Energy, Work, and Power

I. Energy
- kinetic and potential
- conservation

II. Work
- **dot product**
- work-energy relations

III. Springs

IV. Power
- machines and efficiency

	The student will be able to:	HW:
1	Define and apply the concepts of kinetic and potential energy and use the conservation of energy to explain physical phenomena.	1 – 7
2	Calculate mechanical kinetic energy and gravitational potential energy (in Joules) and use conservation of energy to solve related problems.	8 – 16
3	Define and calculate work and solve related problems.	17 – 23
4	Relate and equate work and energy and solve related problems.	24 – 30
5	Solve problems involving work and energy for a mass attached to a spring.	31 – 33
6	Define and calculate power (in Watts or horsepower) and solve related problems.	34 – 41
7	Solve problems involving machines and efficiency.	42 – 45

Work

Work done on an object is defined as the "dot product" of force and displacement:

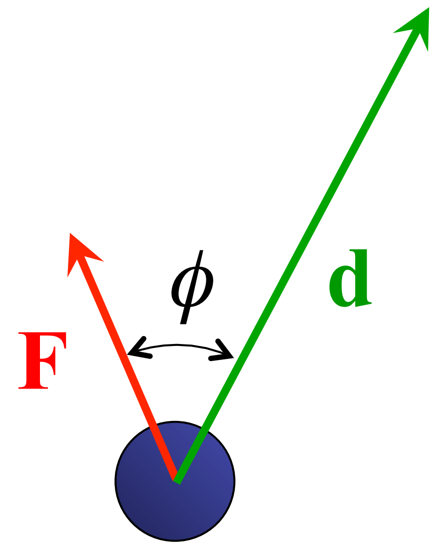
$$W = \vec{F} \cdot \vec{d}$$

which means to multiply *only* the collinear *components* of force & displacement.

This can be shown to equal the following:

$$W = Fd\cos\phi$$

Work



$$W = Fd\cos\phi$$

where: F = magnitude of force

d = magnitude of displacement

ϕ = angle *between* **F** and **d**

(*i.e.* the *difference* in directions)

Force you exert on book:	Displacement of book:	Work you do on the book:
15 N ↑	0 m	0 J
15 N ↑	1 m ↑	15 J
15 N ↑	1 m ↓	−15 J
15 N ↑	2 m ↑	30 J
30 N ↑	2 m ↑	60 J
15 N ↑	2 m →	0 J
5.0 N →	0.5 m →	2.5 J
5.3 N ↗	0.5 m →	1.9 J
0 N	0.1 m ↓	0 J

Key Ideas About Work

- Work is a scalar quantity that may be positive or negative. It does not have a direction like a vector.
- Because energy is required to do work there will always be a corresponding change in energy when work is done.

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When work is done there is always a corresponding energy transfer and/or transformation.

If a force does on an object:	The effect on the object will be:
Positive Work	Increase in Energy
Zero Work	No Change in Energy
Negative Work	Decrease in Energy

The amount of work will precisely equal the amount of change in energy!

Work-Energy Theorem

Positive or negative work done on an object will increase or decrease its kinetic energy:

$$W_{net} = \Delta KE$$

$$W_{net} = KE_f - KE_i$$

where: W_{net} = the sum of work done by all forces acting on the object (may include some negative work values)

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Potential Energy and Work

- Potential energy represents "potential for work to be done" by a certain force.
- Finding the change in potential energy is essentially a "short cut" for finding the work done by a particular *conservative* force.
- The equation $KE_1 + PE_1 = KE_2 + PE_2$ is *not valid* for situations in which work is done by *nonconservative* forces. But, we can "fix it up" and make it more universal…

Work and Conservation of Energy

Work done by nonconservative forces can *alter* the total energy of an object:

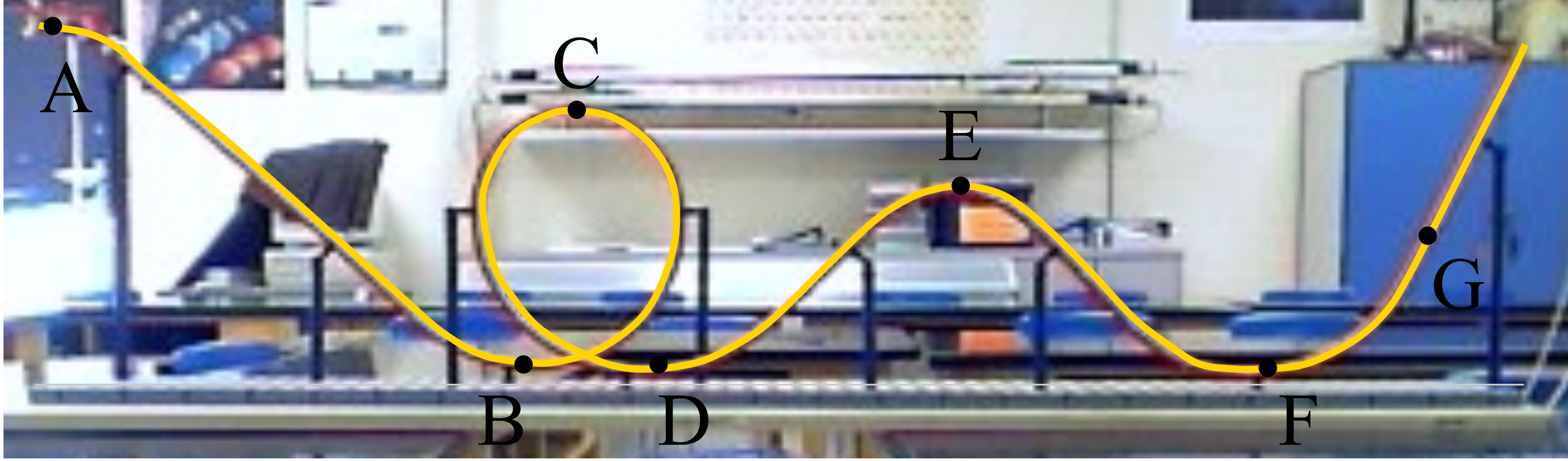
$$W_{NC} + KE_1 + PE_1 = KE_2 + PE_2$$

where: W_{NC} = the sum of work done by all *nonconservative* forces acting on the object between points 1 and 2

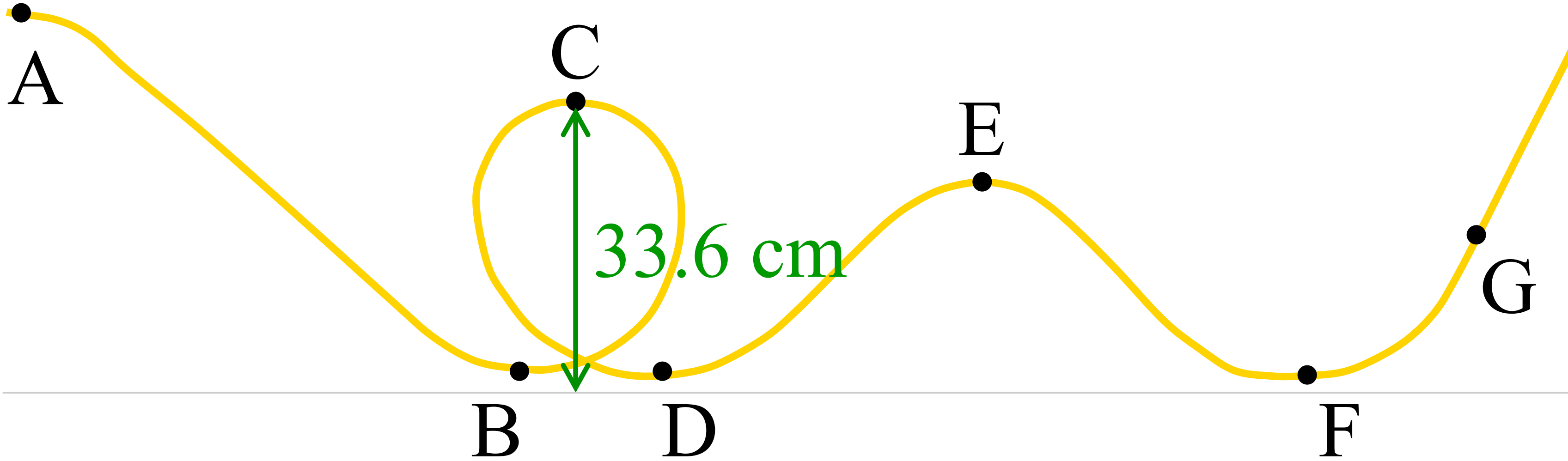
Potential energy can only be determined for **conservative** forces such as gravity or the force of a spring. The amount of work done by such a force depends *only* on change in position.

Nonconservative forces do an amount of work that *depends upon the path* taken as an object moves from one position to another. These include: friction, air resistance, applied forces, tension, etc.

What is the most hazardous point on the track for the riders?



	A	B	C	D	E	F	G
height (cm)	45.3	3.2	33.6	3.2	26.0	3.2	22.8
dist. (cm)	0	70.5	122.0	168.0	216.5	260.5	294.5
radius (cm)	N/A	18.0	12.2	18.0	14.3	23.1	N/A



	A	B	**C**	D	E	F	G
height (cm)	45.3	3.2	**33.6**	3.2	26.0	3.2	22.8
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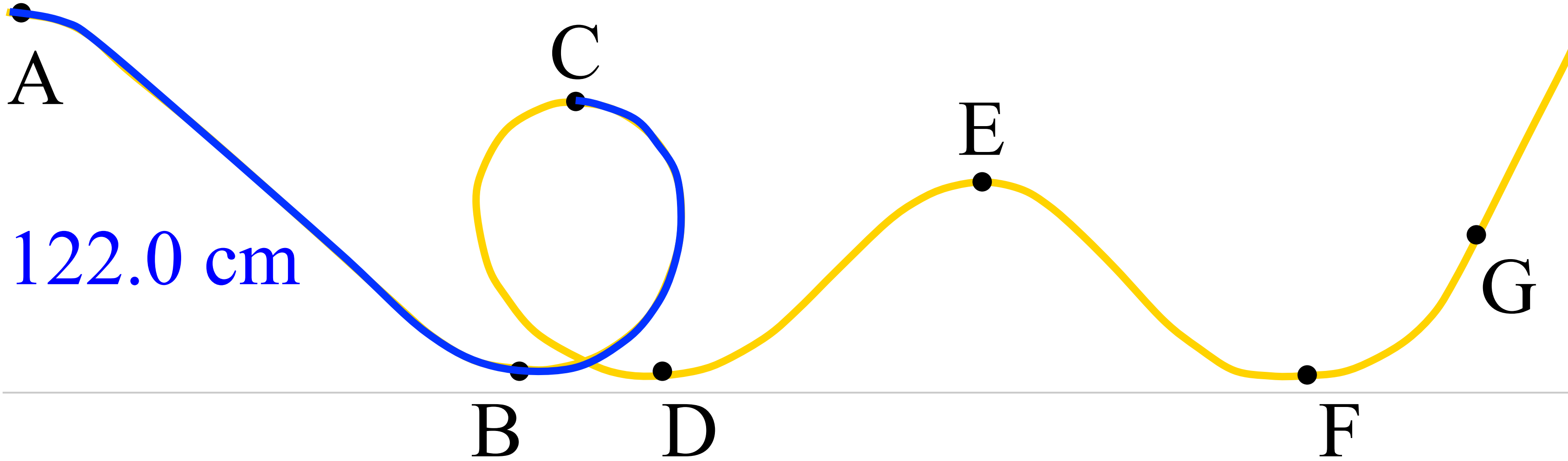

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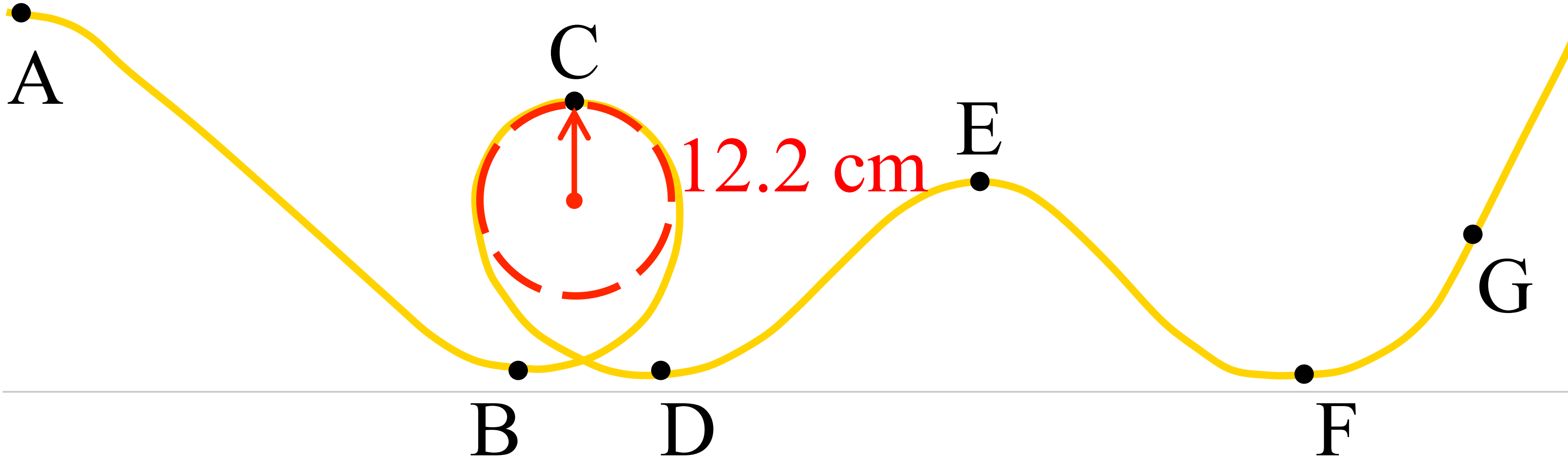

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radius (cm)	N/A	18.0	12.2	18.0	14.3	23.1	N/A
speed (m/s)	0						0
acc. (m/s^2)	–						–

Determine the speed and centripetal acceleration.

Mass = 57.2 g

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dist. (cm)	0	70.5	122.0	168.0	216.5	260.5	294.5
radius (cm)	N/A	18.0	12.2	18.0	14.3	23.1	N/A
speed (m/s)	0	2.68	0.683	2.39	0.735	2.09	0
acc. (m/s^2)	–	40.0	3.82	31.9	3.78	18.8	–

Force of friction = 0.0428 N
Mass = 57.2 g