and record the value. **BE SURE TO ASSIGN SOMEONE TO KEEP TRACK OF THE BALL.**
13. Calculate the percent error between your predicted horizontal displacement and the actual horizontal displacement. You will show these calculations in your lab report, so keep track of them.
14. Now you are done with calculations and computerized data collection. **HOWEVER**, you are not done with the lab. 😊 It's time to look at objective two! To do objective two, you need to combine with one of the lab groups that is using either the PASCO launcher or a wood block launcher. You will start on step 16 (p. 3, wood block) or 14 (p. 5, PASCO launcher) and then finish the remaining steps of the lab.

DATA TABLES AND GRAPHS

- ★ Horizontal launch:
 - ★ Displacement across the table
 - ★ Median time for the ball to travel across the table
 - ★ Vertical displacement
 - ★ Horizontal launch: Actual landing position (horizontal displacement from table)
- ★ Angled launches:
 - ★ The horizontal displacement data for each angled launch in a nifty data table
 - ★ Angled launches: the scatter plot

CALCULATIONS

In your lab report, please be sure to include:

- ★ All calculations you used to find the predicted landing position for the horizontal launch. **CLEARLY IDENTIFY THE EXPECTED HORIZONTAL LAUNCH VALUE THAT YOU CALCULATED.**
- ★ The percent difference between your predicted landing position and the actual landing position from step ten.