PHYSICS 570 – Master's of Science Teaching

"Electricity"
Lecture 8 – Work, Potential Energy and Kinetic Energy

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Course Goals – Math

You will learn scientific notation, and how to calculate with it. CHECK!

You will learn about vectors and how to add them with pictures and with math ("by components") CHECK!

You will get GREAT applications for Trig., algebra, exponents and fractions

CHECK!

Course Goals – Physics

I hope at the end of the first part of the course you will know the difference between charge, current, electric field, potential, voltage, potential energy, power, resistivity and resistance and be able to teach these concepts.

QUANTITY	SYMBOL	UNITS
Charge	q, Q	Coulomb (C)
Force	F	Newtons (N)
Current	I	Amperes (A) C/sec
Resistance	Ω	Ohms
Electric field	E	Newt/Coul
Potential	ϕ	Volts (V) Joule/Coul
Potential Energy	U	Joules ($N \cdot m$)
Work	W	Joules ($N \cdot m$)

Today's theme

Electric potential, relation to work and potential energy.

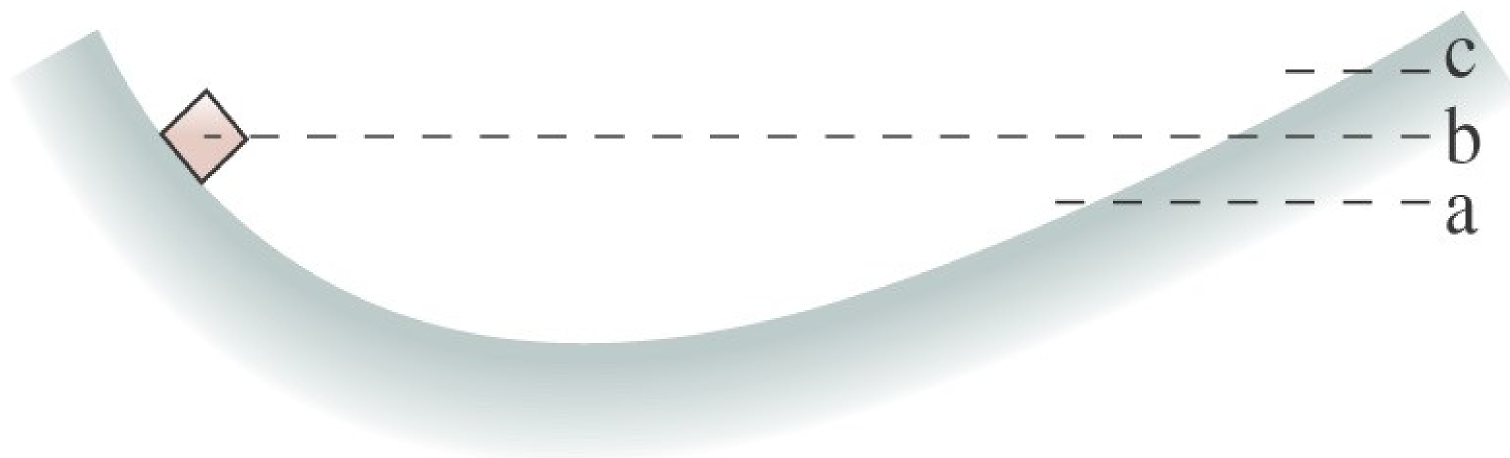
Building up to potential

We will try to understand electric potential energy and voltage by comparing it to gravity.

A positive charge in a constant electric field acts just like a mass in a gravitational field.

Gravitational Potential Energy

$$\text{Total Energy} = m g h_i + \frac{1}{2} m v_i^2 = m g h_f + \frac{1}{2} m v_f^2$$



If the box begins at rest,
and the ground is frictionless,
how high does it go?
A?
B?
C?

Gravitational Potential Energy

Demo … the loop the loop track.

Gravitational Potential Energy and Work9

Work in physics is defined as "Force" times "change in position" if the force is constant.

$$\mathbf{W = F\ \Delta\ x}$$

So for gravity, W = - mgh assuming you were going straight up.

Potential energy is always Work with a minus sign. So U = -W

9For constant gravity, U = mgh

How do you define work if Force and change in position aren't in same direction?

Only the part of motion that is in the SAME DIRECTION AS THE FORCE counts for work.

In vector terms, only the "component" along the force matters.

Mathwise that is $\mathbf{W} = \vec{\mathbf{F}} \cdot \Delta \vec{\mathbf{r}}$

Where the black dot is a special kind of multiplication called a "dot product" that means "only the component along the force matters"

The brick and the pea …

The difference between “physics work” and what most people think is work.

Calculus Bonus (Optional!)

Work in physics is defined as "Force" times "change in position" if the force is constant.

$$\mathbf{W = F\ \Delta\ x}$$

If the force is not constant, then $\mathbf{\Delta\ x \rightarrow dx}$ and $W = \int F(x)\,dx$

For gravity, F(x)= constant = mg so work by gravity is $W = -\int mg\,dx = -mg\,x = -mg\,h$

For a spring, F=-kx $W = -\int kx\,dx = -\frac{1}{2}kx^2$

What if the force isn't constant?

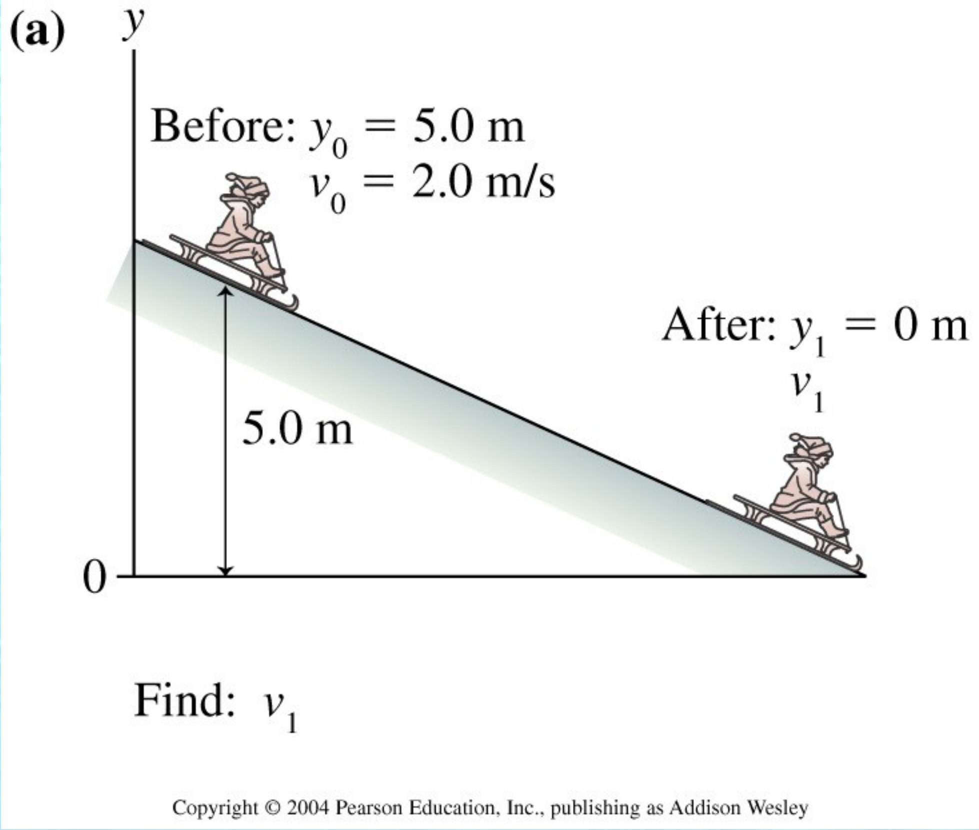
For certain forces (called conservative forces), Work is the same
no matter what path you take. Gravity and electrical force are both conservative.

So if you CAN find a path with constant gravity, you can be sure that the Work on other paths is the same.

Gravitational Potential Energy

$$\text{Total Energy} = U_i + K_i = U_f + K_f$$

$$\text{Total Energy} = mgh_i + \frac{1}{2}mv_i^2 = mgh_f + \frac{1}{2}mv_f^2$$

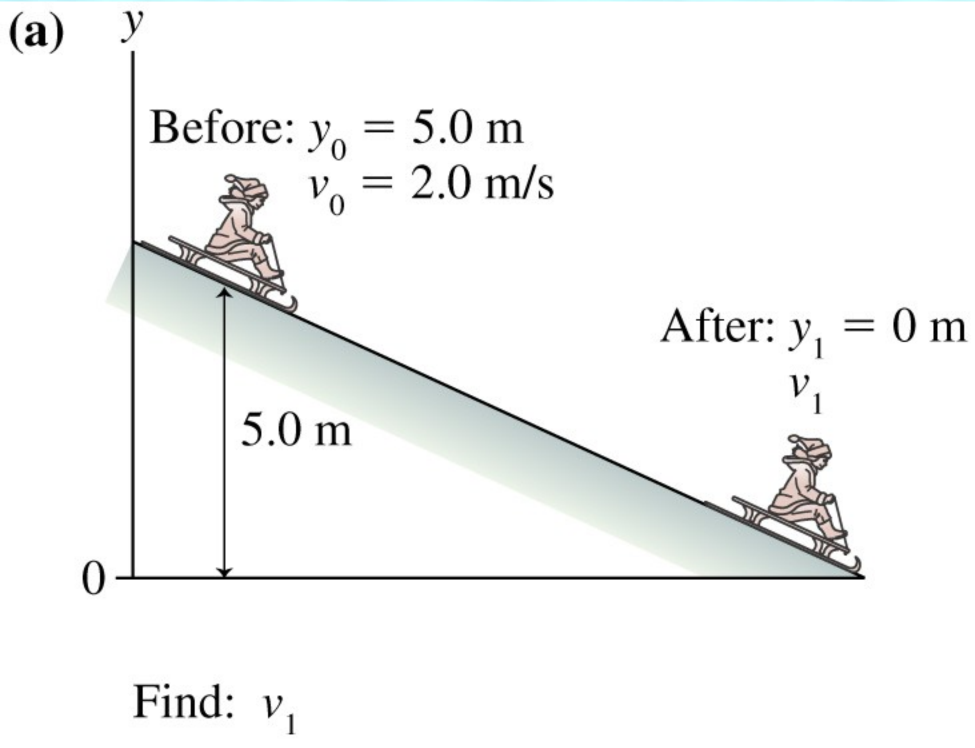


A sledder is going 2 m/s at the top of a hill. What is her speed at the bottom?

Homework: Lecture 8, problem 1

$$\text{Total Energy} = U_i + K_i = U_f + K_f$$

$$\text{Total Energy} = mgh_i + \frac{1}{2}mv_i^2 = mgh_f + \frac{1}{2}mv_f^2$$



Gravitational Potential Energy

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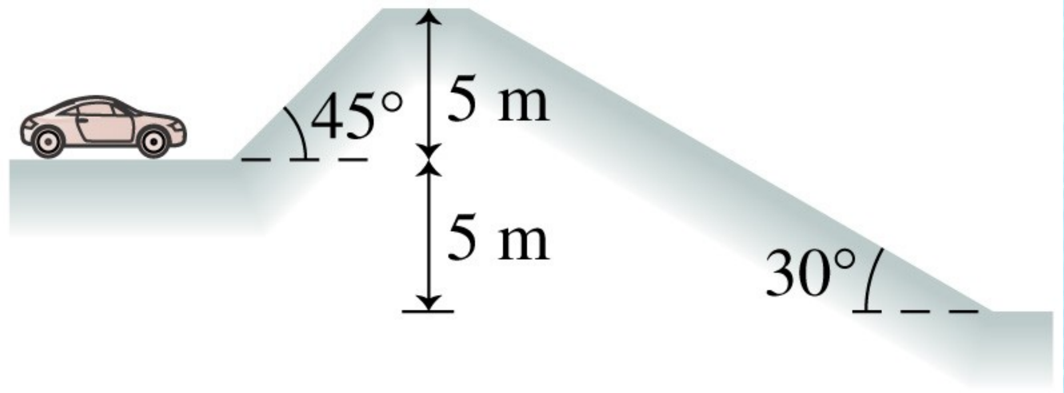


A 1000 kg car approaches a hill at shown at 10 m/second. What is its speed at the bottom of the hill?

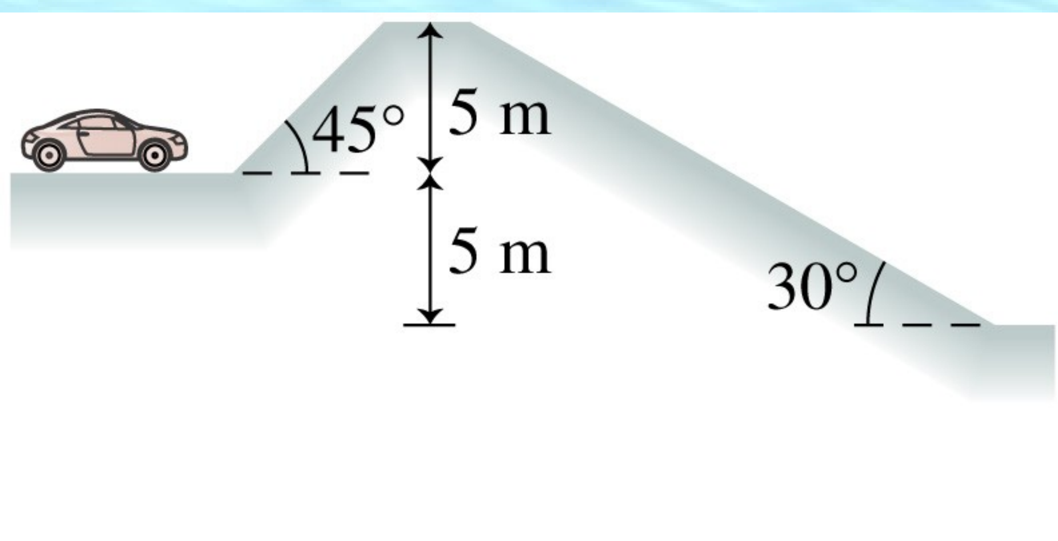
What is its kinetic energy at bottom of hill?

HW: Lecture 8, Problem 2

$$Total\,Energy = U_i + K_i = U_f + K_f$$

$$Total\,Energy = mgh_i + \frac{1}{2}mv_i^2 = mgh_f + \frac{1}{2}mv_f^2$$

$v_f : ?\ K_f : ?$



Gravitational Potential Energy

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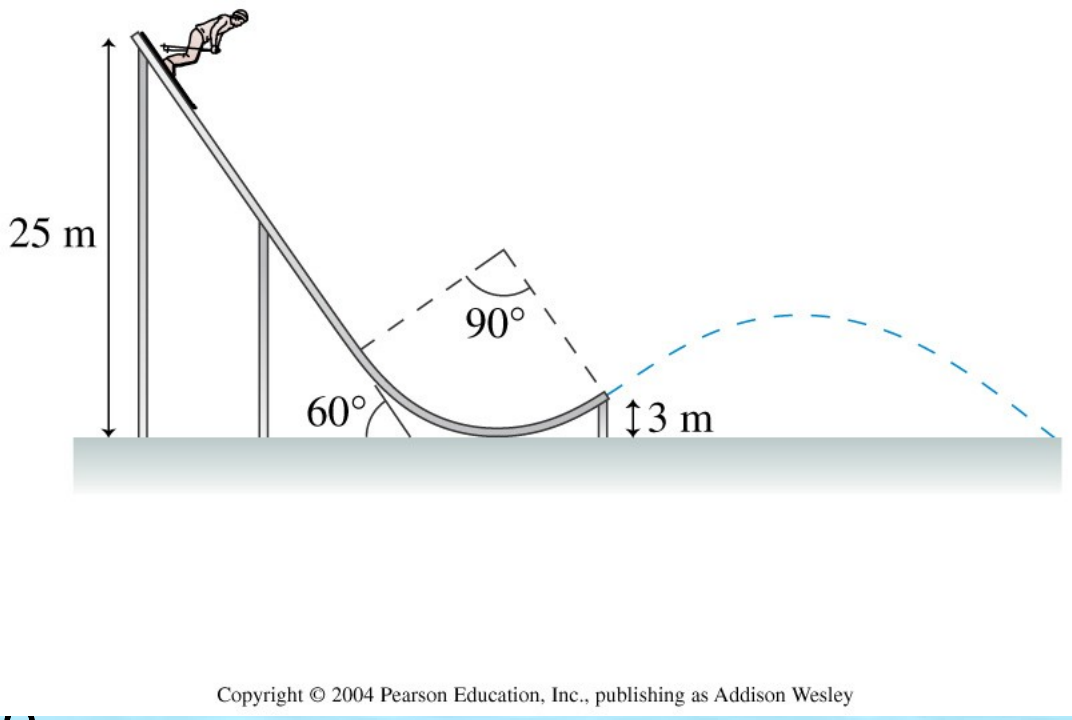


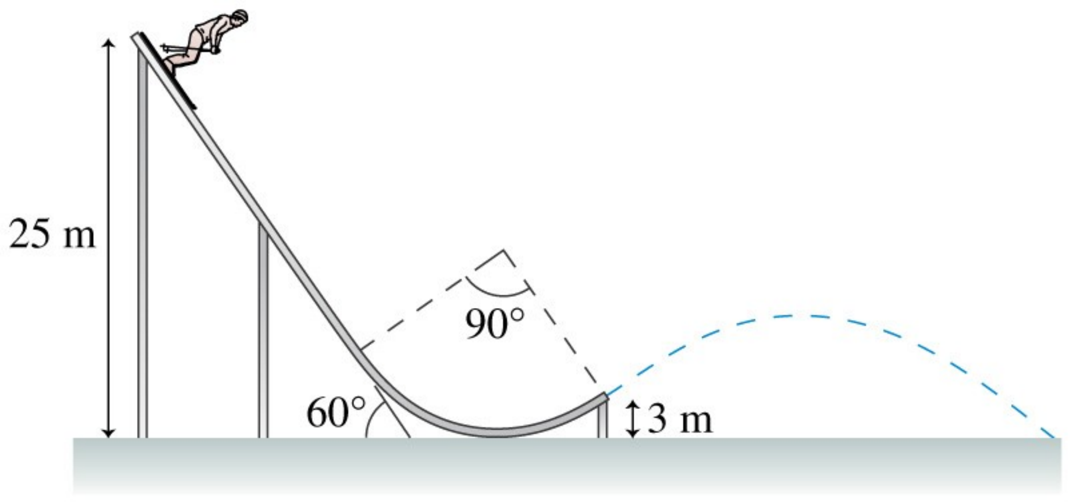
A skier is at rest at top of a ski run. At what speed does he launch off the end of the ramp?

Homework, Lecture 8, Problem 3

Gravitational Potential Energy

$$\text{Total Energy} = U_i + K_i = U_f + K_f$$

$$\text{Total Energy} = m g h_i + \frac{1}{2} m v_i^2 = m g h_f + \frac{1}{2} m v_f^2$$



A skier is at rest at top of a ski run. At what speed does he launch off the end of the ramp?

This works even though skiers path is curved!