YouTube AP Physics 1

VICTORIA PHYZ FALLS X: v=VCxRgrL1Ges

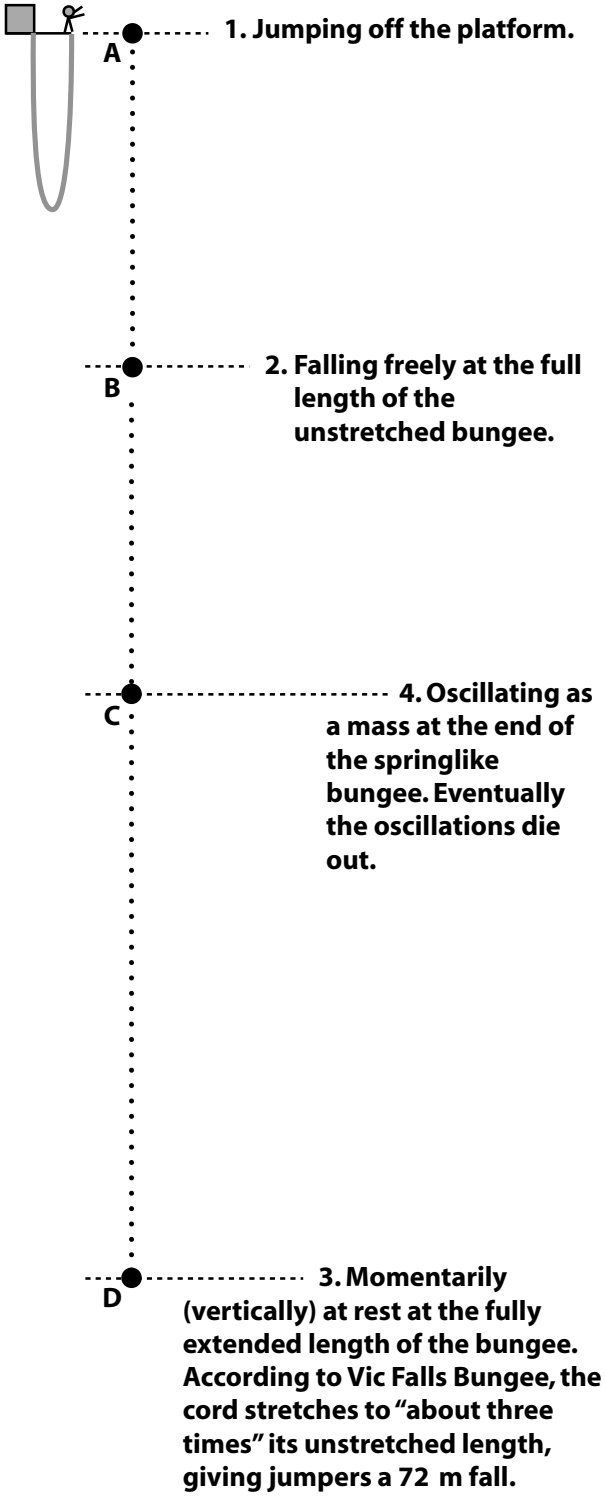
Description

In July 2014 Rio Americano physics teacher, Dean Baird, bungee jumped off the historic Victoria Falls Bridge between Zambia and Zimbabwe in Southern Africa. The Zambezi river flows through a gorge more than 350 feet below. The jump was recorded, and the YouTube address of the video is shown above.

At "weigh-in," the number 111 was written on his arm to denote his mass in kilograms. Coincidentally, the Vic Falls Bungee company advertises the jump as taking "111 Meters of Big African Air". Upon closer inspection, 111 meters is the vertical distance from the bridge to the river. Jumpers are said to drop about 70 meters. Let's call it 72 m for our analysis.

To keep things simple for our story and analysis, let's consider the bungee cord to be an ideal, massless spring and neglect air resistance.

The stages of the motion are described in the diagram to the right. Important points associated with the motion are labeled in the diagram.



Some Quick Numbers

1. What is Baird's weight in newtons?

2. What is the length of the bungee cord when it is relaxed (unstretched)?

3. How long would a ***cordless*** jump last? (Free fall from bridge to river.)

4. How long does Baird's ***corded*** descent last (from A to D in the diagram). Use the video to make this determination.

Thanks to Dan Burns (Los Gatos High School Physics) for assistance with the development of this activity.

The Book of Phyz © Dean Baird. All rights reserved.

Write the "Force and Motion Story" describing what's happening to force and motion in each segment: A to B, B to C, and C to D. Use trend words and expressions such as "increases," "decreases," and "remains constant," direction terms such as "upward," and "downward" (instead of "positive" or "negative"), and magnitude terms such as "minimum" and "maximum" where appropriate. Draw a force diagram showing the forces acting at points A, B,C, and D. Indicate the net force at each point.

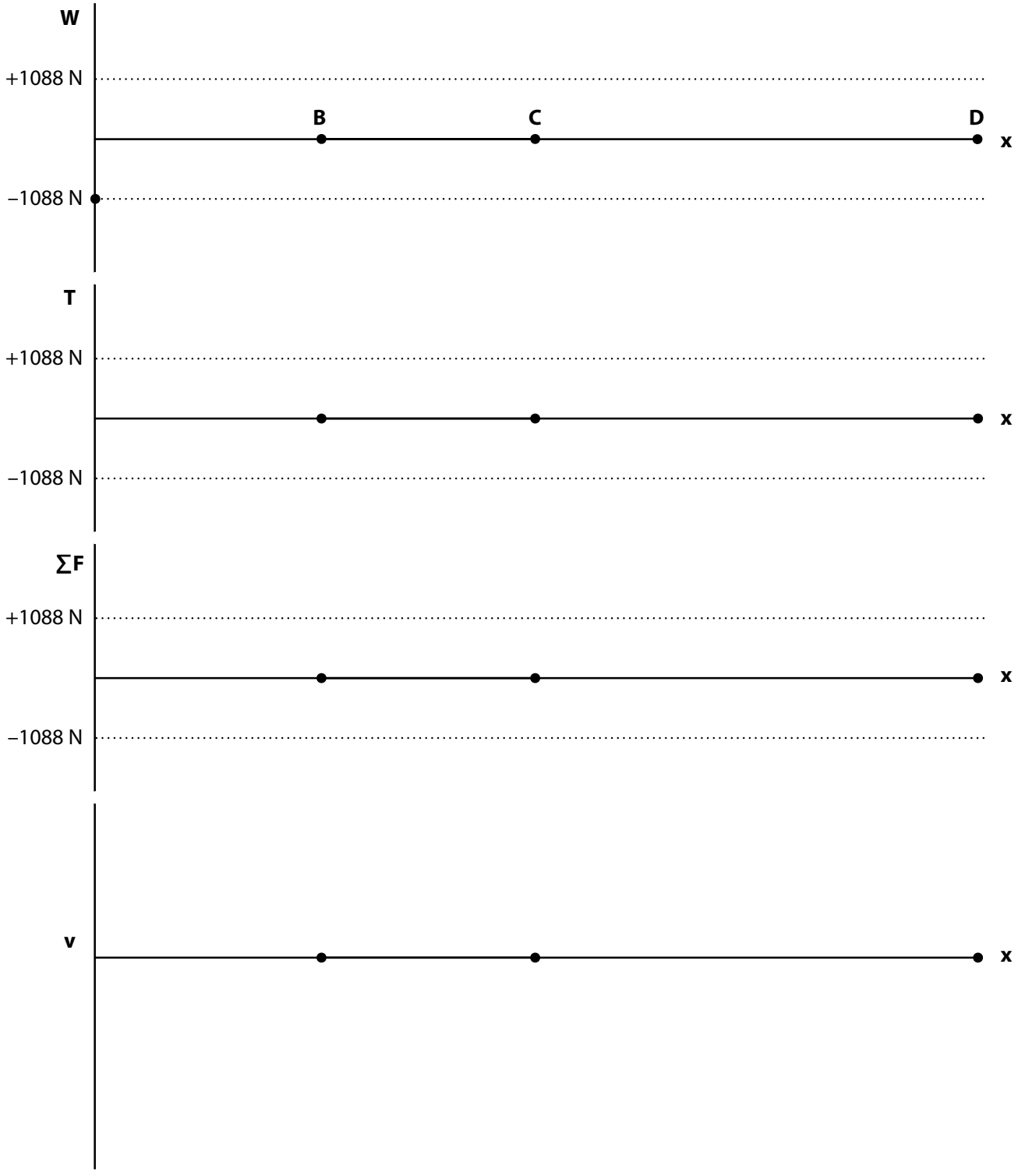
The Force and Motion Story	**Force Diagram**	**Net Force**
From A to B, the net force Therefore the acceleration The velocity		
From B to C, the net force Therefore the acceleration The velocity		
From C to D, the net force Therefore the acceleration The velocity		

The Book of Phyz © Dean Baird. All rights reserved.

Graphing the Force and Motion Story

Various quantities can be plotted with respect to vertical ***distance***. **Consider up to be positive.**

1. Plot the jumper's weight. (The initial value has been plotted. It's negative because up is positive.)
2. Plot the tension in the bungee cord. (The initial value has been plotted.)
3. Plot the net force. (The initial value has been plotted.)
4. Plot the velocity (from stage 1 to stage 3; point A to point D). (The initial value has been plotted.)



The Book of Phyz © Dean Baird. All rights reserved.

5. On the velocity graph, identify the point at which the jumper's speed is at its maximum.

6. On the net force graph, identify the equilibrium point of the bungee-Baird harmonic oscillator.

7. The value of the force constant of the bungee cord is represented somewhere in the graphs. Where is it?

8. The ***speed*** of the jumper increases from A to B. Which is the best characterization of the v vs. x plot from A to B?

__ $v \propto x$ __ $v \propto x^2$ __ $v \propto \sqrt{x}$ __ $v \propto 1/x^2$ __ $v \propto 1/\sqrt{x}$

9. Use a ***dashed*** line to continue the plot of *v vs. t* from Stage 3 to Stage 4. How does your plot account for the up and down oscillations during this phase?

10. Suppose that instead of jumping from the platform on the bridge, Baird had been released from rest at point B. On the Net Force graph, identify the far point beyond equilibrium (on the distance axis) at which he would have come to rest. Label that point "E".

Quantitative Analysis using Tools from Simple Harmonic Motion and Energy Conservation

1. It is possible to determine the force constant of the bungee cord based on what we've been told in the original description and what we can readily measure from the video.
   a. Describe how this can be done.

   b. Record appropriate data and carry out the calculations.

2. Determine the distance from B to C.
   a. Describe how this can be done.

   b. Record appropriate data and carry out the calculations.

The Book of Phyz © Dean Baird. All rights reserved.

3. Baird is in free fall from A to B. His speed at B can be determined.
   a. Describe how this can be done.

   b. Carry out the calculations; show all work.

4. Baird continues to gain speed from B to C as his gravitational potential with respect to C is transformed to both additional kinetic energy ***and*** elastic potential energy in the cord. The speed at C can be determined.
   a. Describe how this can be done.

   b. Carry out the calculations; show all work.

   c. Vic Falls Bungee says that jumpers reach speeds up to 120 km/h. How does the value calculated for Baird compare? [One kilometer = 1000 meters, one hour = 3600 seconds]

   d. How fast would a cordless jumper be traveling at the distance corresponding to point C? Show work.

   How does the cordless bungee speed at C compare to Vic Falls Bungee's stated maximum speed?

The Book of Phyz © Dean Baird. All rights reserved.

5. Distance from equilibrium to maximum stretch (C to D) can be determined. It is helpful here to reset our elastic potential energy zero point to the equilibrium position of the subsequent spring-mass oscillations. That equilibrium point—where the net force on Baird is zero—is point C.

a. Describe how this can be done.

b. Carry out the calculations; show all work.

c. How far is it from point A to point D based on our calculations?

d. According to Vic Falls Bungee, jumpers experience a drop of "about 70 m". How does our value compare?

6. Baird's acceleration at maximum stretch can be determined.

a. Describe how this can be done.

b. Carry out the calculations; show all work.

7. While standing on the bridge, Baird experienced one "*g*". During the initial free fall, Baird experienced zero *g*'s (also known as "apparent weightlessness"). To determine the number of *g*'s being experienced, add 1 to the quotient of Baird's **upward** acceleration divided by *g* (9.8 m/s^2). On the bridge: $1 + 0 / g = 1$. Falling freely: $1 + -g / g = 0$.

What was Baird's acceleration at the point of maximum stretch?

To see what **could** have happened in the video, research Erin Langworthy's 2011 Victoria Falls bungee jump.

The Book of Phyz © Dean Baird. All rights reserved.