**Name: _____**

Inquiry Question
Realistic animations have become the real "game-changer" when it comes to special effects. Virtually any story can be realistically created. Can you determine how realistic an animation is using your knowledge of kinematics?

It is an animator's job to balance "realism" with "effect". Graphs can provide a great deal of information when it comes to describing an object's motion. Certainly, the shape of the graph can provide clues, but what about the slope and intercept? How does the slope change over time? What does this tell you about the motion? What does the area under a *velocity-time* graph represent? Animators that create videos must know when to bend the laws of physics, and when to hold true. Let's have a look at the animation below and see if we can determine both the good and bad physics involved.
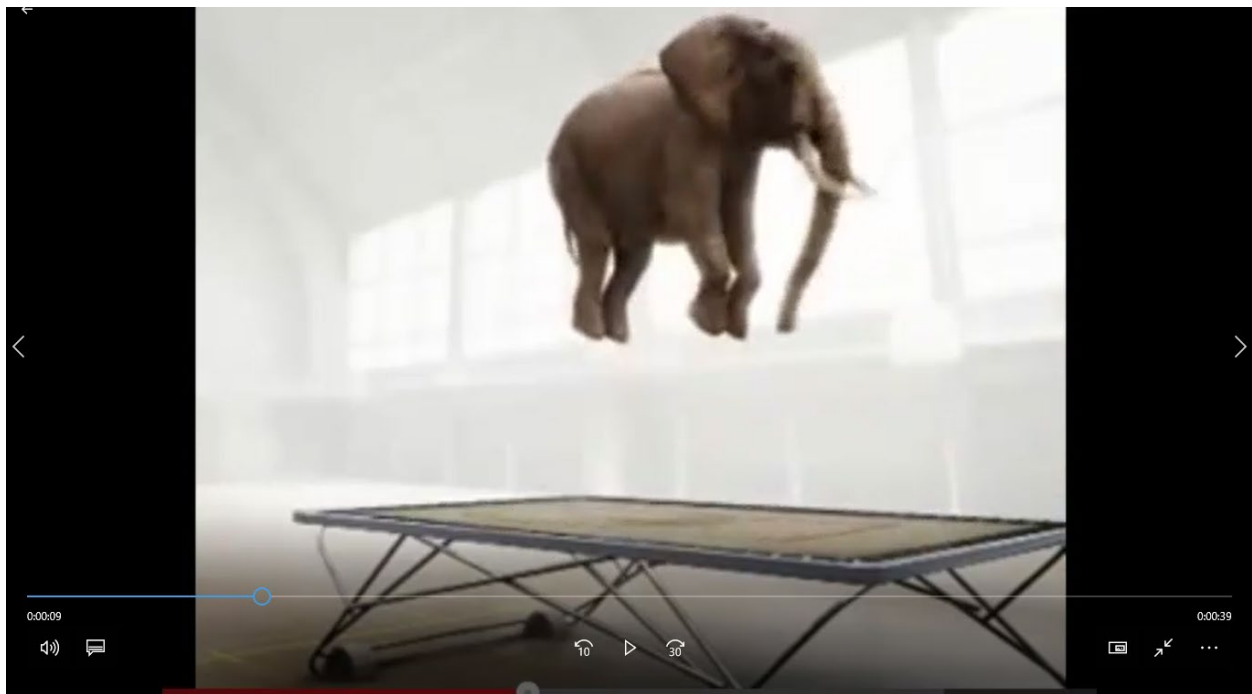
| Instructions |
|---|
| Using a pencil, answer the following questions. The lab is marked based on clarity of responses, completeness, neatness, and accuracy. Do your best! Please ensure that any data measured (or recorded) includes the appropriate number of significant digits (only one uncertain digit). |
| This activity is divided into three sections:

• **Core** – this first section explores only the basic "core" ideas involved in understanding. Students must demonstrate a sound understand with all of their answers in this section BEFORE attempting the next section.
• **Mastery** – Your instructor will NOT review this section if the Core section above shows any misconceptions. In this section students will make predictions and apply the concepts and ideas learned above. For complete mastery it is expected that data collection and scientific procedures will be as accurate as possible. All work shown should be clear with any units included. Answers should be rounded off to the correct number of significant figures based on the data collected.
• **Ace** – Once again, your instructor will only look at this section provided he/she is confident that the above Mastery criteria has been met. In this section students will demonstrate a deeper understanding of the concepts through error analysis, experimental design etc. Physics concepts from other units already covered will often be required here. |

Instructions:

Open the pdf instructions file and download the *Tracker* software from the link below. Video tutorials on the use of Tracker are included. See Free-Fall instructions below for additional support.

Click here for pdf Instructions

## **Tracker Software (click to install)**

To get you started quickly we have also created **video instructions**. They have been broken down into two parts on *YouTube*. You may need the *.pdf* above as well for lab-specific data analysis instructions. Follow the links below

Tracker Tutorial Part 1 (How to load the movie, set the scaling and origin, and crop the contents to the motion you wish to analyze)
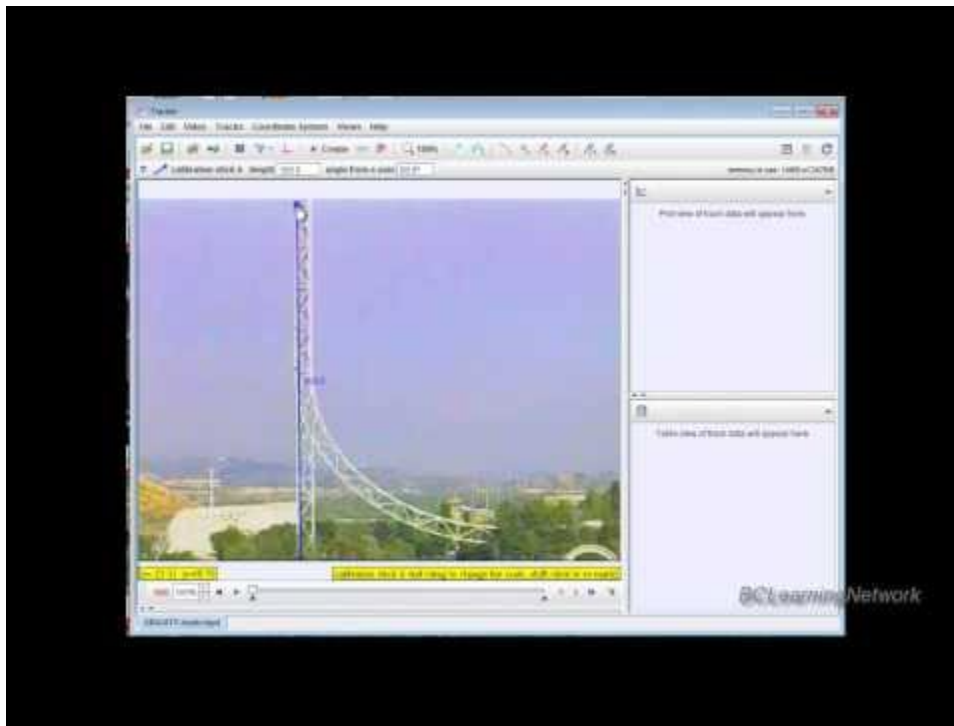
Tracker Tutorial Part 2 (How to collect, analyze and graph data)
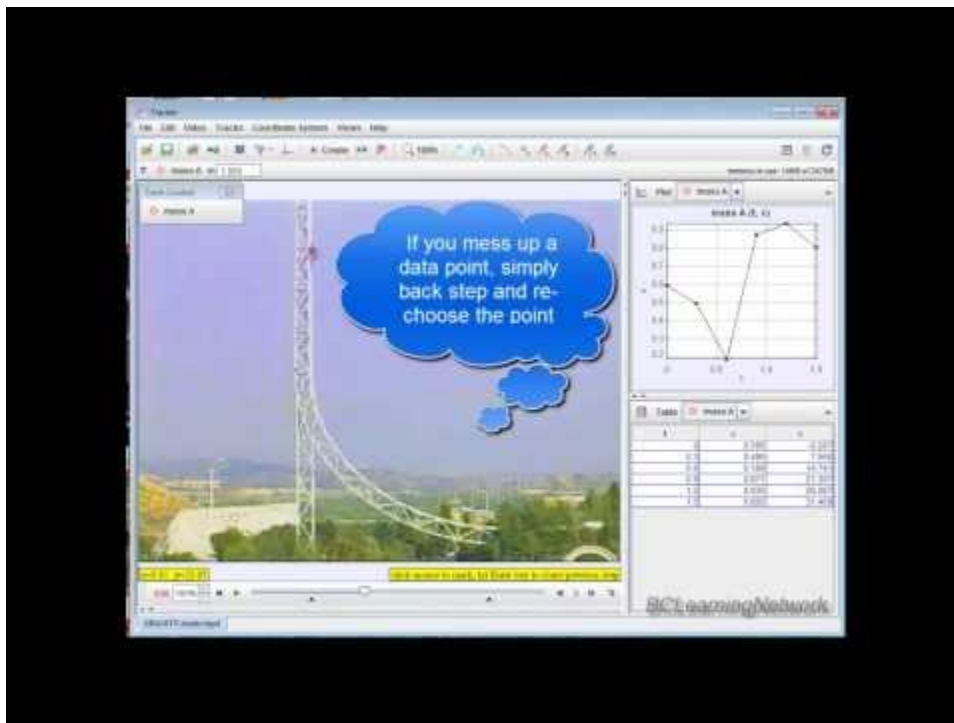
<u>Right-Click here</u> and chose *Copy Link Location* for the video showing the elephant jump
<u>Elephant Jump Video</u>
(right click and select copy link location, open is browser to download. Then open the download folder to view the file and change extension to .mp4 - vs. .zzz)

Refer to the *pdf lab instructions* (above)

See *Software Instructions* in the "Projects" area. Having successfully "TRACKED" your elephant **over the vertical portion of the jump** using the software as described in the instructions, it's now time to begin our analysis.

Analysis Begins…

Examine the Elephant Jump video clip. You task is to demonstrate that the video animators knew their physics.

Pick an appropriate segment of the video where the physics can be tested using *Tracker* software. A good clip will be one where the camera remains stationary (or close to stationary) and shows the entire "motion in question" (ie one camera angle from afar is ideal)

To properly analyze the motion you must *scale* your video using some known length. This object should be at the same location of your object.
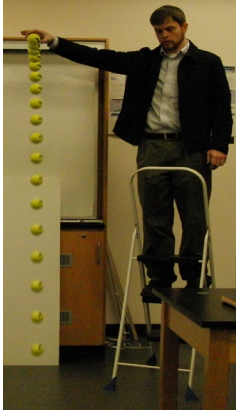
Make sure that the video is not shown in slow motion or any other format that could be difficult to interpret. Slow motion will only work if you are told "how slow".

Since the elephant is jumping straight up and down you need only analyze your motion in the vertical direction (y). Be sure to construct meaningful graphs for analysis of slopes or areas if required.

The videos show a projectile (elephant soaring through the air off of a trampoline. Projectiles, as you know, must adhere to certain characteristics here on Earth. Answer the basic projectile questions below. The answers to these questions should provide you with a "game plan" as to how you will go about proving the motion is realistic.

Part 1: Core

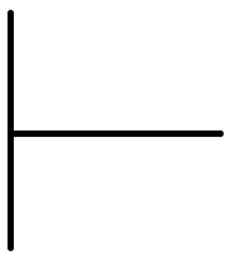1. A ball is is photographed using a high speed strobe effect as shown below. It shows the position of the ball at equal time intervals. The ball can be photographed this way when it is dropped from rest at a height, h, or, after the ball strikes the floor it is photographed as it climbs back up to its apex. The pictures are the same. Discuss the vertical component(s) and motion of a typical projectile by completing the table below.
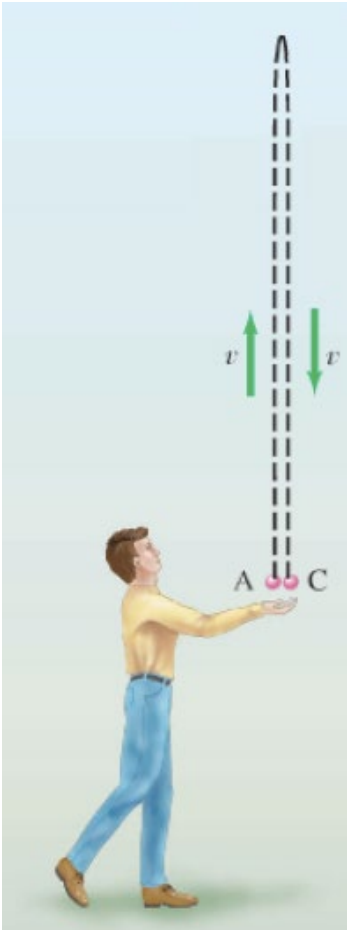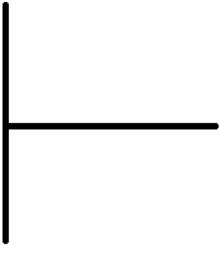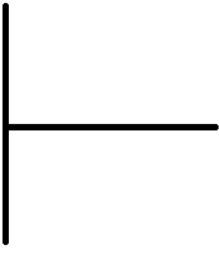
On the way UP (to the apex after the bounce)	*Describe/Discuss:*
	What is happening to v_y? _____ _____ What is a_y? _____ What direction is a_y? _____ What about d_y in this region? _____ _____
At the apex 	What is v_y at the apex? _____ What is a_y at the apex? _____ What direction is a_y at the apex?_____ What can we say about d_y at this point? _____ _____
On the way back down (past the apex)	What is happening to v_y? _____ _____ What is a_y? _____ What direction is a_y? _____ What about d_y in this region? _____ _____
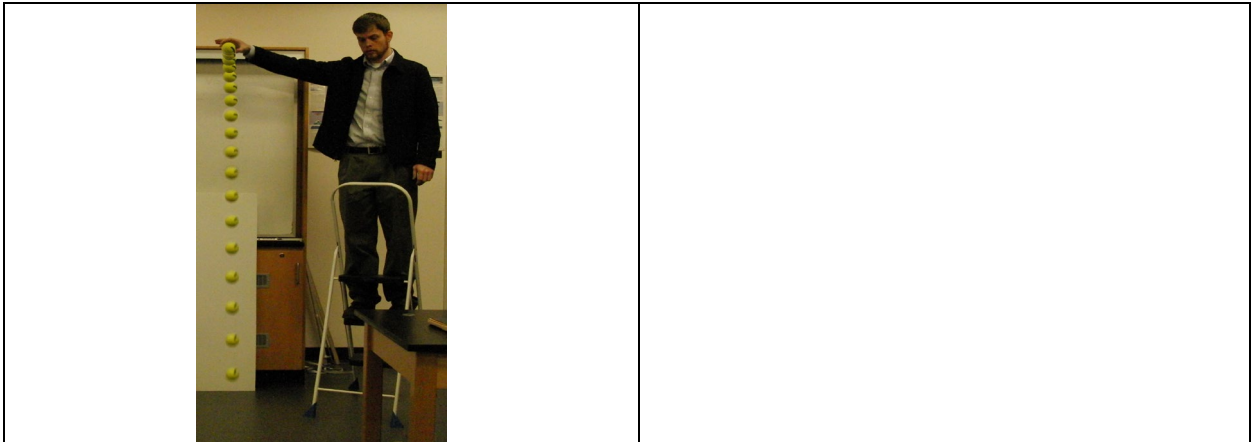
2. What about the various kinematics graphs for the "ideal" vertical projectile? Draw the "ideal" shape for each graph indicated for the three types of vertical projectiles described below.

Projectile 1: (launched from ground until it reaches maximum height)	
	d_y vs t graph:
	v_y vs t graph:
Projectile 2: (dropped from a high building until it reaches the groundt)	
	d_y vs t graph:

v_y vs t graph:

Projectile 3: (tossed into the air and returns back to original position)	
	d_y vs *t* graph:
	v_y vs *t* graph:

3. What does the <u>slope</u> of a **d-t** graph represent? _____

4. What does the <u>slope</u> of a **v-t** graph represent? _____

5. What does the <u>area</u> of a **v-t** graph represent? _____

6. What would the "ideal" slope be for your **v_y** vs **t** graph? _____

Collect data and analyze graphs with the *Tracker* software:

Download and install the *Tracker* software. Refer to the instructional videos for a quick overview of the software and its features.

Download the *full Elephant Jump* video to analyze. Load the video into the *Tracker* program. Watch the clip and find the section that you want to analyze.
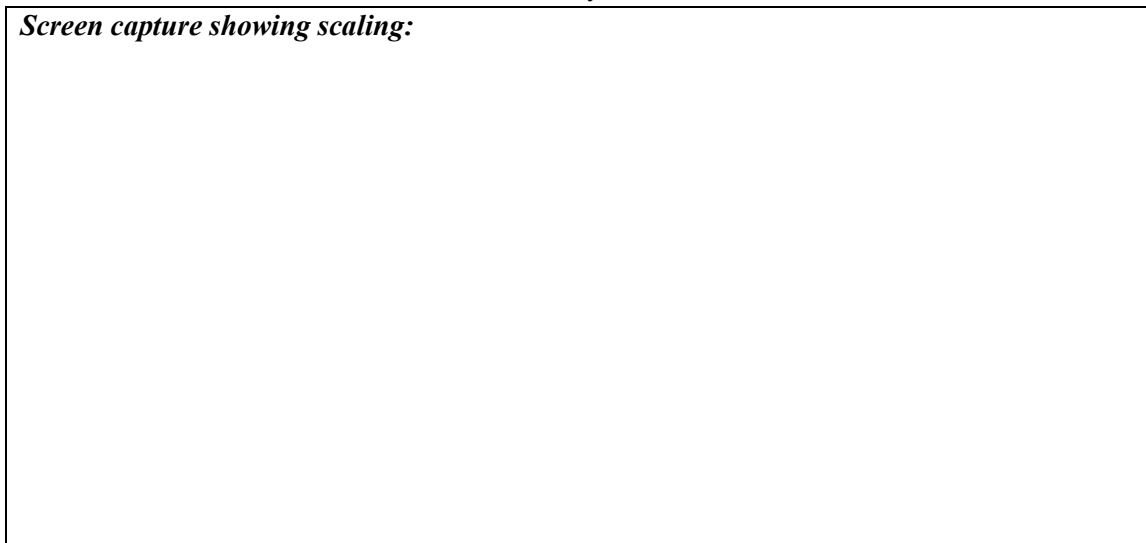
Elephant Video:

Slide the play-bar at the bottom of the video to place beginning and ending tabs for the section that you are analyzing (frames 347 to 536). For scaling, you may assume that the trampoline is **5m in diameter.**

General Pointers:

- Watch the instructional video for tips on scaling.
- Track the centre of mass of the elephant as this should follow our "ideal" projectile path *(choose the middle of his body at all times)*
- Paste any necessary pictures or graphs into the boxes below for analysis. In *Tracker* you can simply right click on any image or graph and choose *Snapshot* to create a ready-made image for your report.

1. Perform a screen capture (right-click, *Snapshot*) of your freefall. Paste the capture into the window below and be sure to show the scale that you used.

Screen capture showing scaling:

2. Create the graphs below using *Tracker*. Take *Snapshots* and paste them into the appropriate window.

> d_y vs t ("y" vs t on *Tracker*)
>
>
> v_y vs t

3. Using a different colour pen, show the "ideal" graph for each over top of the graphs you pasted.

4. Complete the table below by discuss both the "good" and the "bad" physics as demonstrated by each graph. Be sure to discuss the general shape of each graph along with any strange anomalies not normally present (such as deviations in slope, flattened regions, incorrect directions etc.)

Graph:	"Good" Physics	"Bad" Physics
d_y vs t		
v_y vs t		

Part 2: Mastery

1. For an "ideal" projectile, one of the above graphs should be a straight line while the elephant is free from the trampoline. Which graph are we referring to? _____

2. What is the "ideal" slope for this graph? _____

Use the *Analyze* feature found by right clicking on the above graph that should be straight. Highlight the region(s) of each graph that should be straight and use *Analyze* to determine the equation of each region in slope-intercept form by choosing *Linear Fit*.

3. The slopes (as found by *Tracker*) might not be what you expect. Discuss how slight alterations in the original scaling of your video would affect each slope. In other words, if the scale you chose was too big, how would this affect the value of the slope?

   _____

   _____

4. For the graph determined in (1) above, discuss the slopes in the regions described below in terms of how close they are to expected values for ideal projectiles.

Graph Title:	Discuss Slopes (compare to expected)	How do these slopes affect the "realism" of the motion
Region 1: Elephant on its way up		
Region 2: Elephant on its way back down		
Region 3: Elephant at the apex		
Region 4: Entire graph		

Part 3: Ace

Assuming that you have set the **scale to be 5m** (diameter of trampoline), examine your d_y vs t graph ("y" vs. t on *Tracker*).

Right-click on the graph window and choose *analyze*. A new window should be displayed with just your d_y vs t graph visible for analysis. If other graphs are also present they can be "turned off" by de-selecting them above the data column on the right hand side.

1. What, precisely, does the slope of the *tangent* line on a ***d*** vs t graph represent?

   _____
   _____

Select the *Measure* tab above the graph and choose *Slope*. As you move your mouse across the graph you will notice a <u>tangent line</u> that follows on the graph itself. The slope of this tangent line is given on the bottom right of your graph. *(Note: a slope of 1.2E1 means 1.2 x 10^1 in this program)*

2. Assuming that the diameter of your trampoline is set to 5m use your d_y vs t graph to estimate the initial launch velocity of your elephant. Explain what you used to find this value.
   Initial velocity, v_0 = _____
   How v_0 was determined: _____

3. Using v_0 from above, calculate the maximum height that your elephant should reach under ideal conditions. Show all information, equations, and calculations below:

   <div style="border:1px solid black; padding:10px;">

   Calculate "ideal" maximum height for Elephant

   h_{ideal} = _____ m
   </div>

4. Examine your d_y vs t graph. What was the maximum height, h_{max}, reached by your elephant? *(be careful! – note the original position of your elephant on your graph. It may not be zero.)*

   _____

5. By what factor is h_{ideal} larger than h_{max}? _____ times larger

6. **Your final task** - Given that the trampoline is assumed to be **5m in diameter**, how could the **speed of the movie** be adjusted to represent a realistic free fall here on earth? You will need to determine how much time should have elapsed for the elephant to have reached h_{max}. Show all your work below.

> *Calculations to determine how many times faster or slower the movie should run at for a realistic free fall:*
>
>
>
>
>
>
>
>
>
>
>
>
>
> **Speed Up** or **Slow Down** (*circle choice*) by a factor of _____ x

7. Open your clip in a video player that allows for Play Speed control. Set your speed according to your answer above. Find the section that you analyzed. Record the "adjusted" motion for this region only and **submit the video file to your teacher for evidence**.