
TARZAN
A-O A-O-O-O A-O-O A-O-O-O-O-O A-O-O-O-O-O-O-O-O-O-O-O-O-O-O-O-O-O-O-O-O
E=MC²

IMAGINE THIS!

You are running as fast as you can through the jungle with fifty head-hunters chasing you. Your breath is short, and your mouth is dry, but there is no stopping. For if you stop, you die.

Suddenly there's a cliff.
Beside you - a vine.
Across the chasm – a cave.

Do you swing across?

Of course, you do! You are "Tarzan, King (or Queen) of the Jungle"!

But consider:

1. What if sharp rocks surround the cave? How will you avoid them?
2. What if obstacles (huge rocks) are sticking up from the bottom of the chasm? How will you avoid them?
3. What if you must let go of your vine part way across the chasm? Can you still safely make it to the cave?

These are just a few of the situations that could develop if you were "Tarzan, King (or Queen) of the Jungle."

Now, it is your job NOT to be "Tarzan, King (or Queen) of the Jungle," but to be "Tarzan, King (or Queen) of the Classroom." There are multiple levels of difficulty in this task you will attempt to conquer. The higher the level, the more advanced the calculations. It will be your job to get Tarzan across the chasm free of injury (in this case get a water balloon safely through a square hole in plywood surrounded by pins).

Your instructor will give you certain variables, and you will be expected to calculate the others. You will then swing the water balloon using your findings. If you are correct, Tarzan will go into the cave without harm. But if you are wrong, get ready for the water to fly.

GOOD LUCK!

The Energy Concept and Its Relation to the Tarzan Swing

Starting with level 4 of the Tarzan Swing, it will become extremely important for you to understand the energy conservation concept. So, this is a brief introduction to the concept.

Any time an object is in motion, it has KINETIC ENERGY, or energy of motion. Any time an object has energy, this means it is capable of doing work. For example, if I throw an eraser across the room, it could hit someone and wake them up if they happened to be napping. The eraser has the ability to do work because it is in motion. The amount of kinetic energy that an object has depends upon its mass and speed. The relationship is as follows:

$$KE = \frac{1}{2}mv^2$$

m = mass of the object (kg)
v = speed of the object (m/s)
KE = kinetic energy (Joules)

When an object is at an elevated position, it has the potential to do work. For example, if I have a heavy pot sitting on a shelf in my home, then the pot could fall and smash itself (or something else). We call this type of energy POTENTIAL ENERGY because it is stored energy. The pot, because of its elevated position and the force of gravity, has the potential to fall and break itself. The amount of gravitational potential energy that an object has depends upon its mass, its height, and the acceleration of gravity. The relationship is as follows:

$$PE = m\,g\,h$$

m = mass of object (kg)
g = 9.8 m/s^2
h = height of object (m)

Energy cannot be made or destroyed. It can only be converted from one form to another. When an object starts at an elevated position and then begins to fall (or swing downward), its potential energy (stored energy) is converted to kinetic energy (energy of motion). So, setting KE = PE, we can solve out for the object's speed after it has fallen a distance h.

$$KE = PE$$

$$\frac{1}{2}mv^2 = m\,g\,h$$

$$mv^2 = 2\,m\,g\,h$$

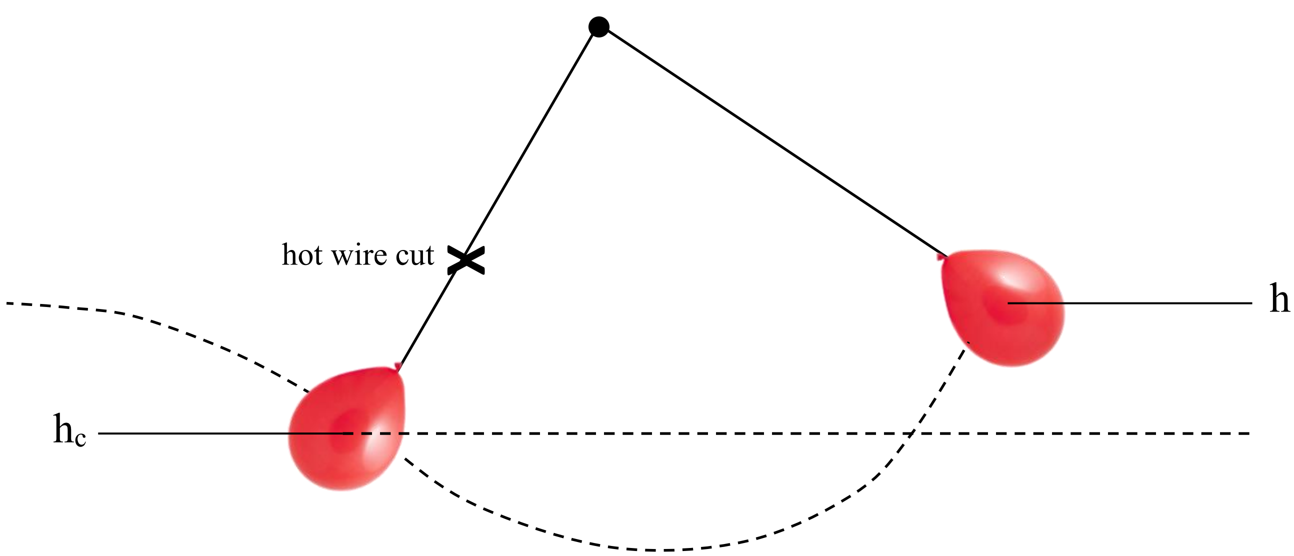
$$v^2 = 2\,g\,h$$

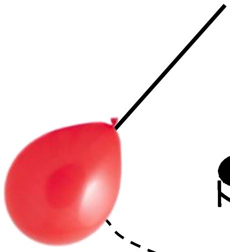
$$v = \sqrt{2\,g\,h}$$

Thus, when the Tarzan water balloon has fallen a total distance h, it will have a speed v as determined by the above equation. If you can determine the height of your Tarzan balloon at some point in its motion – for example when it enters the cave opening, or perhaps when the vine is cut - and you know its height when you released it, then you can determine its speed at that point. For example:

$$v = \sqrt{2\,g\,(h - h_c)}$$

$g = 9.8\ m/s^2$ or $386\ in/s^2$
h = height of Tarzan balloon when released (m or inches)
h_c = height of Tarzan balloon when vine is cut (m or inches)
v = speed of Tarzan balloon when vine is cut (m/s or inches/s)





Beware of Low-Energy Solutions in LEVELS 5 - 8

This caution applies in particular to Levels 5 - 8.

Even accounting for the majority of the energy lost in the swing process, there is still a small unaccounted-for amount of error in the kinetic energy. Suppose 10 millijoules more energy is lost in the swing process than expected. Let us consider the effect on two types of solutions: a moderate kinetic energy solution, and a very low kinetic energy solution.

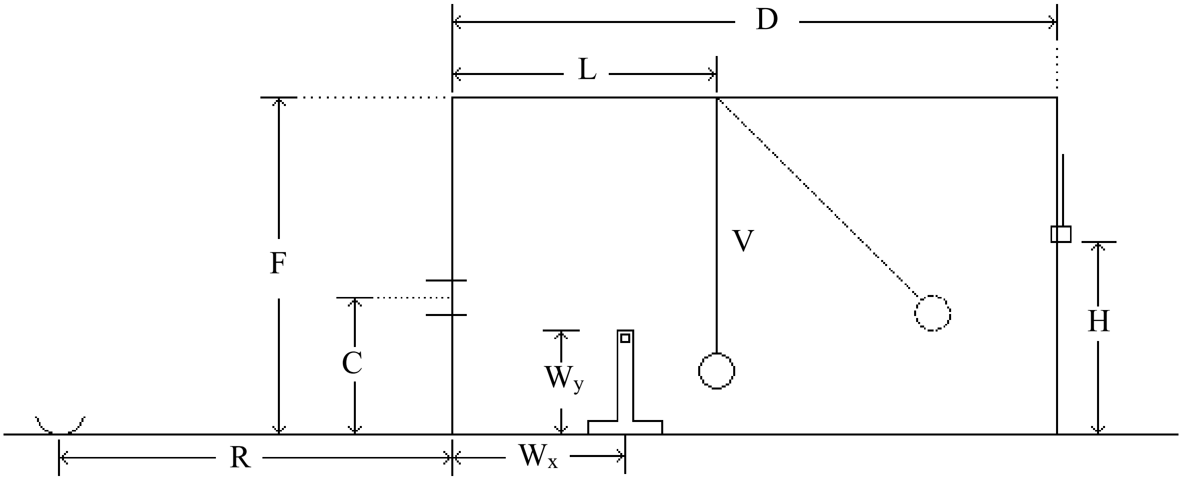
moderate KE (500 mJ): $$\frac{10\ mJ}{5000\ mJ}\ x\ 100\% = 0.2\%\ \text{error}$$

very low KE (50 mJ): $$\frac{10\ mJ}{50\ mJ}\ x\ 100\% = 20\%\ \text{error}$$

Thus, low kinetic energy solutions have a larger percentage error in the speed of the balloon than more moderate energy solutions. This makes low kinetic energy balloon paths less reliable and repeatable than moderately high energy solutions.

Figure 14: A small drop of water makes very little difference when added to a large bucket of water. However, this same small drop of water makes a noticeable difference when added to a very small puddle of water.

LEVEL 6



Student Objective:

To determine Tarzan's vine length (V), release height (H), pivot point location (L), and landing spot (R), such that when the vine is cut, Tarzan projects safely through the cave and into a basket.

Given:

Floor to pivot point (F) = 66.75 inches
Release plane to cave plane (D) = 85.75 inches
Maximum vine length = 62 inches
Vine tensile strength = 10 Newtons
Balloon mass $\approx$ 100 grams
Balloon diameter $\approx$ 2.5 inches or 6.3 cm
Basket height (N) = 6 inches

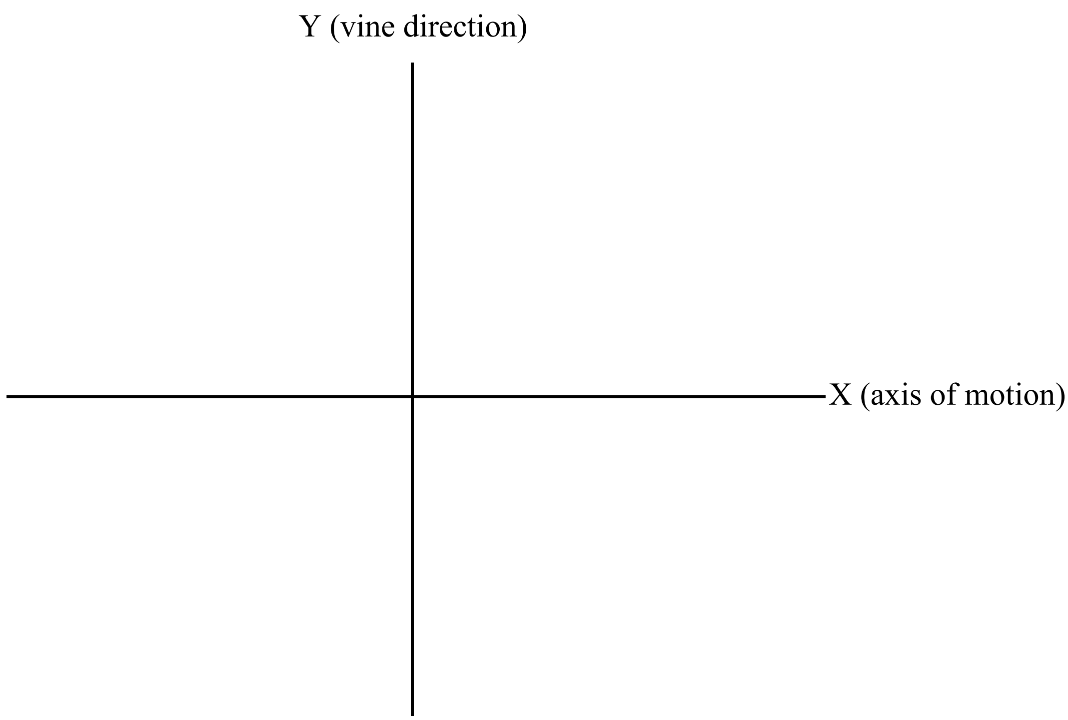
Cave height (C) = ________
Distance of wire from cave (W_x) = ________
Distance of wire off ground (W_y) = ________

Be sure to consider an energy loss (friction/air-resistance) of 3% when Tarzan swings across the chasm.

Instructions:

Show all of your calculations that were necessary to solve this level including a calculation using the coordinate system below to show that the maximum vine tension exerted by your solution does not exceed the vine tensile strength. Attach extra pages if necessary. Sketch accurately the path of Tarzan such that he is projected safely into the cave. Include the hot wire position in your sketch. NOTE: Keep in mind that after Tarzan's vine is cut, he will be undergoing projectile motion and follow a parabolic trajectory. How will you accurately draw this parabolic path in your diagram? Explain your method as part of your report.

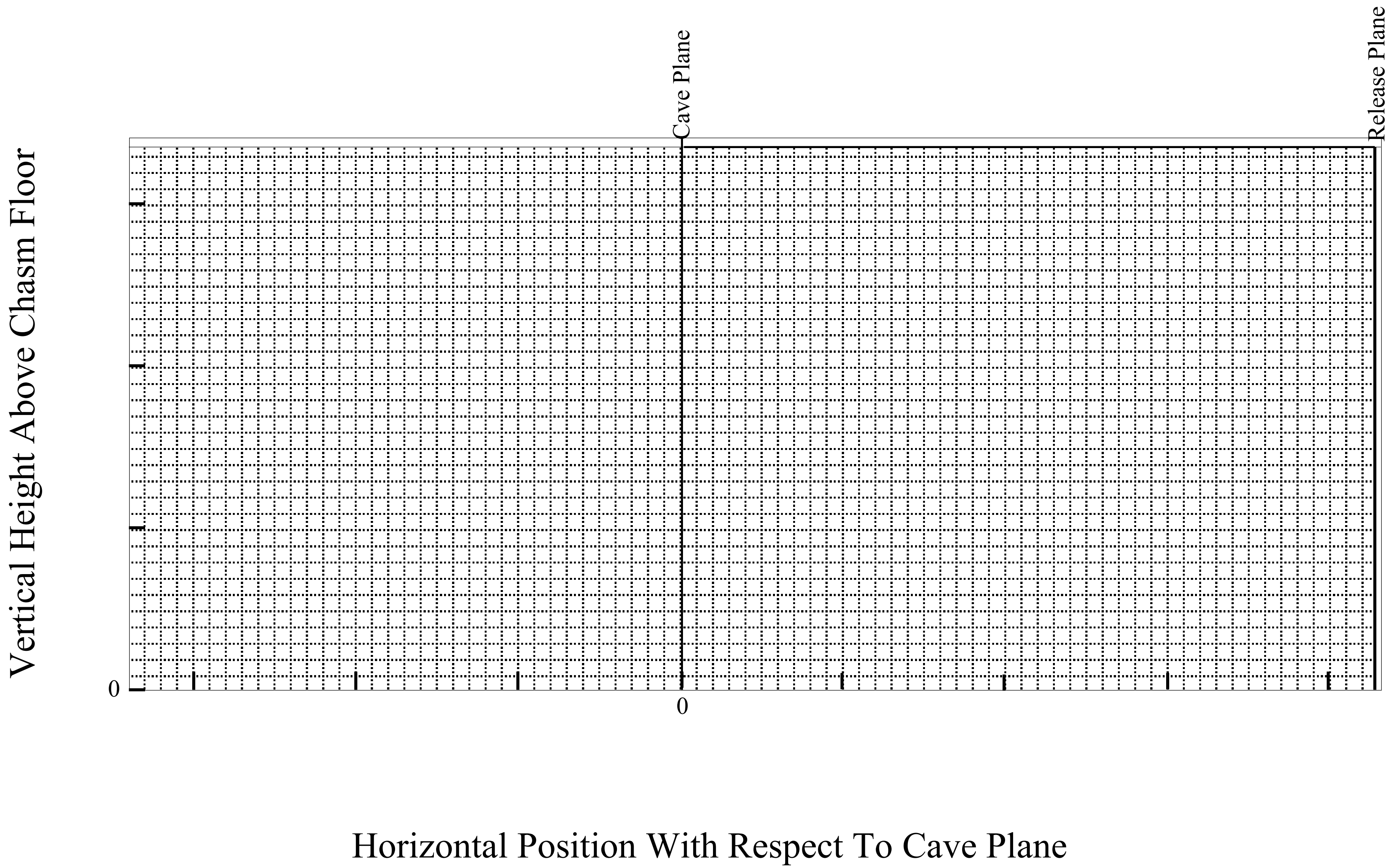
Sketch a free body diagram for Tarzan when he is at the bottom (lowest part) of his swing. Remember to include the air-resistant force here (assuming Tarzan is moving toward the left as shown in the schematics thus far). Also, do not forget to include the weight of the water balloon.



We know that the forces on Tarzan along the radial (vine) direction must sum to the necessary centripetal force.

$$\Sigma F_y = \frac{m v^2}{r}$$

Write the appropriate force equation and solve for tension (T) in the vine.



Cave Plane
Release Plane
Vertical Height Above Chasm Floor
0
0
Horizontal Position With Respect To Cave Plane