MECHANICAL ENERGY

NEW MEANINGS

2 Volunteers

- Place a chair on the table
- Hold a chair at the same height
- the big question:
    - who did more work?

Work

$$W = F\,d$$

Work = **F**orce **x** **d**istance

- Joules (J) = N m
- Force and Distance must be collinear

col·lin·ear *adj* \kə-ˈli-nē-ər, kä-\

Definition of COLLINEAR

1 : lying on or passing through the same straight line

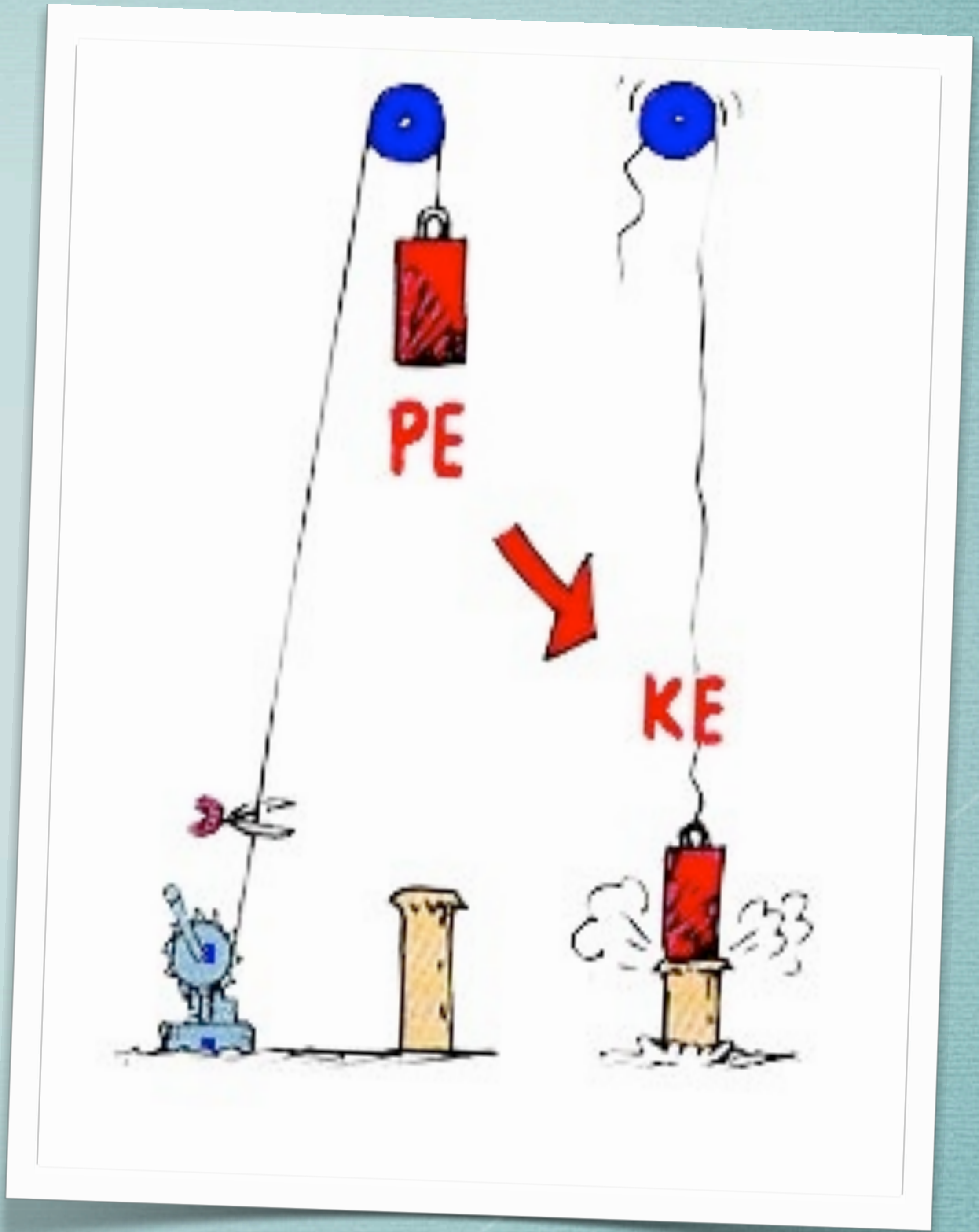
2 : having axes lying end to end in a straight line <*collinear* antenna elements>

— **col·lin·ear·i·ty** *noun*

Kinetic & Potential

Kinetic - Energy of a mass in motion

Potential - Energy stored for later



Potential Energy

$$PE = mgh$$

- mass (kg)
- gravity (9.8 m/s^2)
    - height (m)
- the height must be relative to some "ground" level

Kinetic Energy

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

- mass (kg)
- velocity (m/s)
- KE is often relative to an original velocity of 0 m/s (0 Joules)

Conservation of Energy

- Find the total Energy at any one point
- The total can not change in a closed system
- KE is often used to find final velocities

Another Volunteer

Another Volunteer

- A race to put the chair on the desktop

Another Volunteer

- A race to put the chair on the desktop

Another Volunteer

- A race to put the chair on the desktop
- Who was stronger?

Another Volunteer

- A race to put the chair on the desktop
- Who was stronger?
- Who did more Work?

Another Volunteer

- A race to put the chair on the desktop
- Who was stronger?
- Who did more Work?
- So what's the difference?

Power

How Fast Work is Done

P = **W**ork / **t**ime

- Watts (W) = J/s
- 1 hp = 550 ft lb / s = 746 W

Sled Pull

Work and Power

- A Father uses a force of 150N to pull a sled with a total weight of 500 N. The Rope makes an angle of 35º with the horizontal. They go a distance of 75 m in 2 minutes

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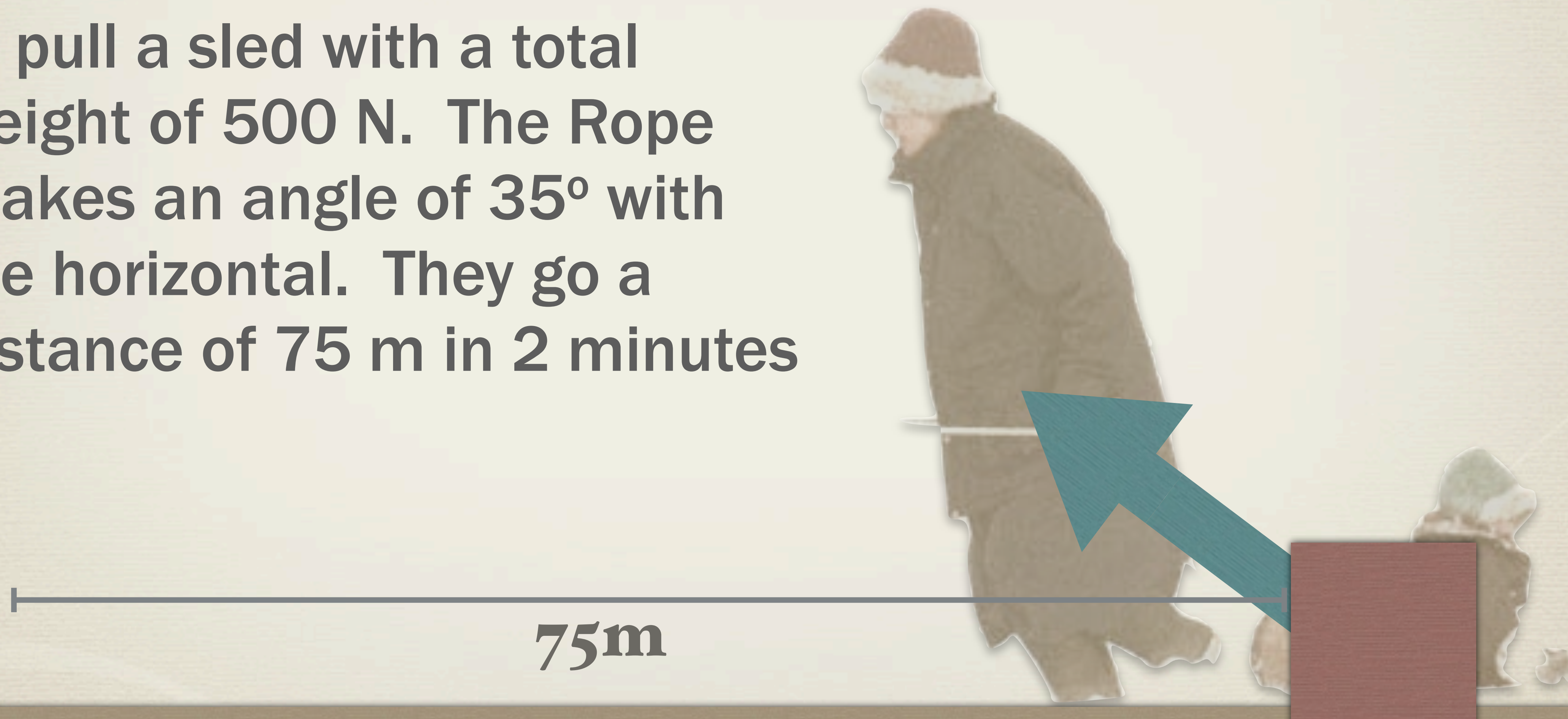

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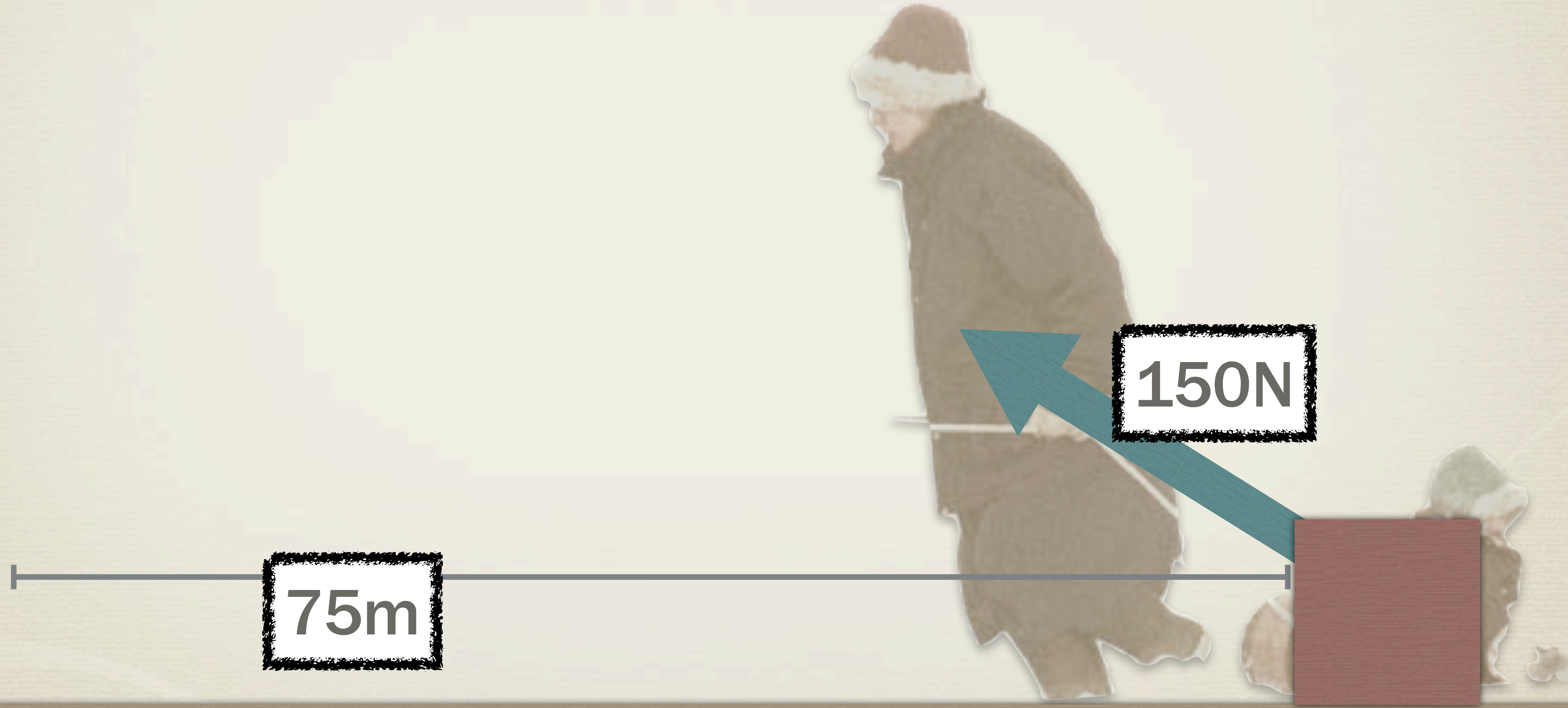

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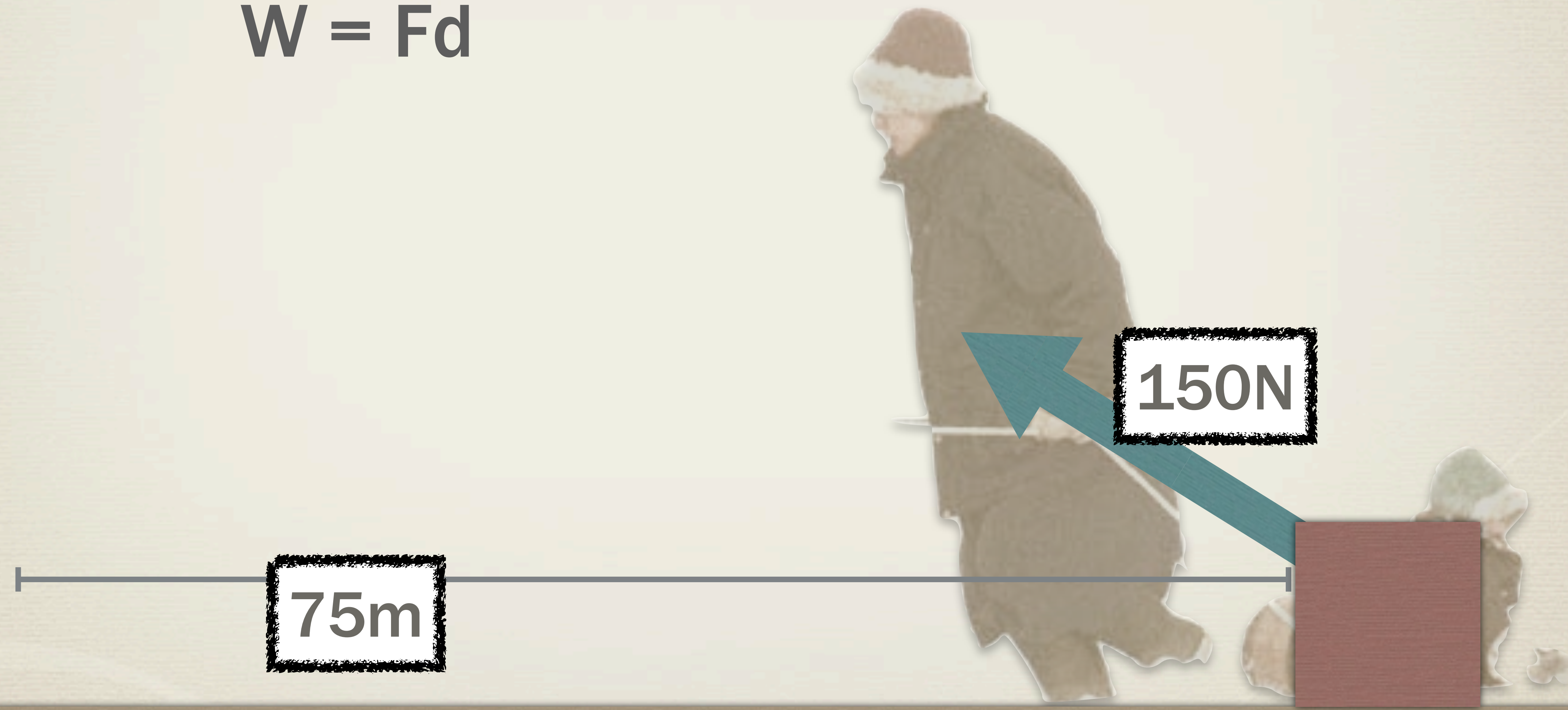
W = Fd

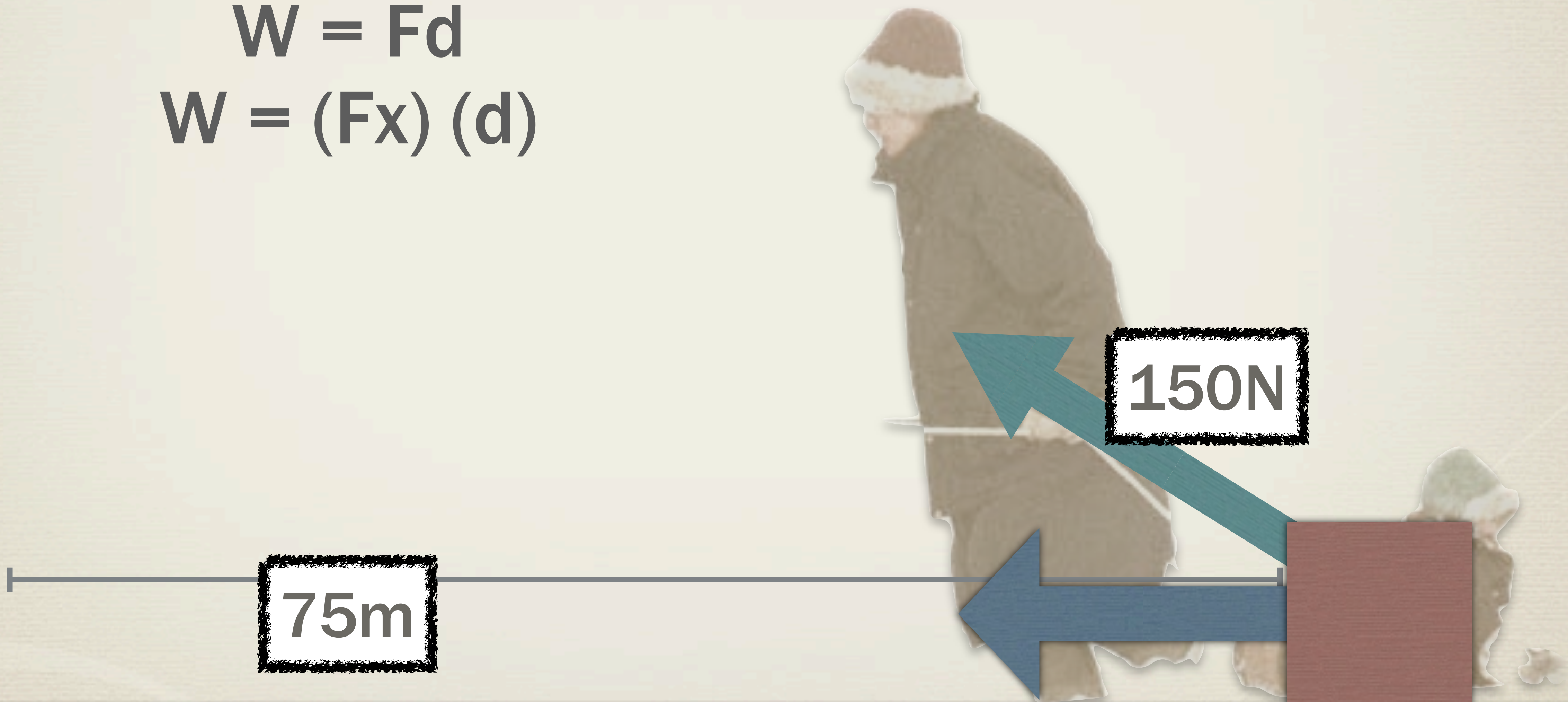


Work and Power

- A Father uses a force of 150 N to pull a sled with a total weight of 500 N. The Rope makes an angle of 35 degrees with the horizontal. They go a distance of 75 m in 2 minutes

$$W = Fd$$

$$W = (F_x)(d)$$



Work and Power

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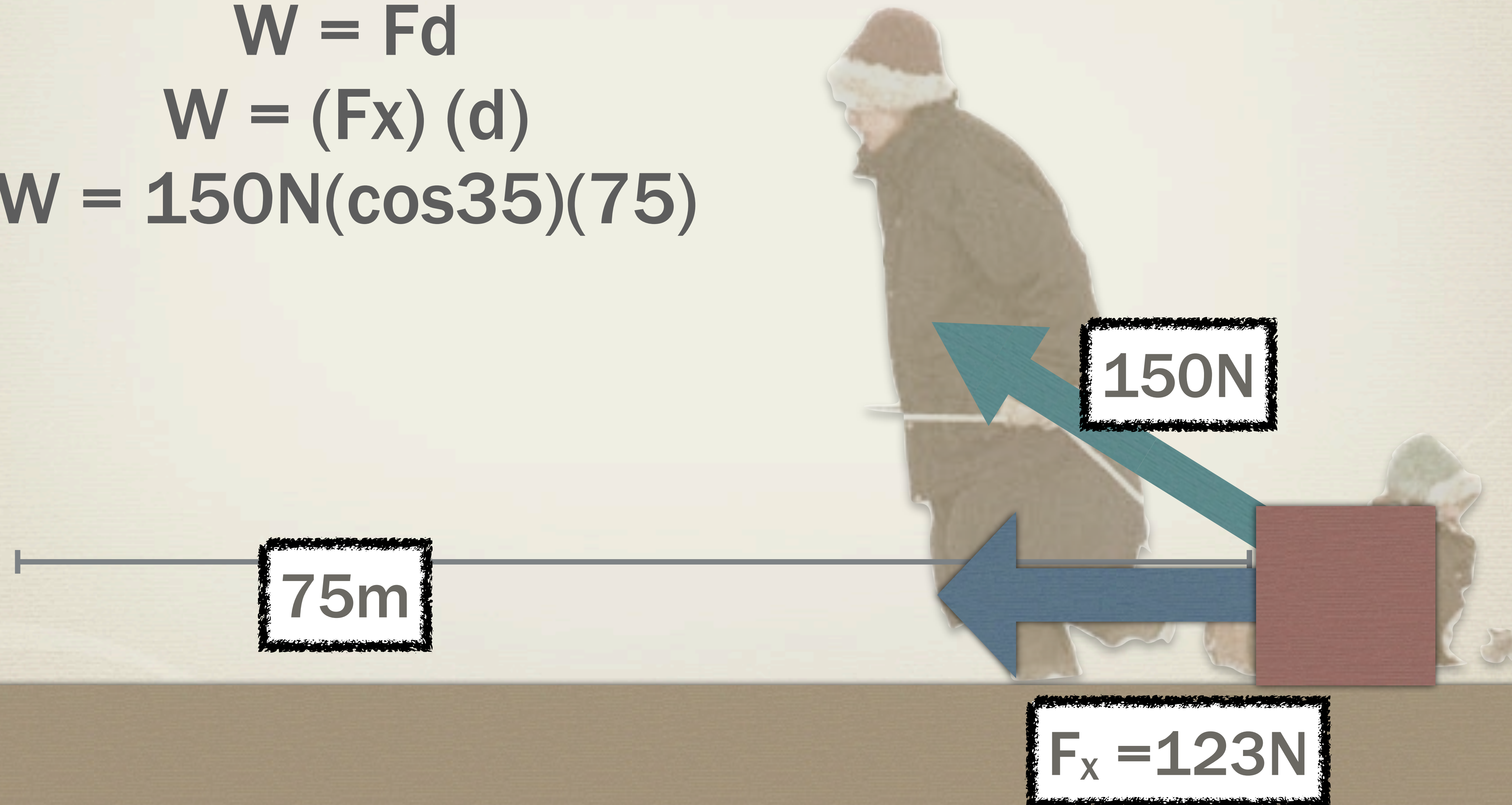
$$W = Fd$$

$$W = (Fx)(d)$$

$$W = 150N(\cos 35)(75)$$



Work and Power

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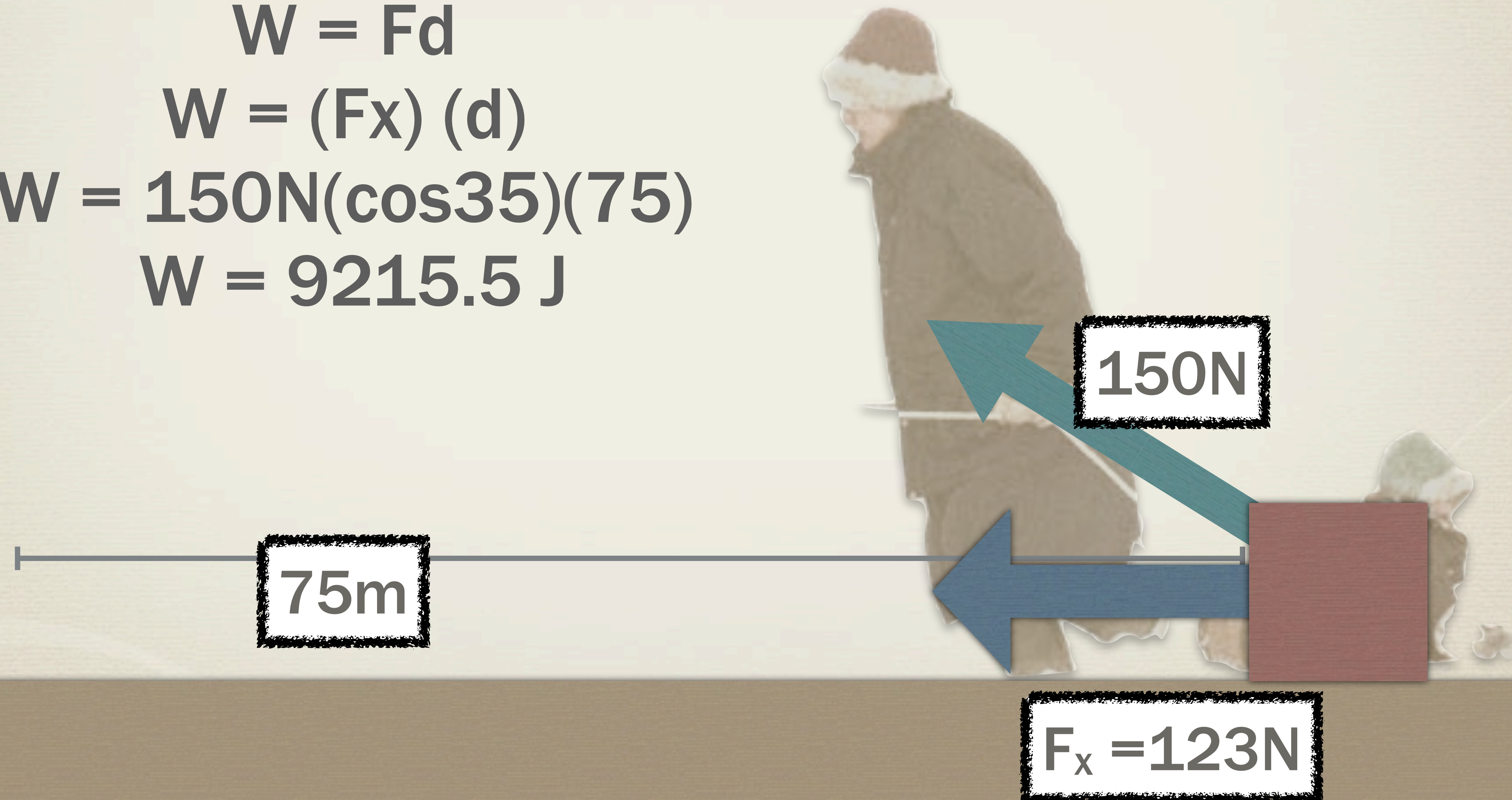
$$W = Fd$$

$$W = (Fx)(d)$$

$$W = 150N(\cos 35)(75)$$

$$W = 9215.5\ J$$



Work and Power

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$$W = Fd$$

$$W = (Fx)\ (d)$$

$$W = 150N(\cos 35)(75)$$

$$W = 9215.5\ J$$

note: Only the "x" force was used and 500 N was not important

Work and Power

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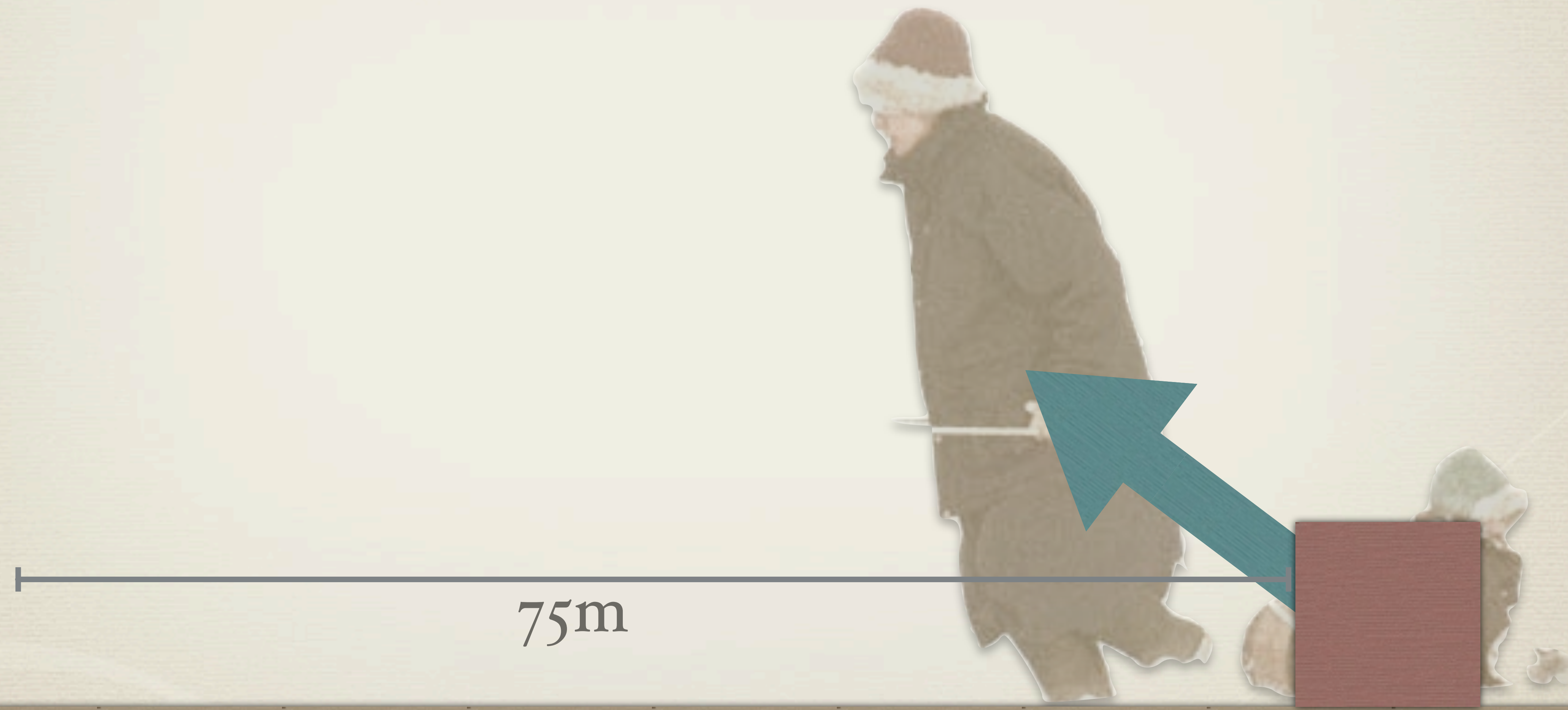

Work and Power

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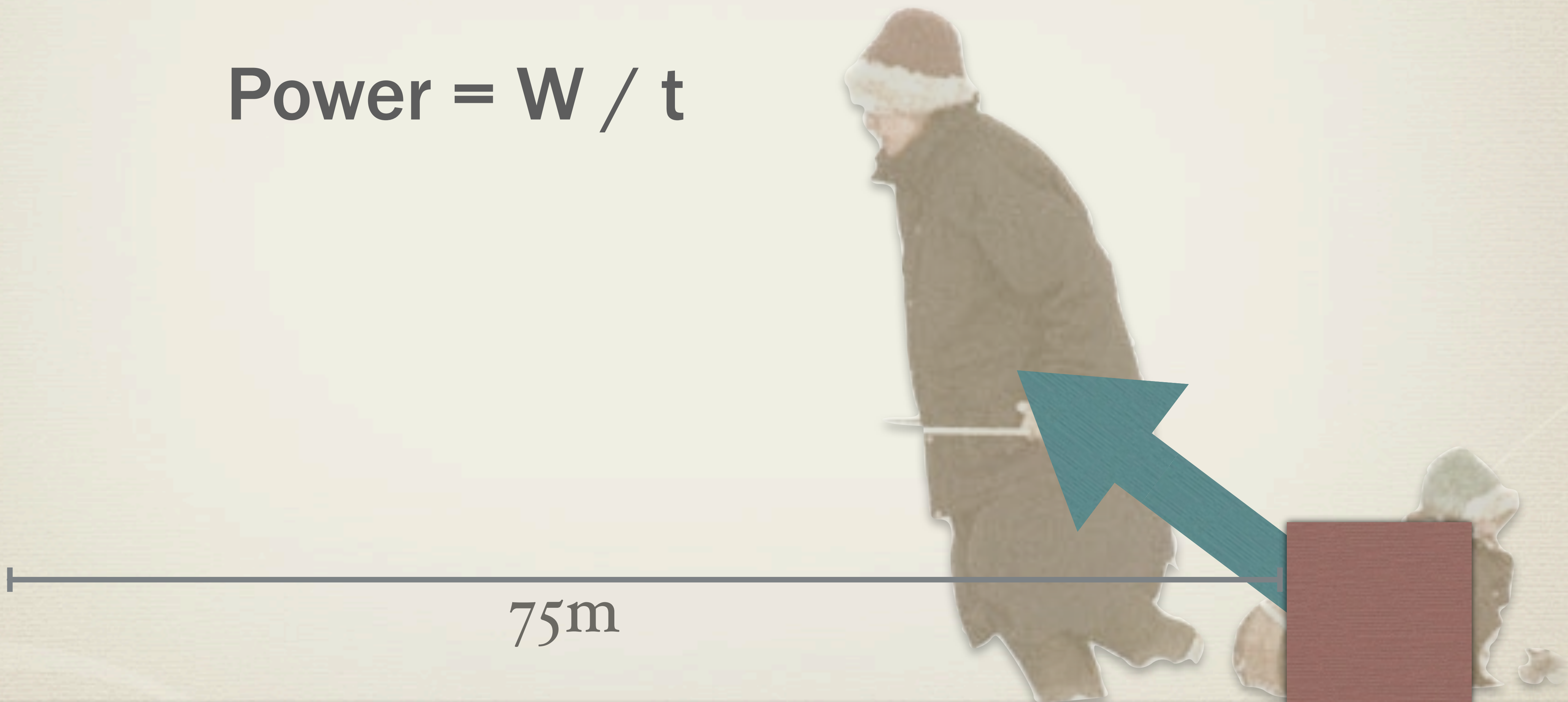
Power = W / t



Work and Power

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$$\text{Power} = W / t$$

$$P = 9215.5 \text{ J} / 120 \text{ s}$$

Work and Power

- A father uses a force of 150 N to pull a sled with a total weight of 500 N. The Rope makes an angle of 35 degrees with the horizontal. They go a distance of 75 m in 2 minutes

$$\text{Power} = W / t$$
$$P = 9215.5\ J / 120\ s$$
$$P = 76.8\ \text{Watts}$$

75m

Work and Power

- A father uses a force of 150 N to pull a sled with a total weight of 500 N. The Rope makes an angle of 35 degrees with the horizontal. They go a distance of 75 m in 2 minutes

Power = W / t

P = 9215.5 J / 120 s

P = 76.8 Watts

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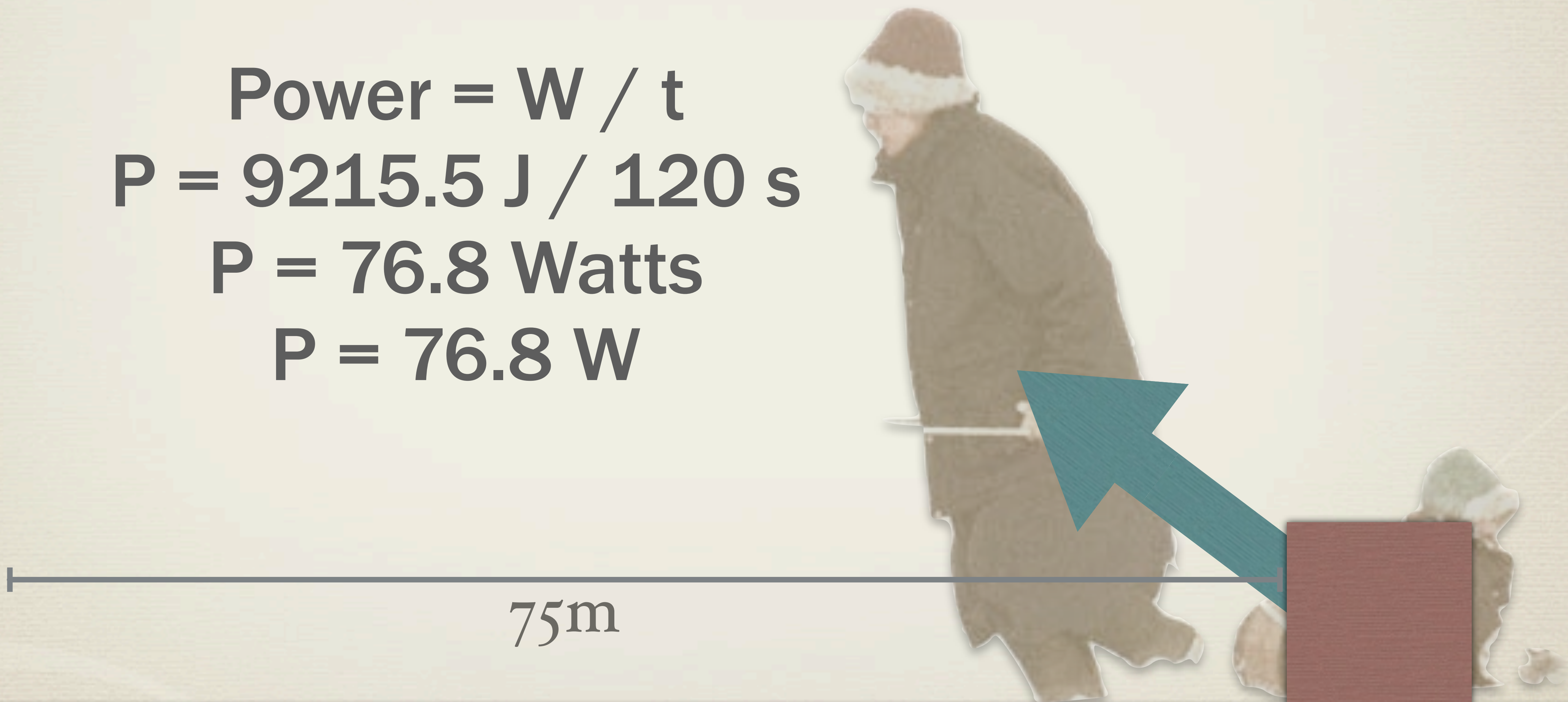
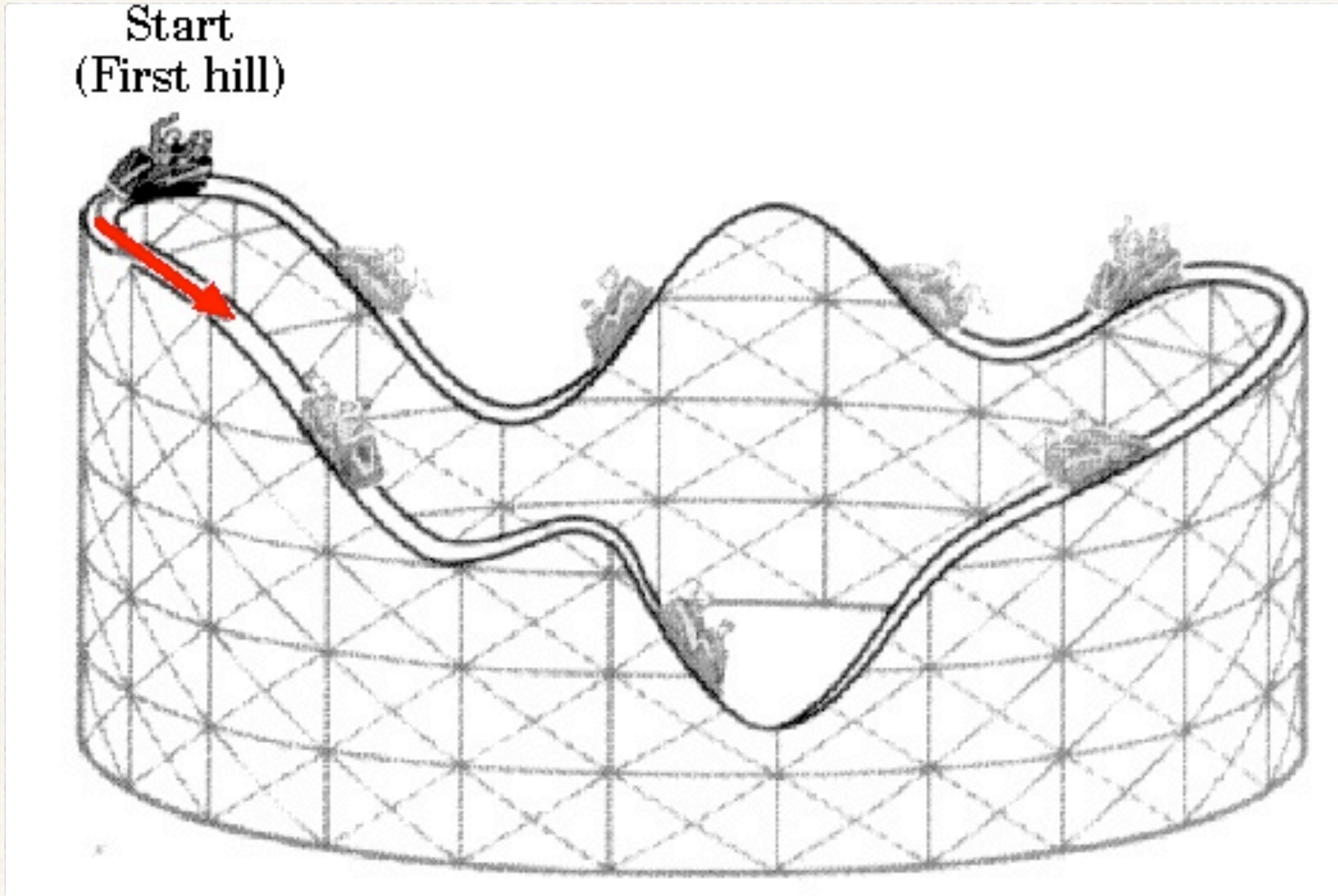
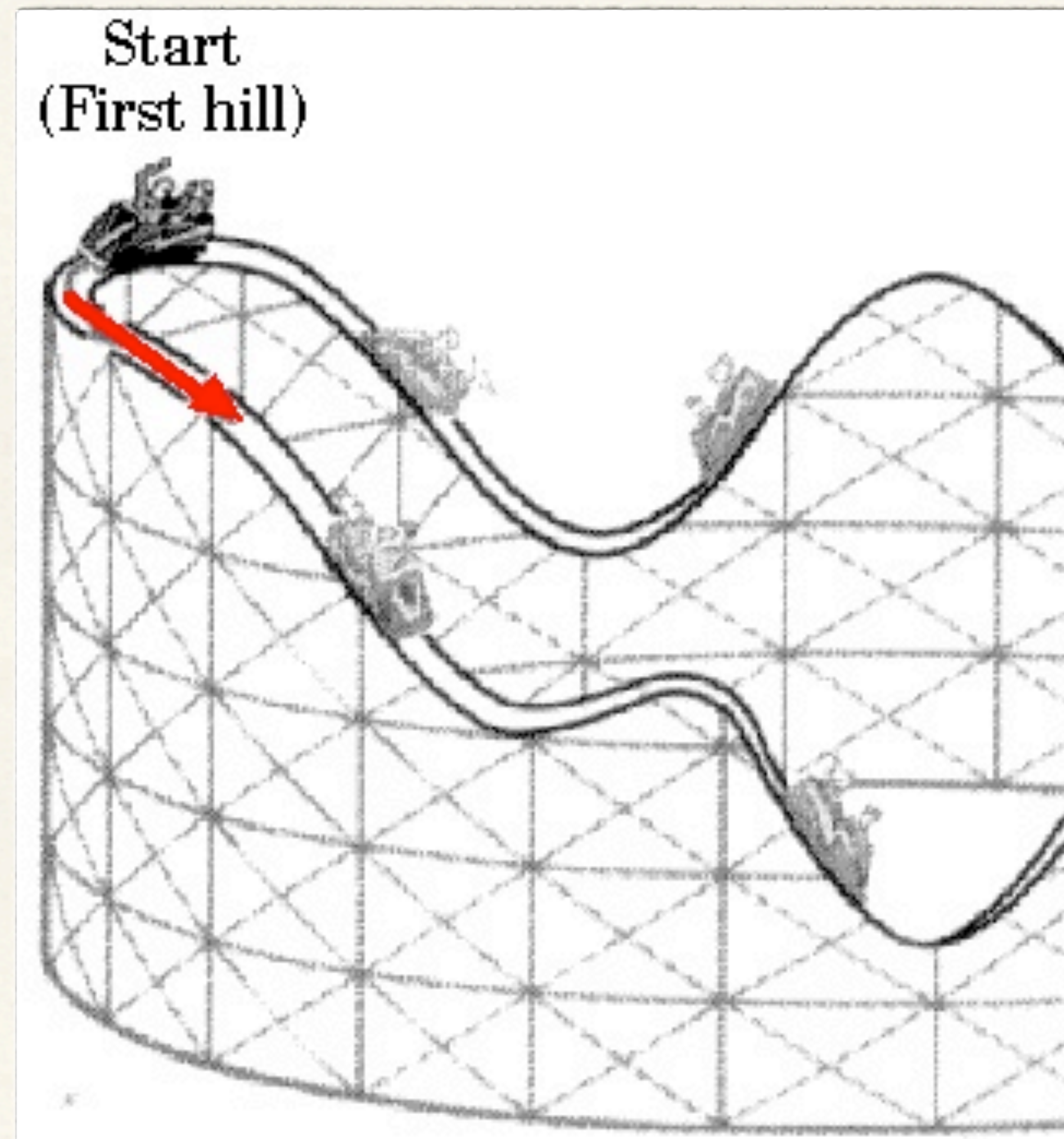




The Roller Coaster

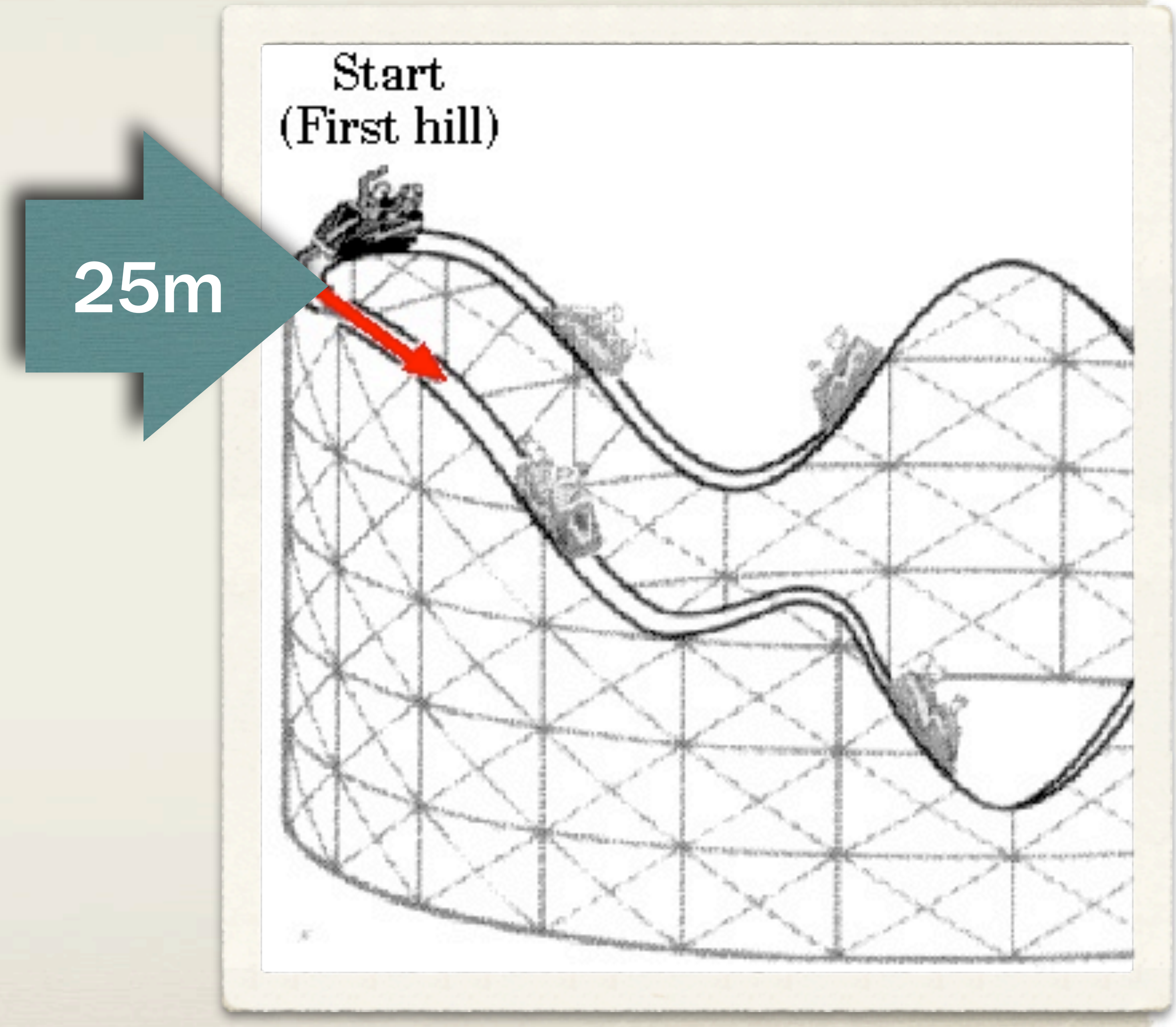
Conservation of Energy Problems

Roller Coaster



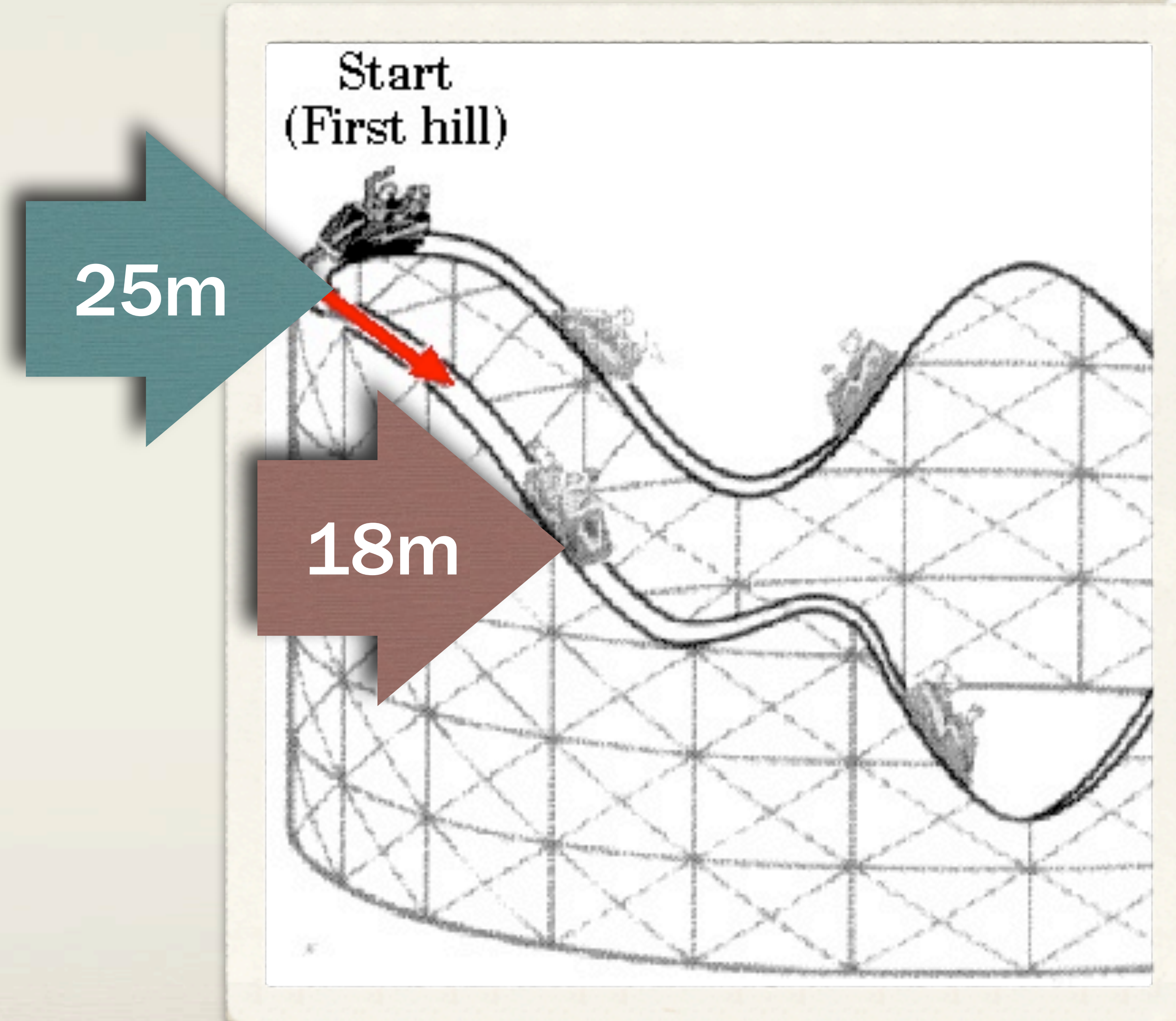
Roller Coaster

- If the roller coaster car has a total mass of 1000 kg, and starts with almost no velocity at the top...



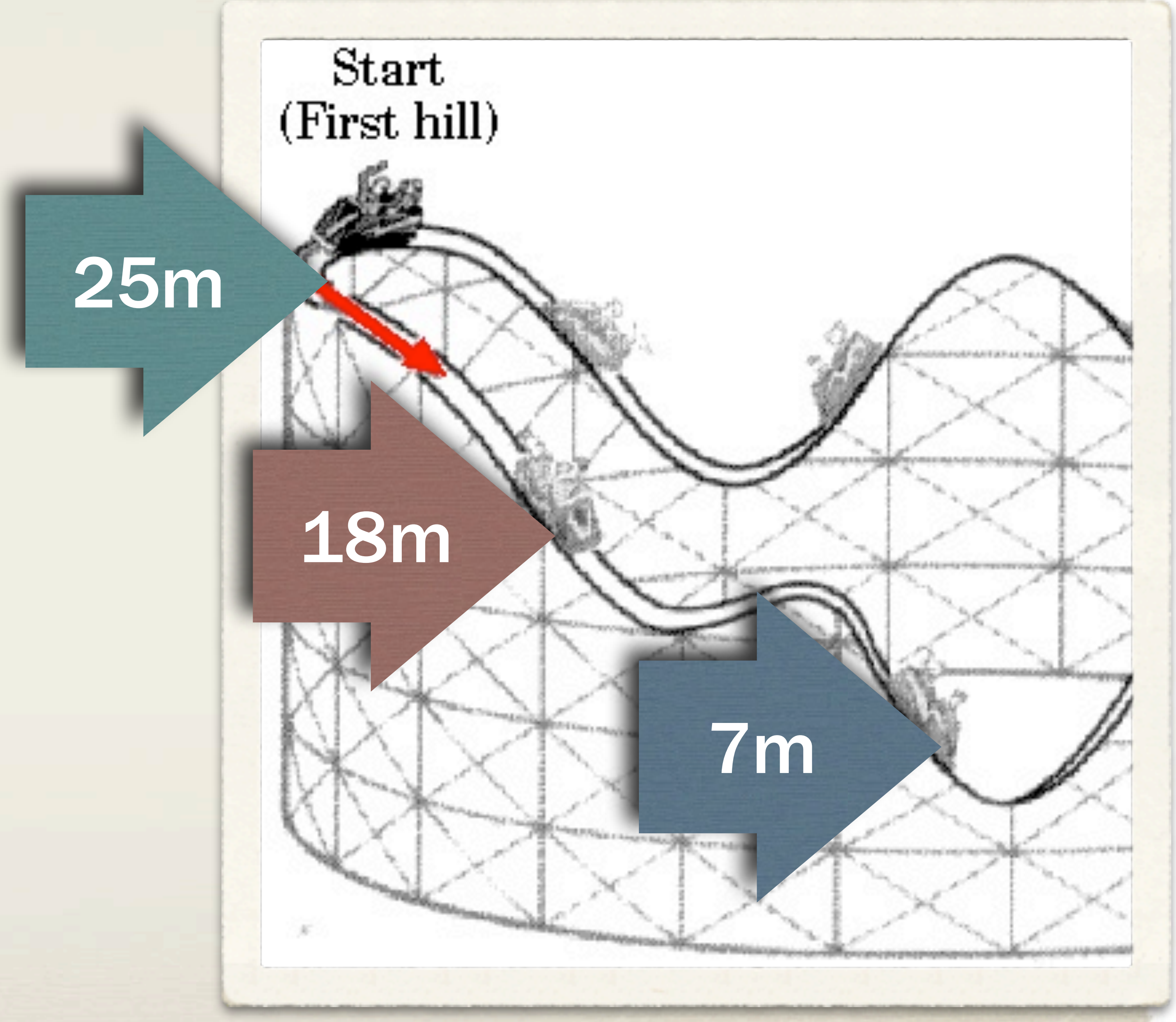
Roller Coaster

- If the roller coaster car has a total mass of 1000 kg, and starts with almost no velocity at the top...
- Find the velocity at point B



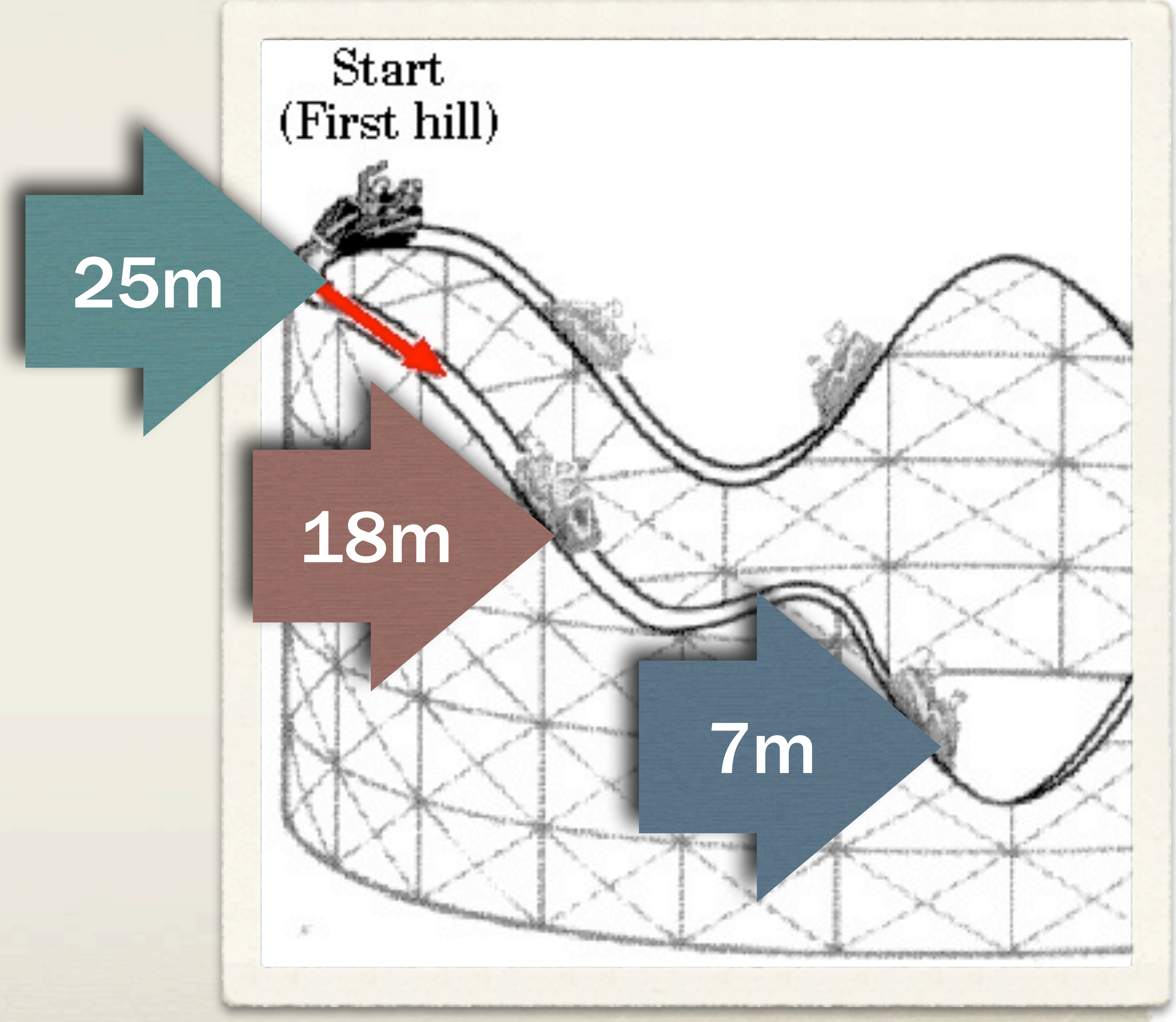
Roller Coaster

- If the roller coaster car has a total mass of 1000 kg, and starts with almost no velocity at the top...
- Find the velocity at point B
- Find the velocity at point C



Make it Simple

- If the roller coaster car has a total mass of 1000 kg, and starts with almost no velocity at the top...
- Find the velocity at point B
- Find the velocity at point C



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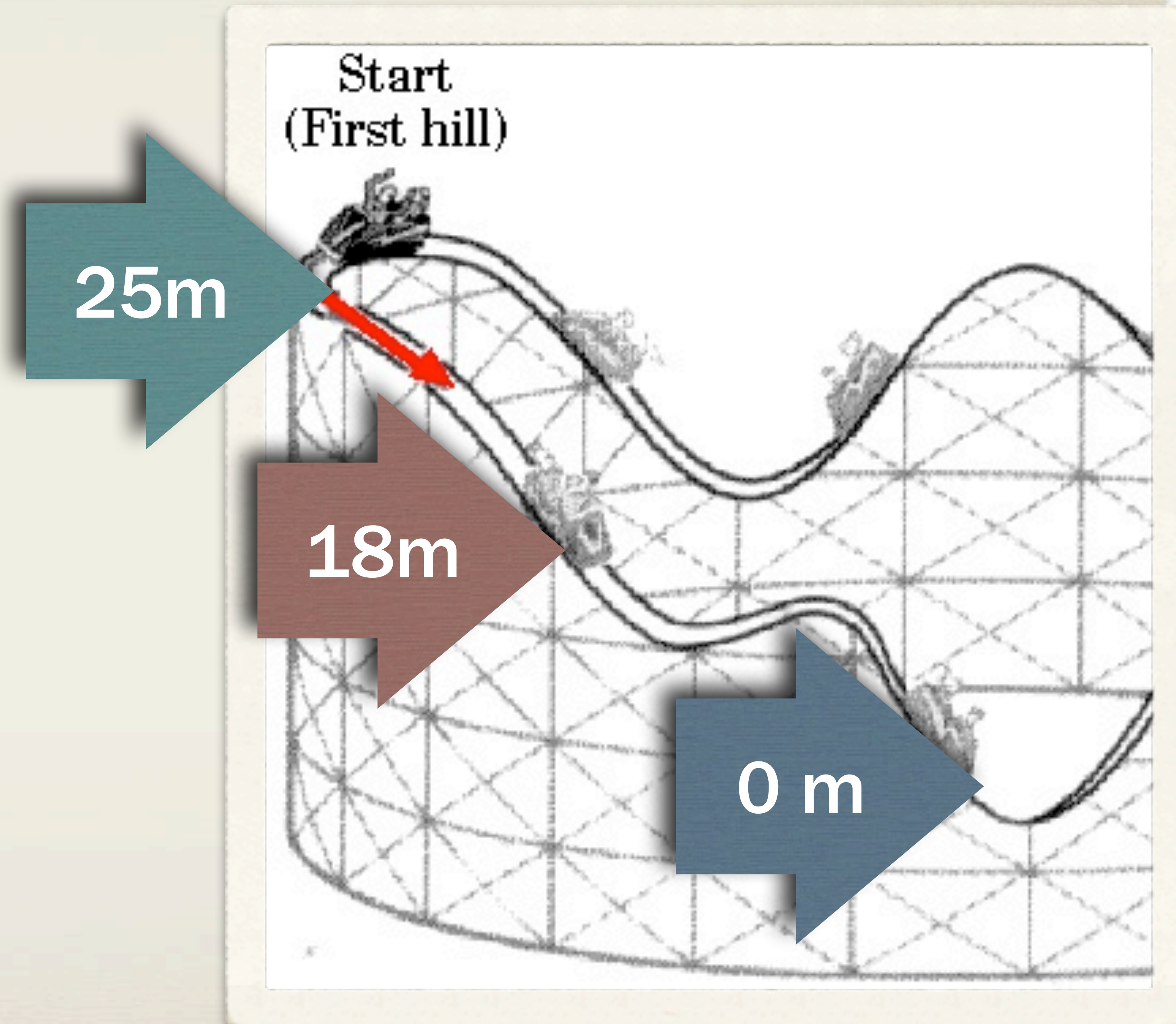

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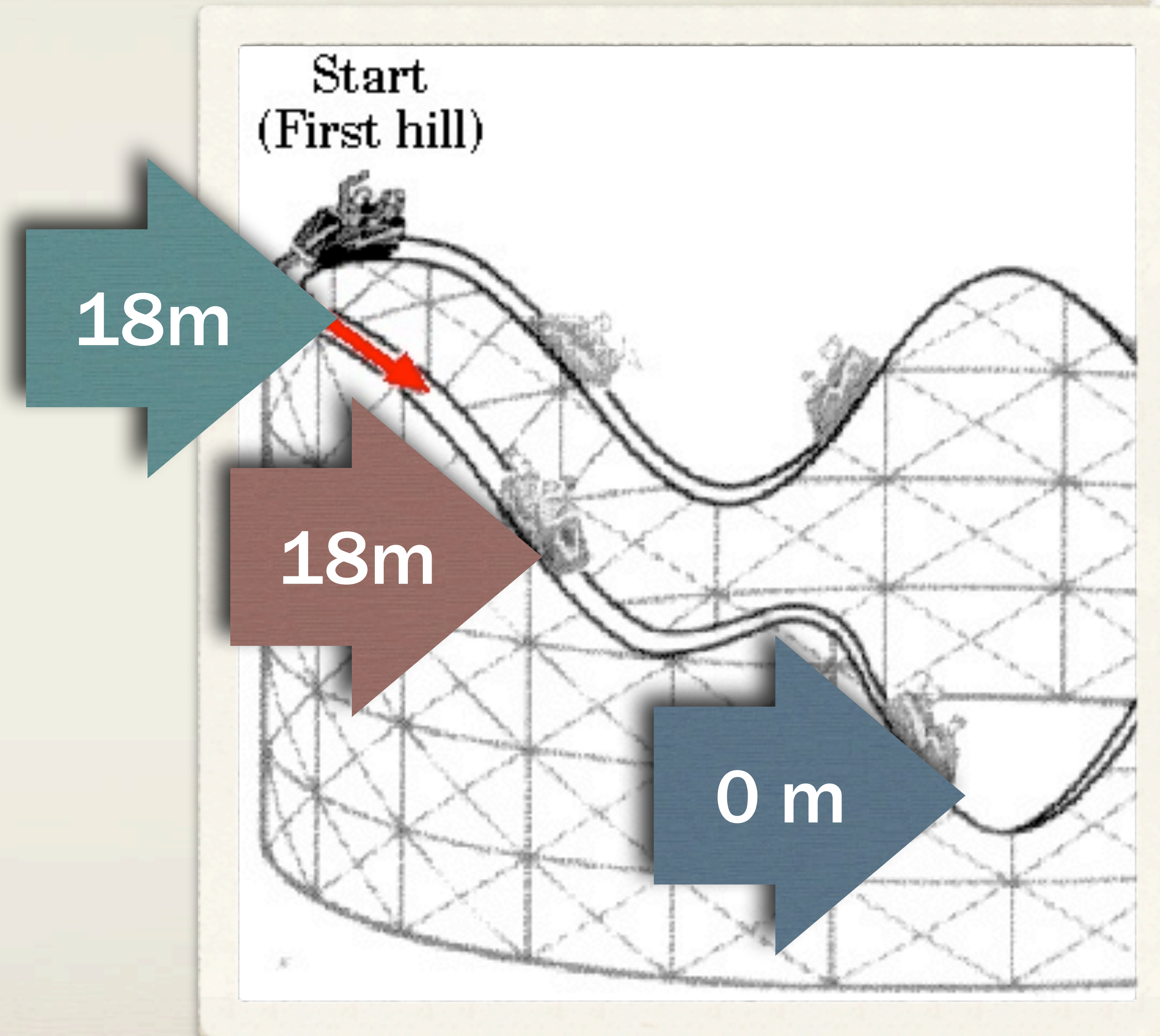

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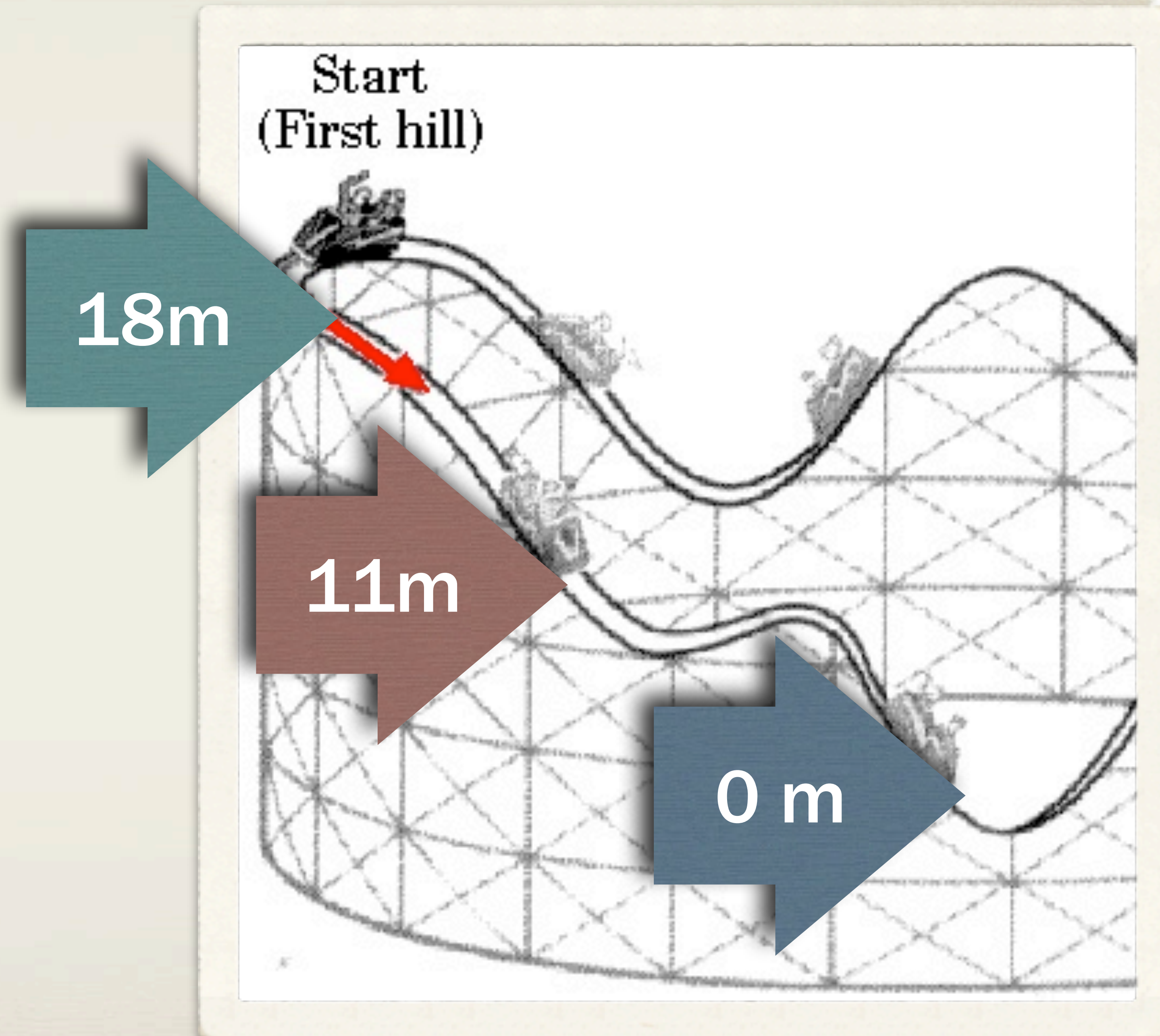
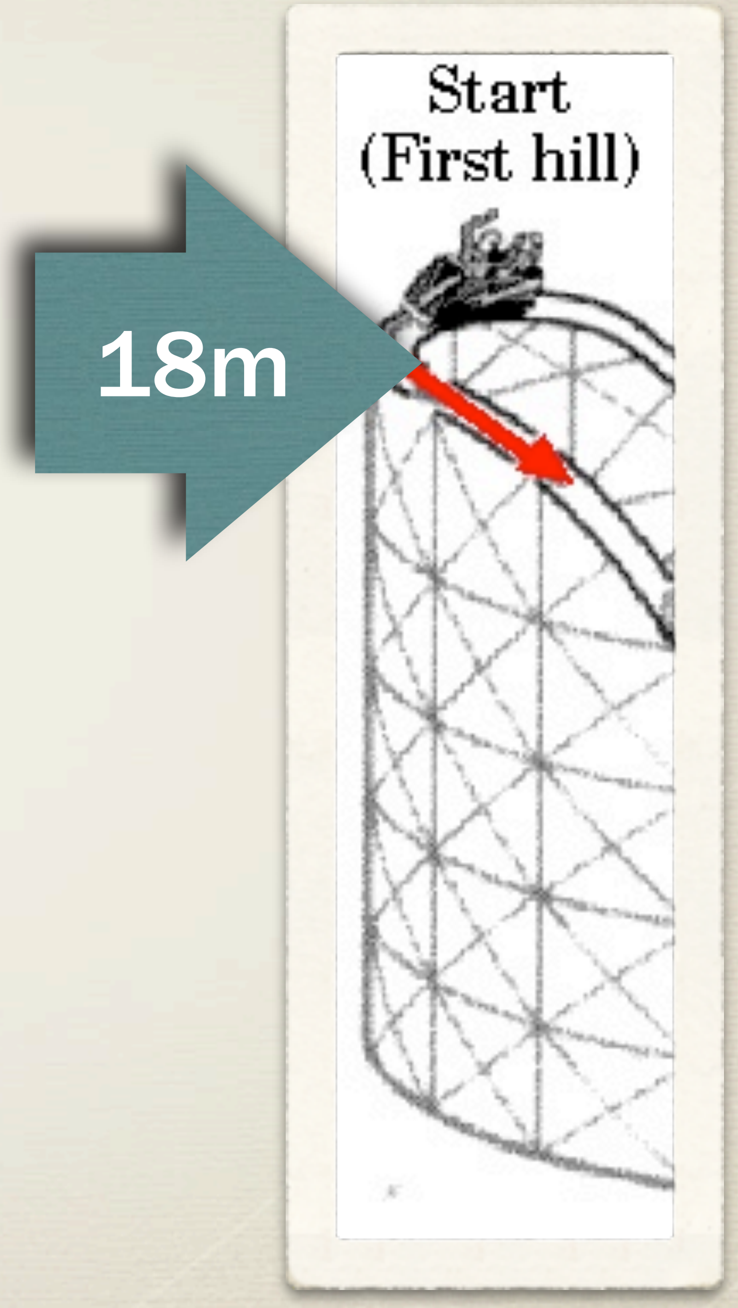
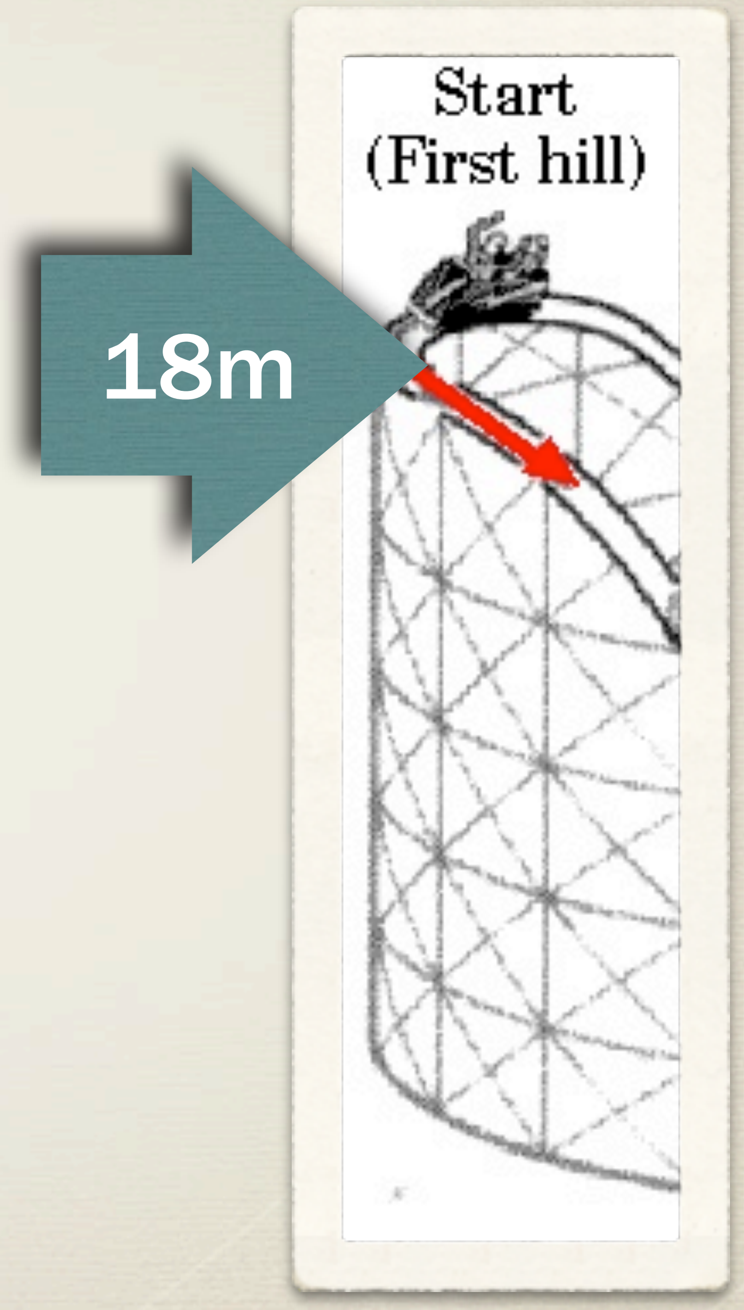


At the top (18m)



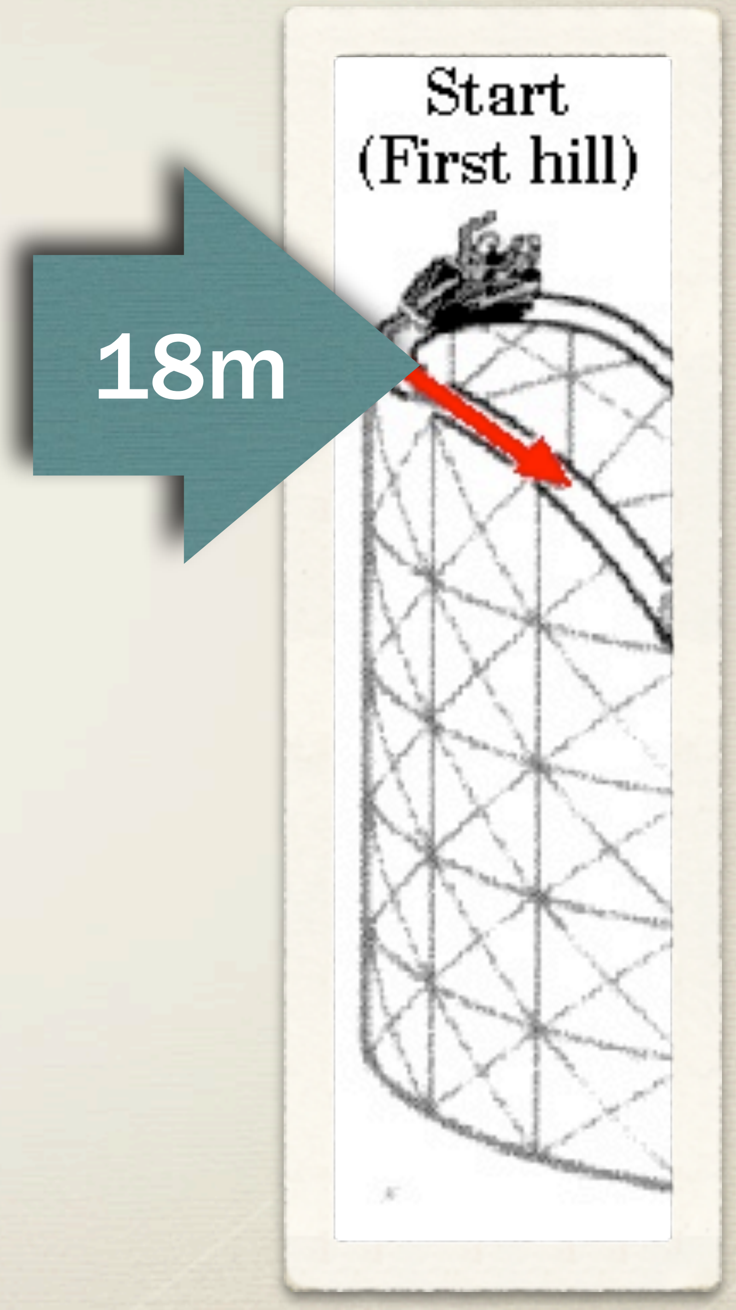
At the top (18m)

- Given Info:
  - m = 1000kg
  - v = 0 m/s
  - h = 18 m



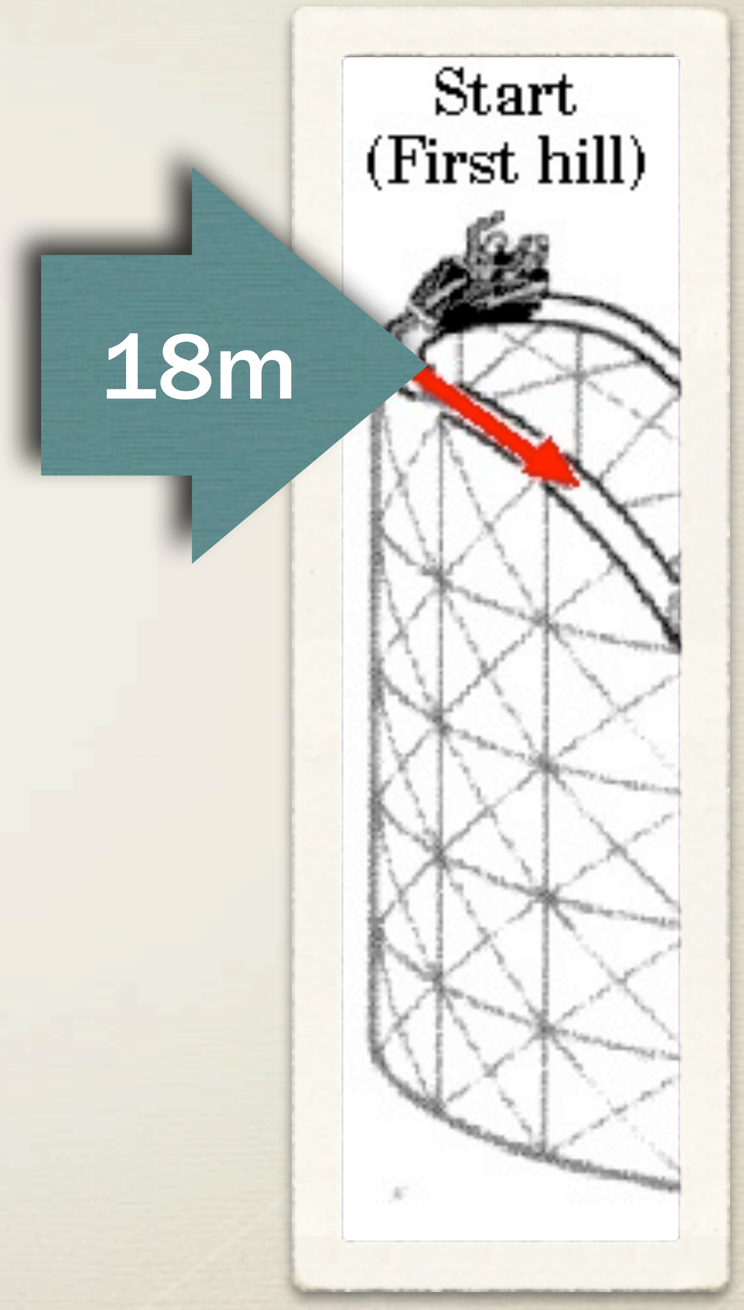
At the top (18m)

- Given Info:
  - m = 1000kg
  - v = 0 m/s
  - h = 18 m
- PE = mgh



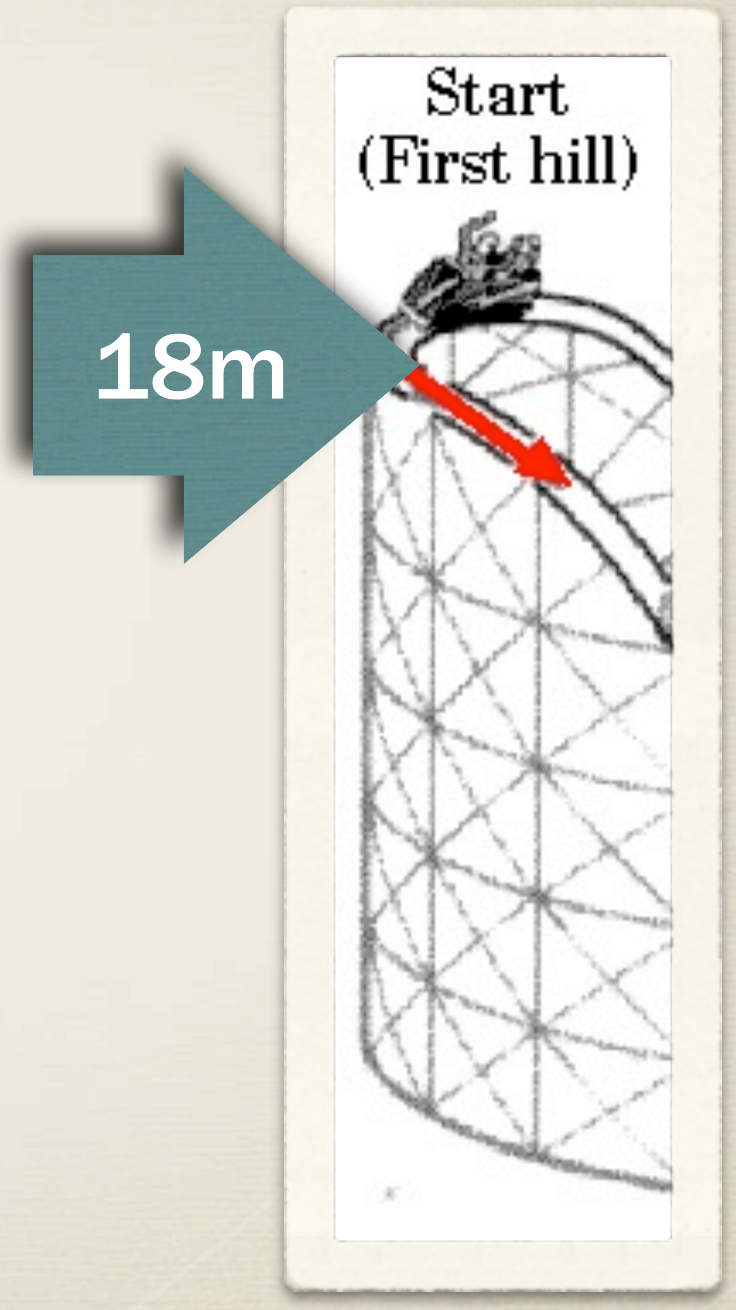
At the top (18m)

- Given Info:
  - m = 1000kg
  - v = 0 m/s
  - h = 18 m
- PE = mgh
- PE = (1000)(9.8)(18)



At the top (18m)

- Given Info:
  - m = 1000kg
  - v = 0 m/s
  - h = 18 m
- PE = mgh
- PE = (1000)(9.8)(18)
- PE = 176,400J



At the top (18m)

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- PE = mgh
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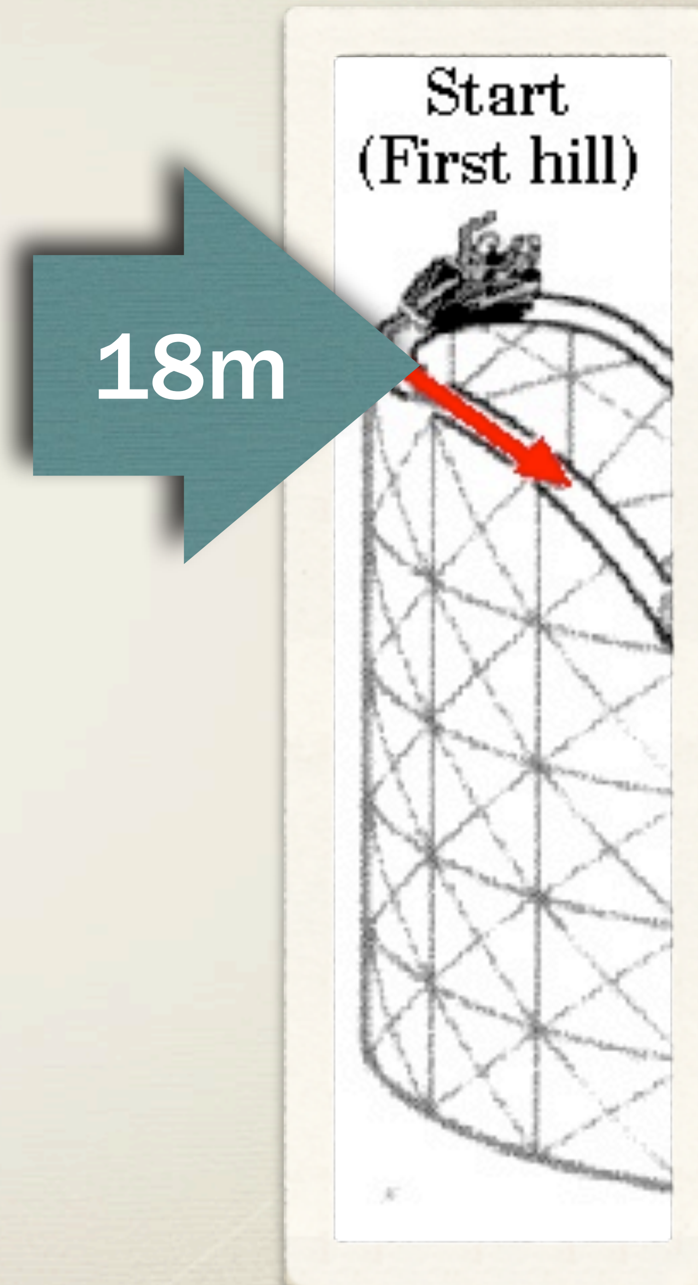
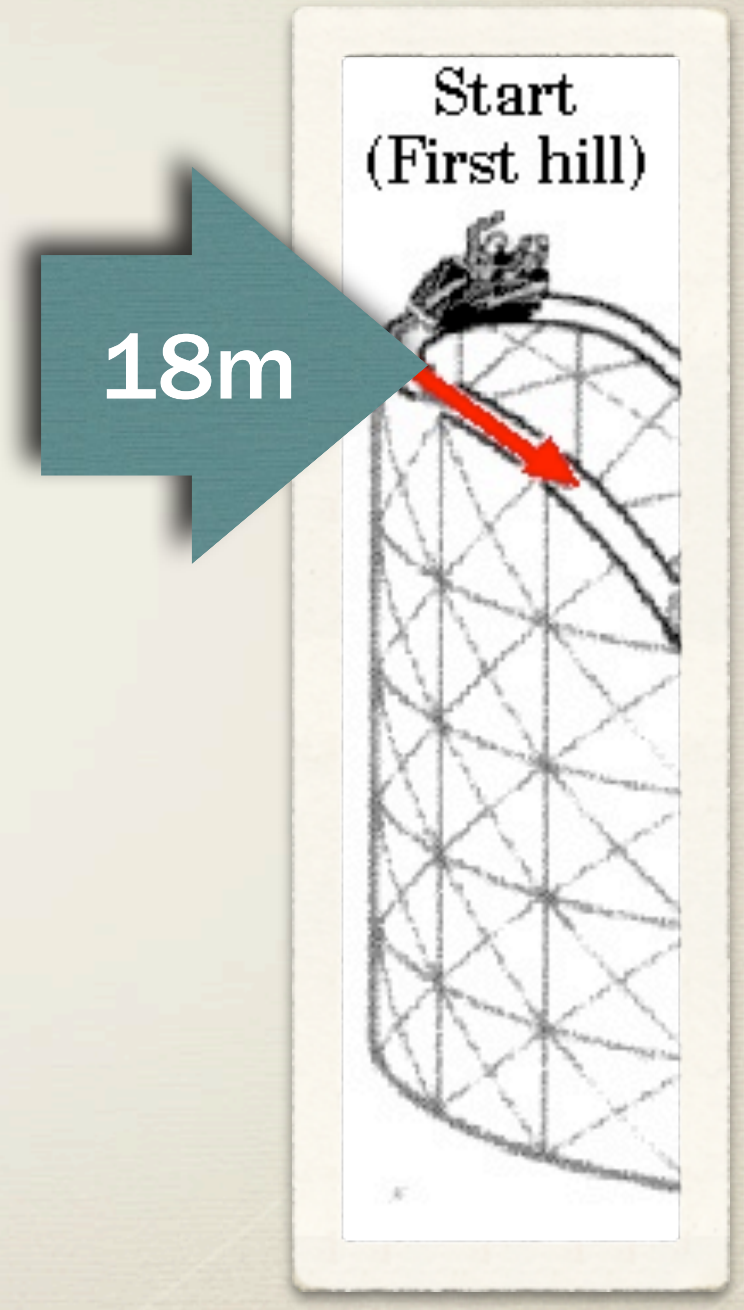
- PE = 176,400J
  - *PE = 176.4 kJ*



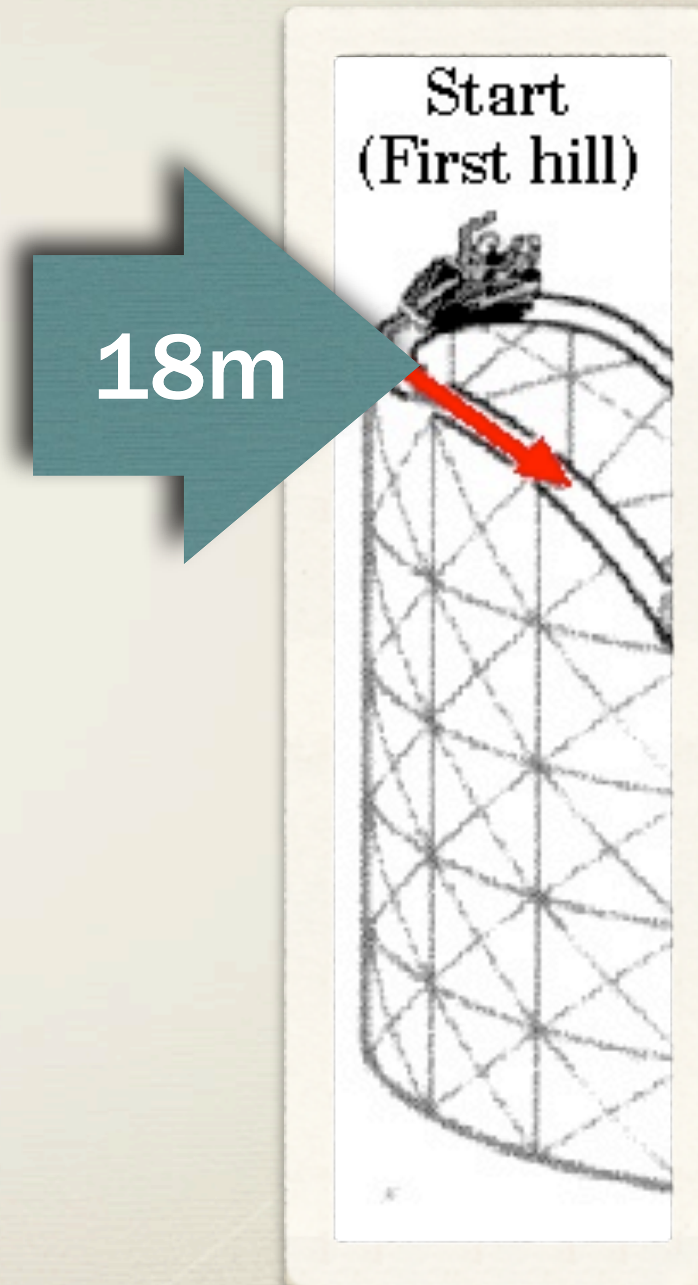
At the top (18m)

- Given Info:
  - m = 1000kg
  - v = 0 m/s
  - h = 18 m
- PE = mgh
- PE = (1000)(9.8)(18)
- PE = 176,400J
  - *PE = 176.4 kJ*
- KE = ½(mv^2)= 0 J

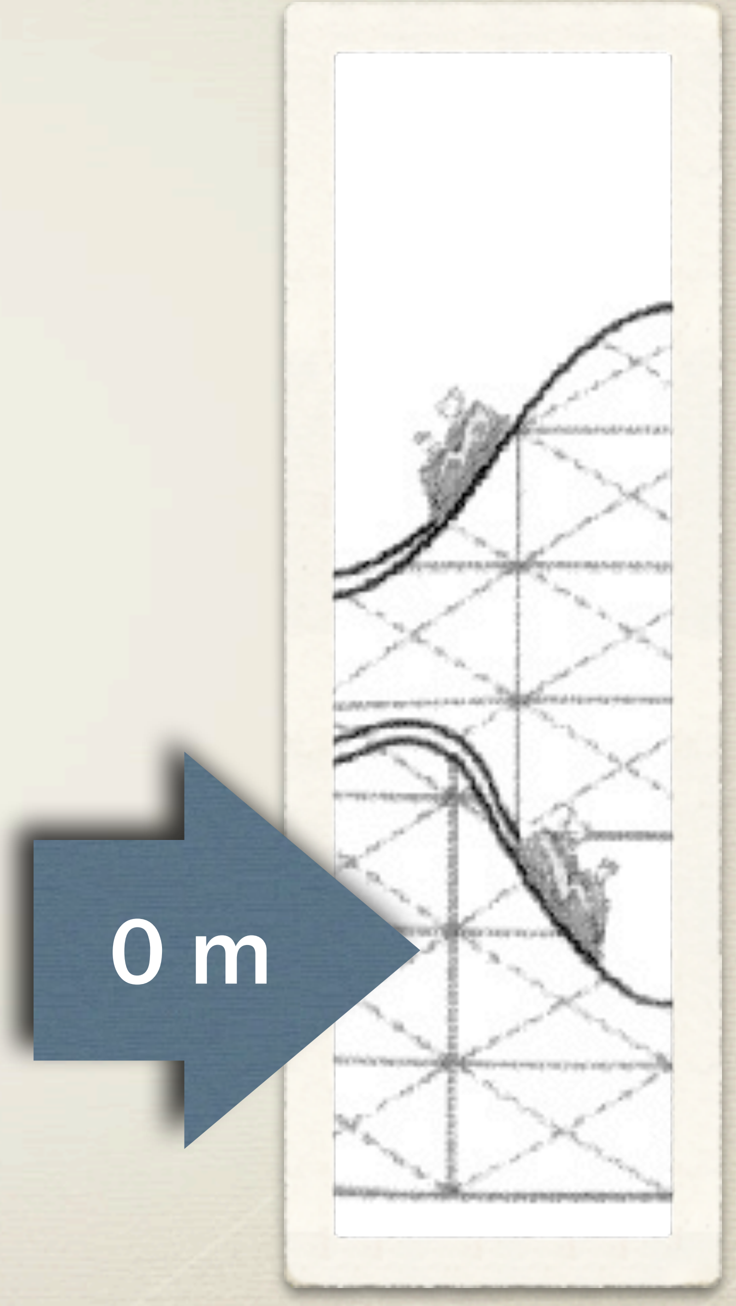


At the top (18m)

- Given Info:
  - m = 1000kg
  - v = 0 m/s
  - h = 18 m
- PE = mgh
- PE = (1000)(9.8)(18)
- PE = 176,400J
  - *PE = 176.4 kJ*
- KE = ½(mv^2)= 0 J
- TE = 176.4 kJ



At the bottom (0 m)



At the bottom (0 m)

- Given Info:
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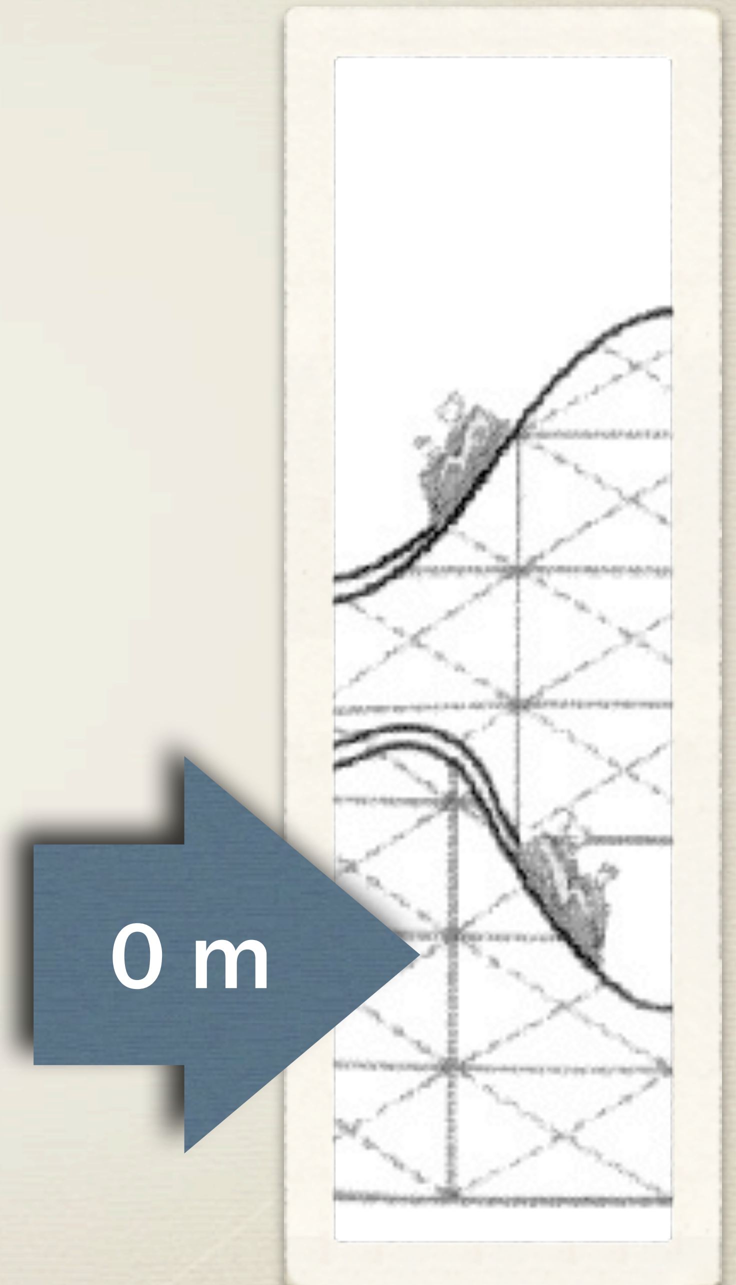
  - TE = 176.4 kJ



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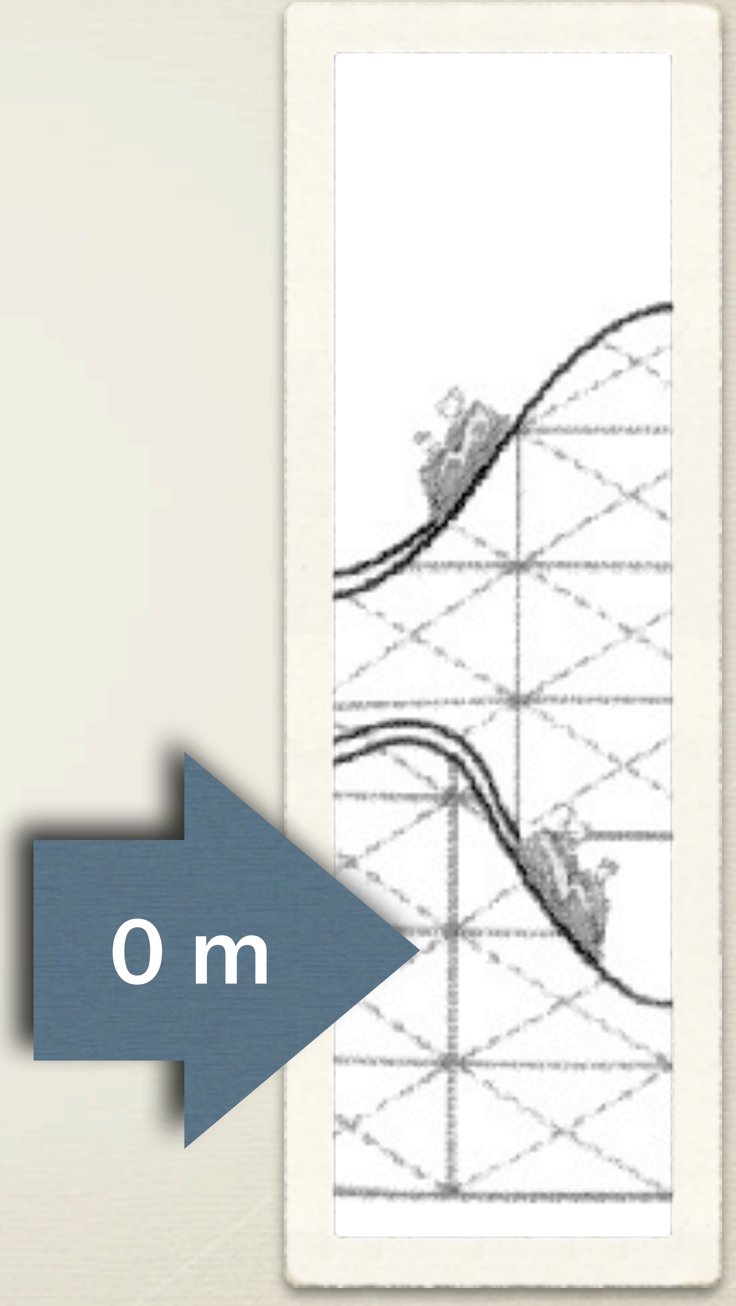
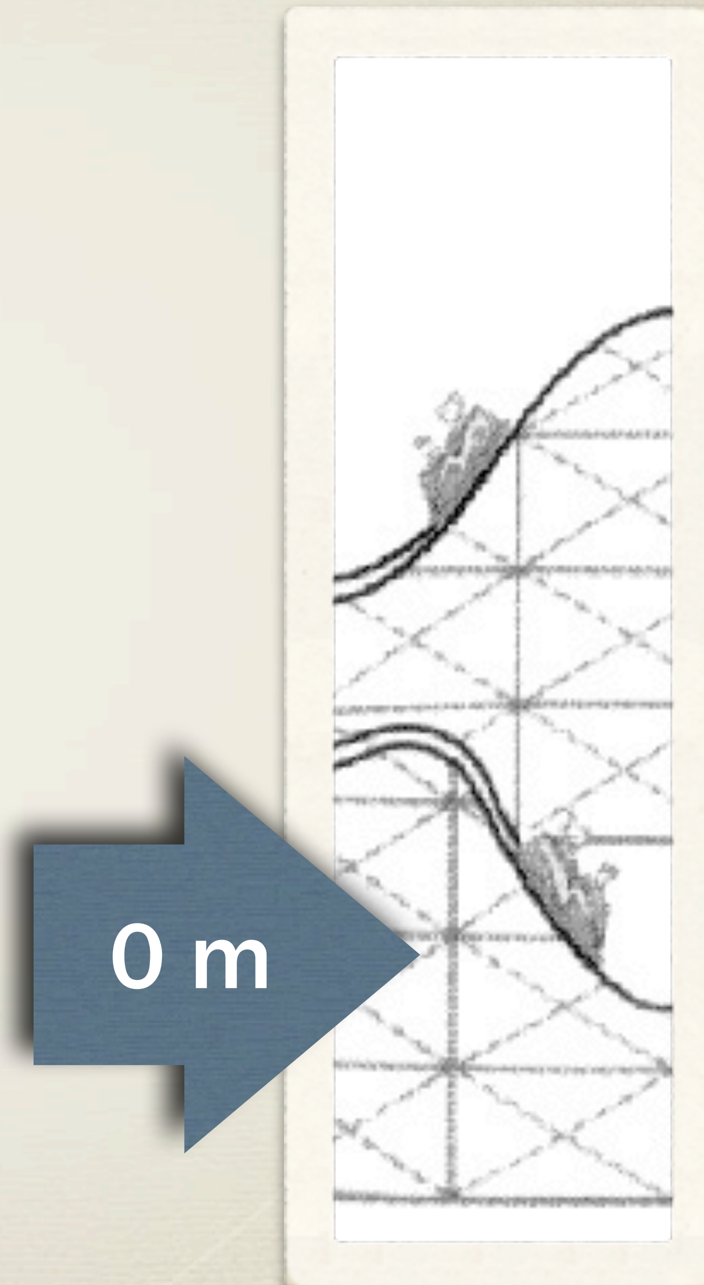
- PE = mgh = 0 J



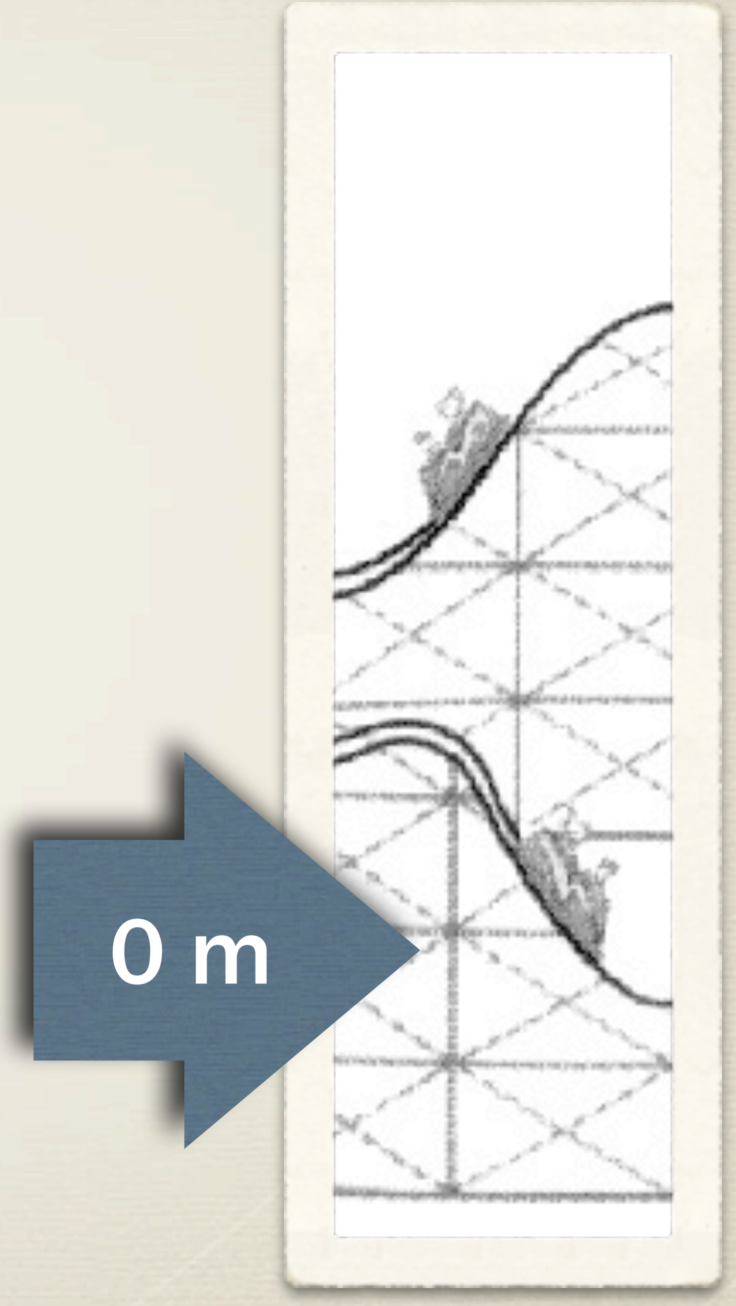
At the bottom (0 m)

- Given Info:
  - m = 1000 kg
  - h = 0 m
  - TE = 176.4 kJ
- PE = mgh = 0 J
- KE = 176,400 J



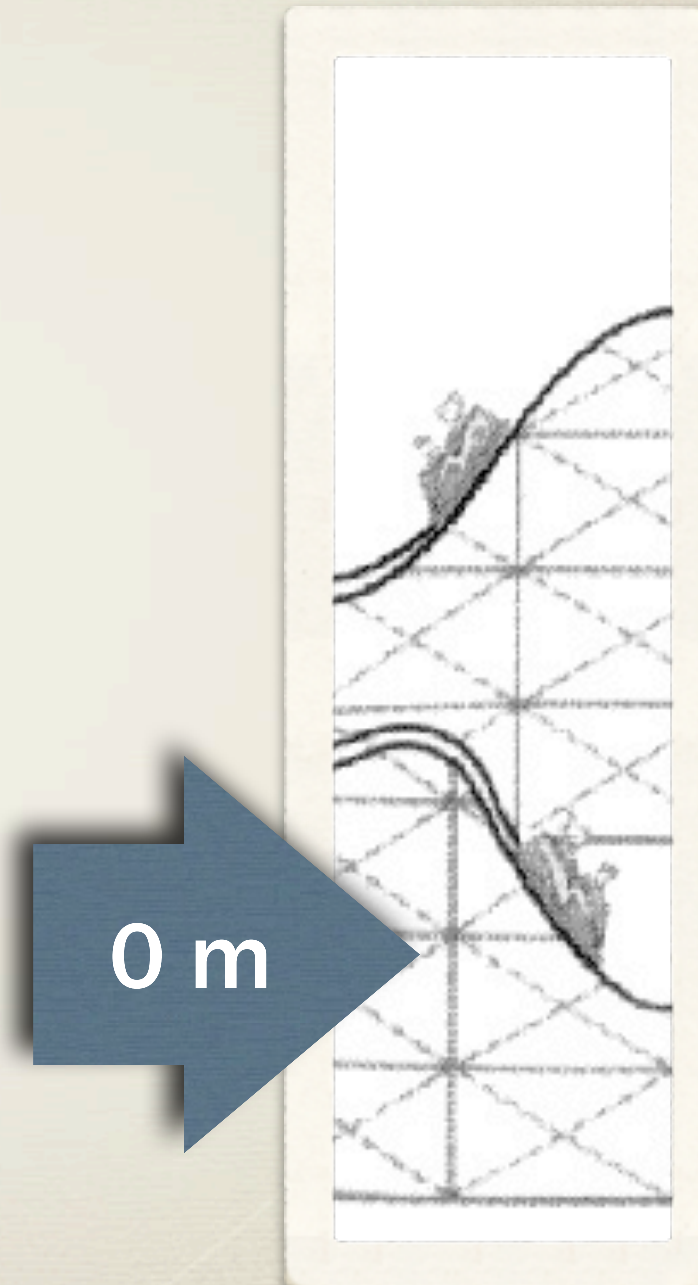
At the bottom (0 m)

- Given Info:
  - m = 1000 kg
  - h = 0 m
  - TE = 176.4 kJ
- PE = mgh = 0 J
- KE = 176,400 J
  - 176,400 J = ½(1000)v^2



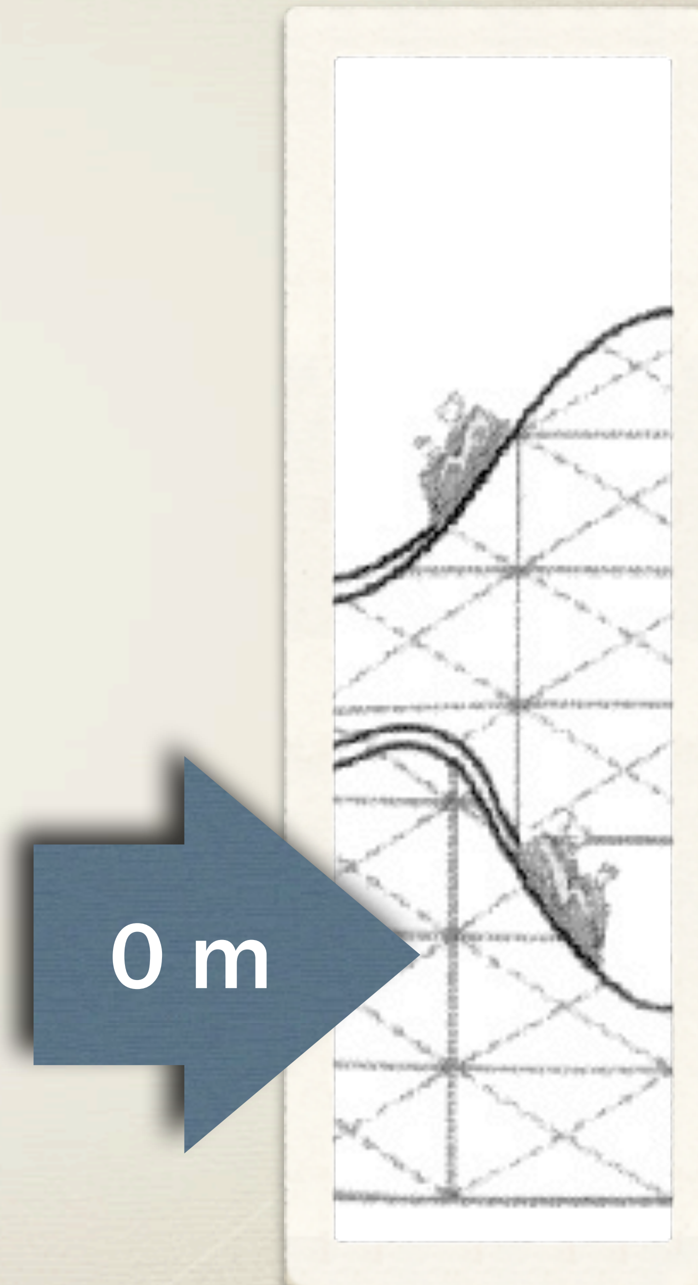
At the bottom (0 m)

- Given Info:
  - m = 1000 kg
  - h = 0 m
  - TE = 176.4 kJ
- PE = mgh = 0 J
- KE = 176,400 J
  - 176,400 J = ½(1000)v^2
  - v^2 = 352.8

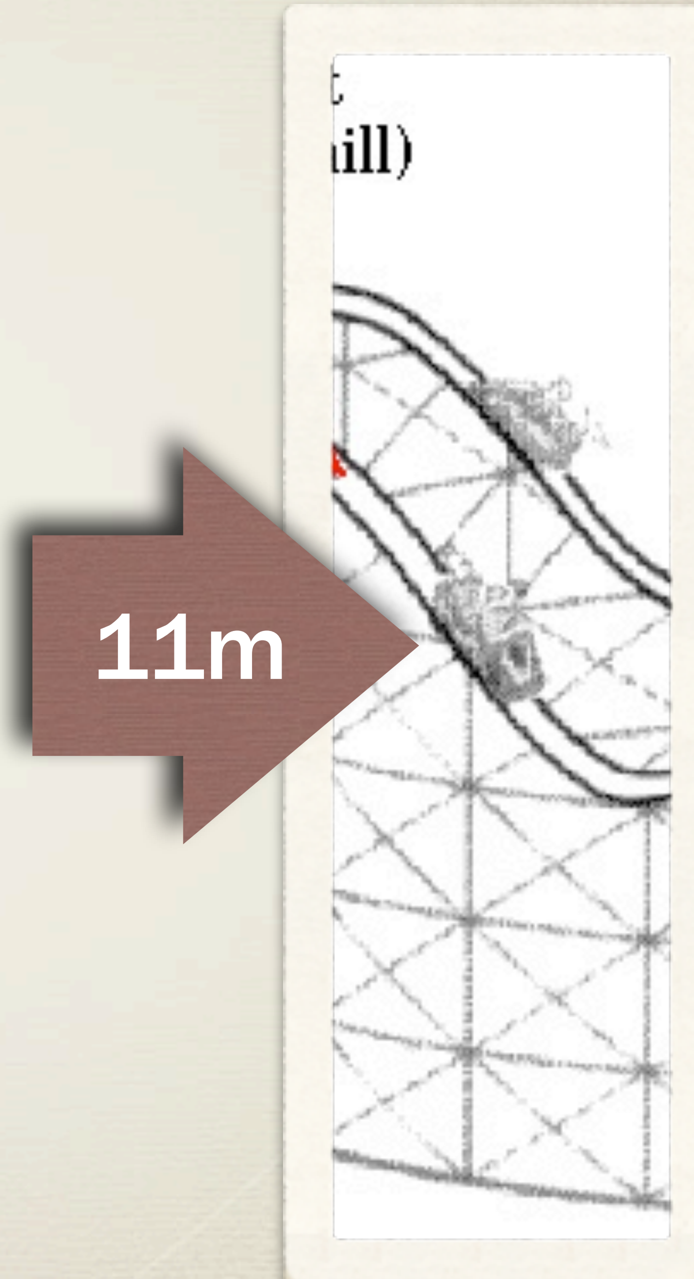


At the bottom (0 m)

- Given Info:
  - m = 1000 kg
  - h = 0 m
  - TE = 176.4 kJ
- PE = mgh = 0 J
- KE = 176,400 J
  - 176,400 J = ½(1000)v^2
  - v^2 = 352.8
  - v = 18.78 m/s

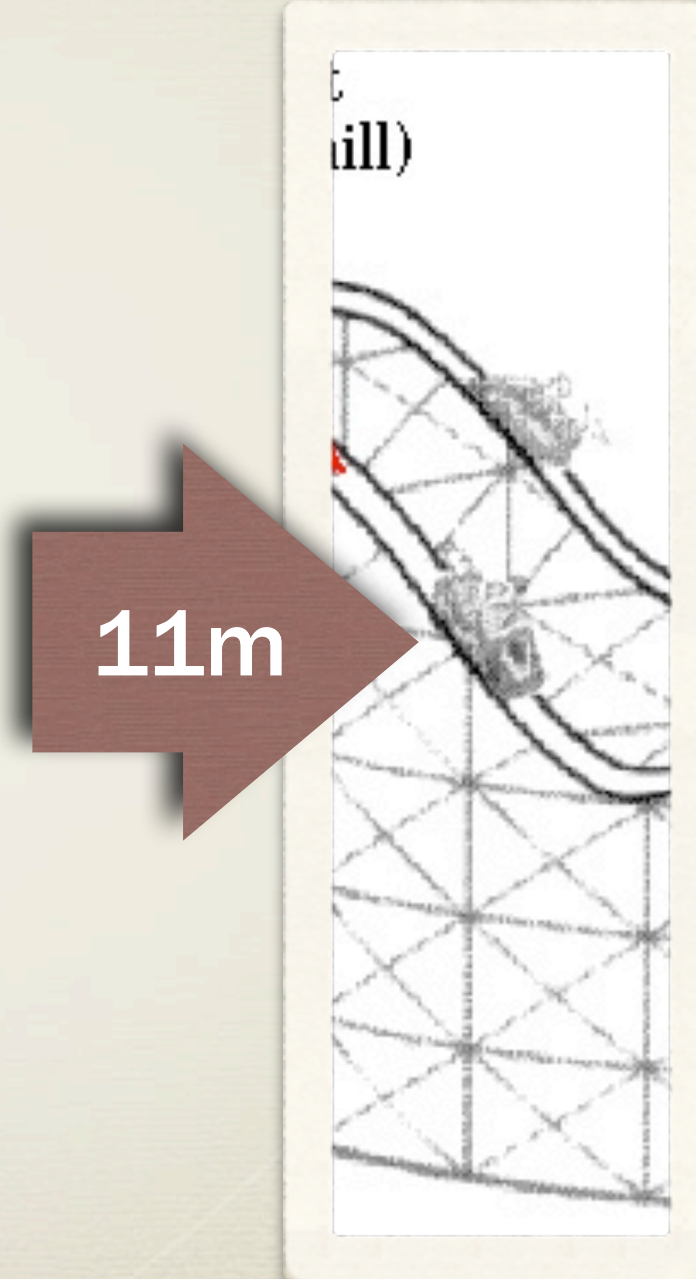


At point B(11m)



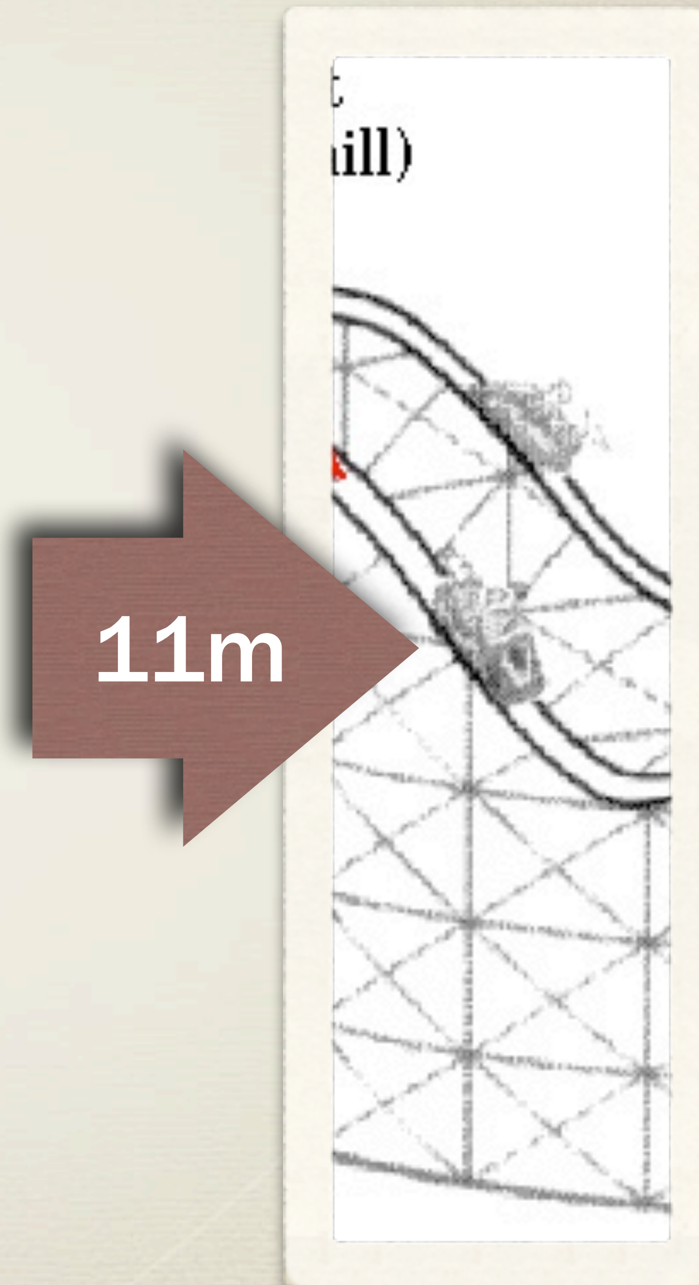
At point B(11m)

- Given Info:
  - m = 1000 kg
  - h = 11 m
  - TE = 176.4 kJ



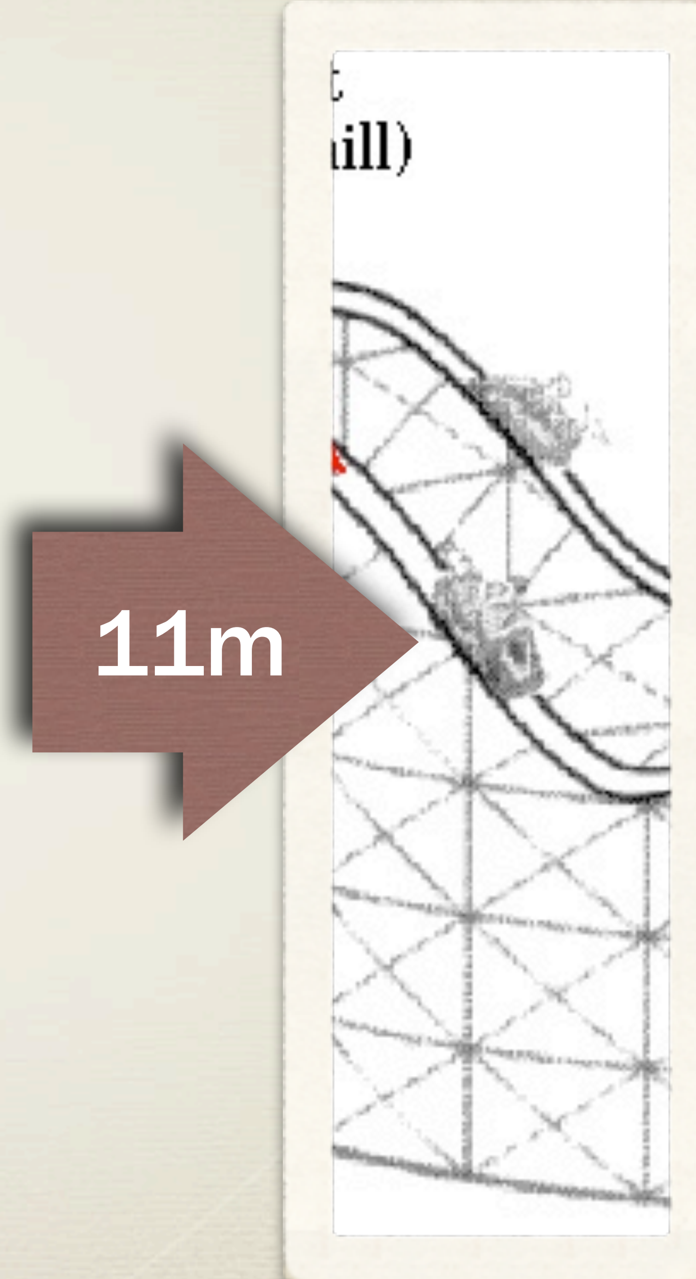
At point B(11m)

- Given Info:
  - m = 1000 kg
  - h = 11 m
  - TE = 176.4 kJ
- PE = mgh



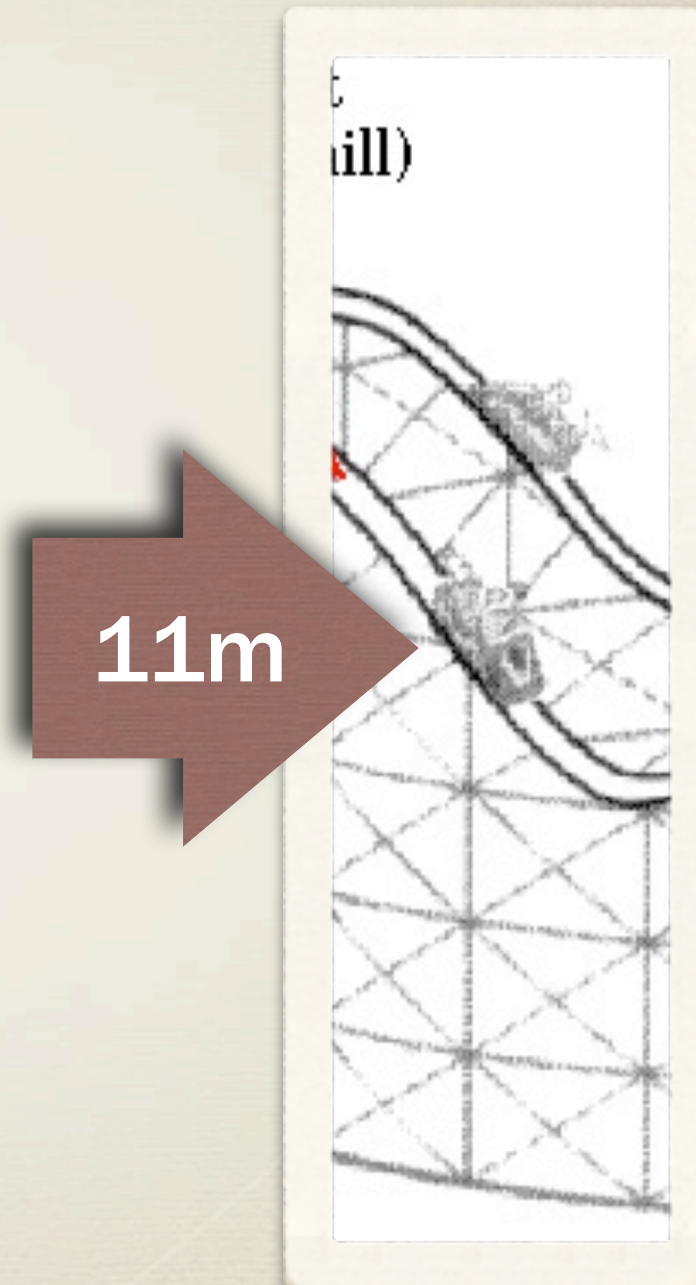
At point B(11m)

- Given Info:
  - m = 1000 kg
  - h = 11 m
  - TE = 176.4 kJ
- PE = mgh
- PE = (1000)(9.8)(11)



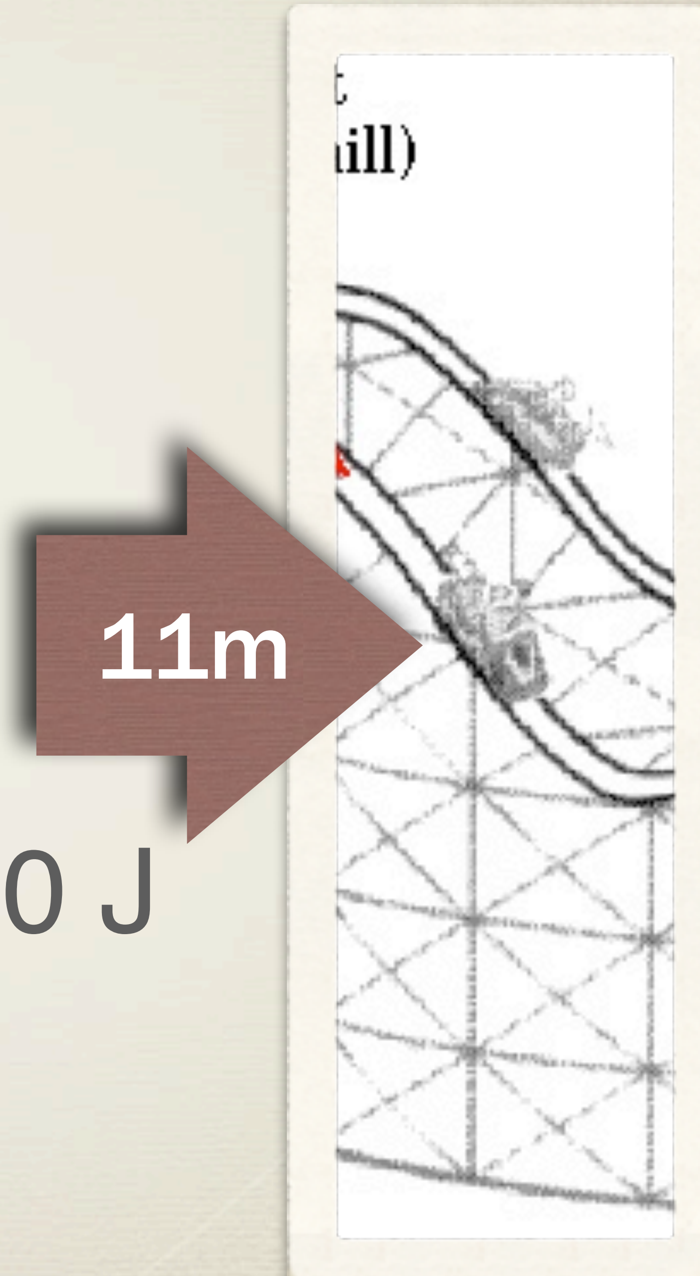
At point B(11m)

- Given Info:
  - m = 1000 kg
  - h = 11 m
  - TE = 176.4 kJ
- PE = mgh
- PE = (1000)(9.8)(11)
  - PE = 107,800 J



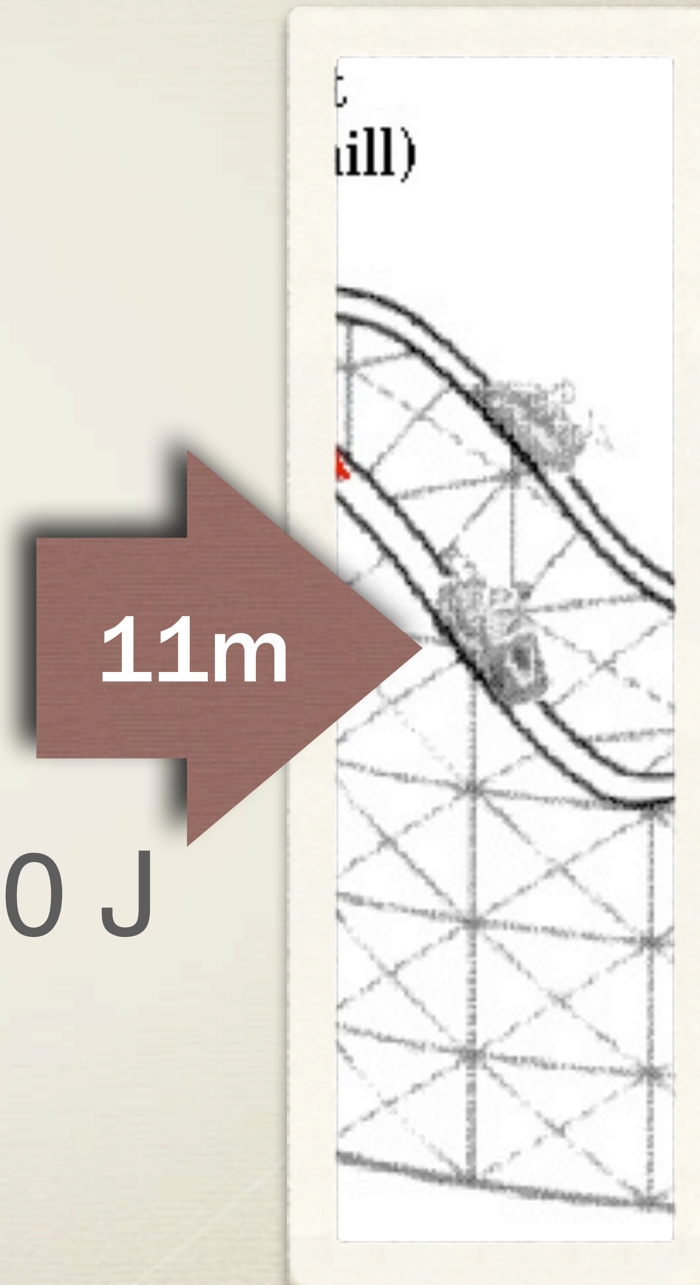
At point B(11m)

- Given Info:
  - m = 1000 kg
  - h = 11 m
  - TE = 176.4 kJ
- PE = mgh
- PE = (1000)(9.8)(11)
  - PE = 107,800 J
- KE = 176,400-107,800 J = 68,600 J



At point B(11m)

- Given Info:
  - m = 1000 kg
  - h = 11 m
  - TE = 176.4 kJ
- PE = mgh
- PE = (1000)(9.8)(11)
  - PE = 107,800 J
- KE = 176,400-107,800 J = 68,600 J
- KE = 68,600 J = ½(mv^2)



At point B(11m)

- Given Info:
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  - h = 11 m
  - TE = 176.4 kJ
- PE = mgh
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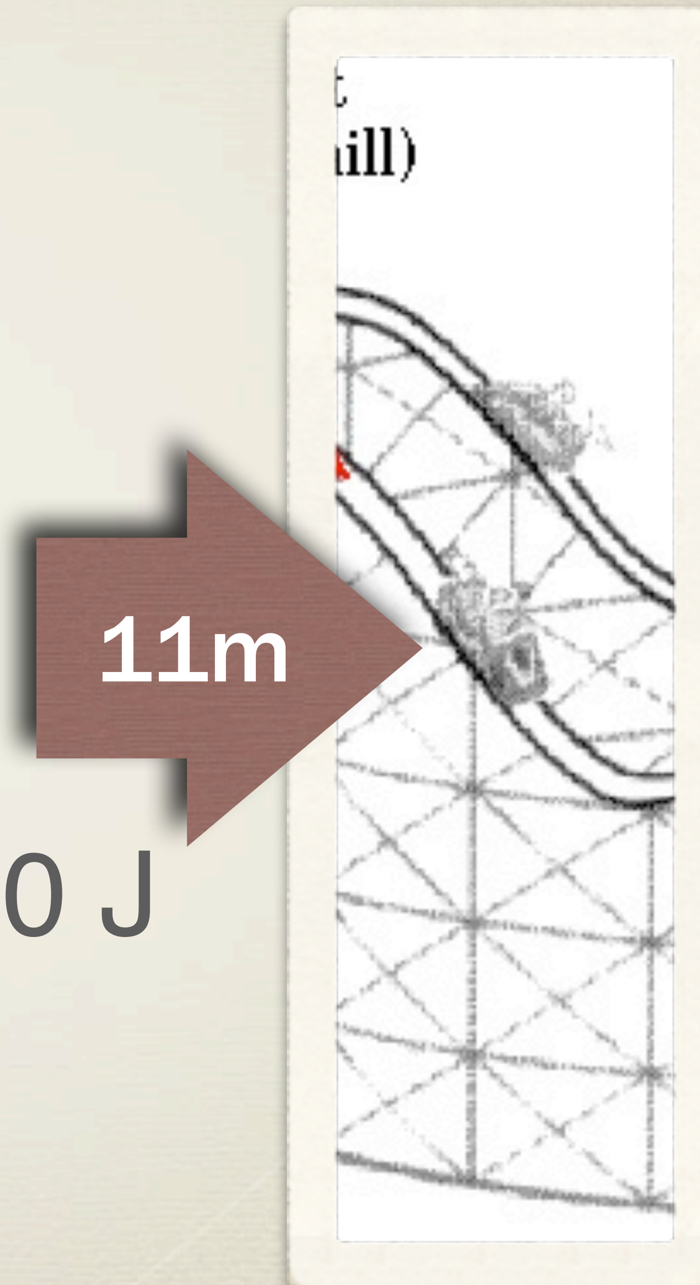
- KE = 176,400-107,800 J = 68,600 J
- KE = 68,600 J = ½(mv^2)
  - 68,600 J = ½(1000)v^2



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- PE = (1000)(9.8)(11)
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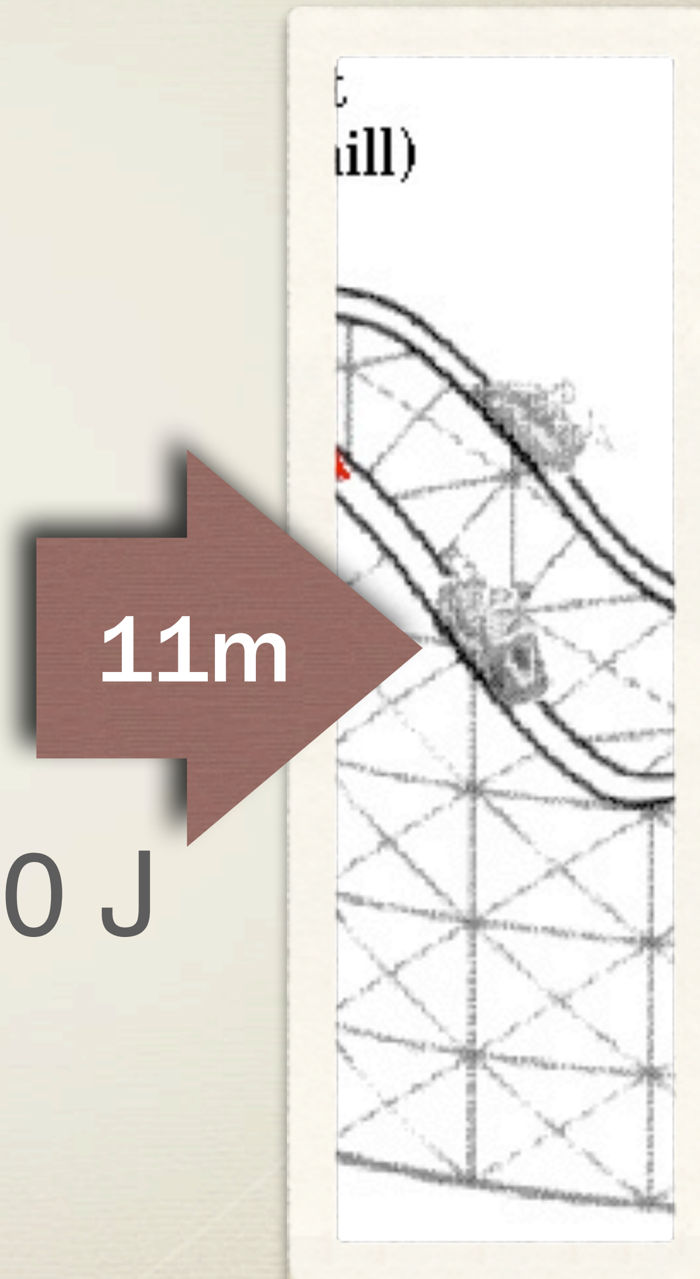
- KE = 176,400-107,800 J = 68,600 J
- KE = 68,600 J = ½(mv^2)
  - 68,600 J = ½(1000)v^2
  - v = 11.71 m/s



Pendulum Swing

Conservation of Energy Problems

Find the Speed

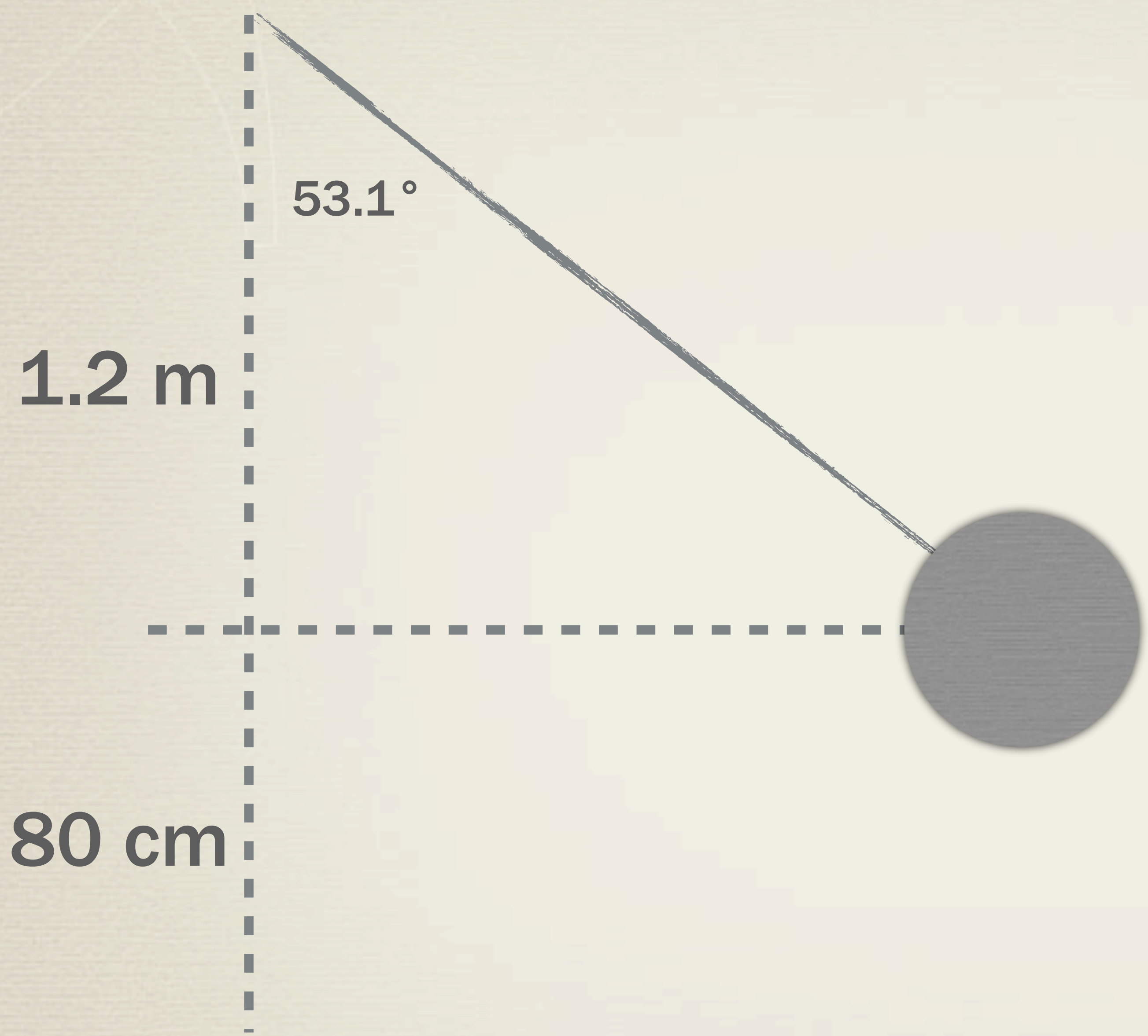
- A pendulum bob on a 2m string is released from a height of 80cm.
- What is the maximum velocity of the pendulum?
- What is the speed at half the height?

Find the Speed

A 100g pendulum bob on a 2m string is released from a height of 80cm.

What is the maximum velocity of the pendulum?

What is the speed at half the height?

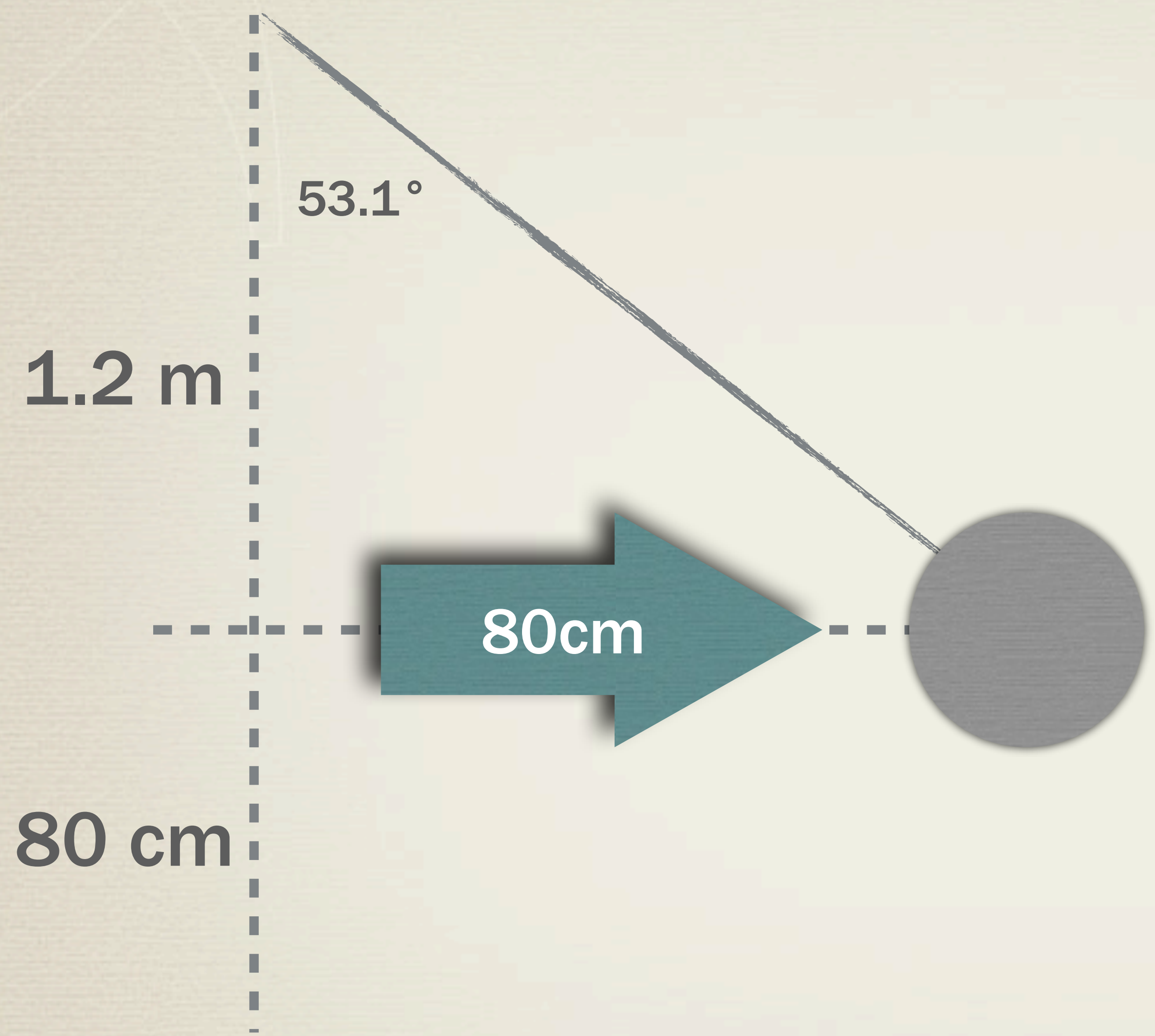


Find the Speed

A 100g pendulum bob on a 2m string is released from a height of 80cm.

What is the maximum velocity of the pendulum?

What is the speed at half the height?

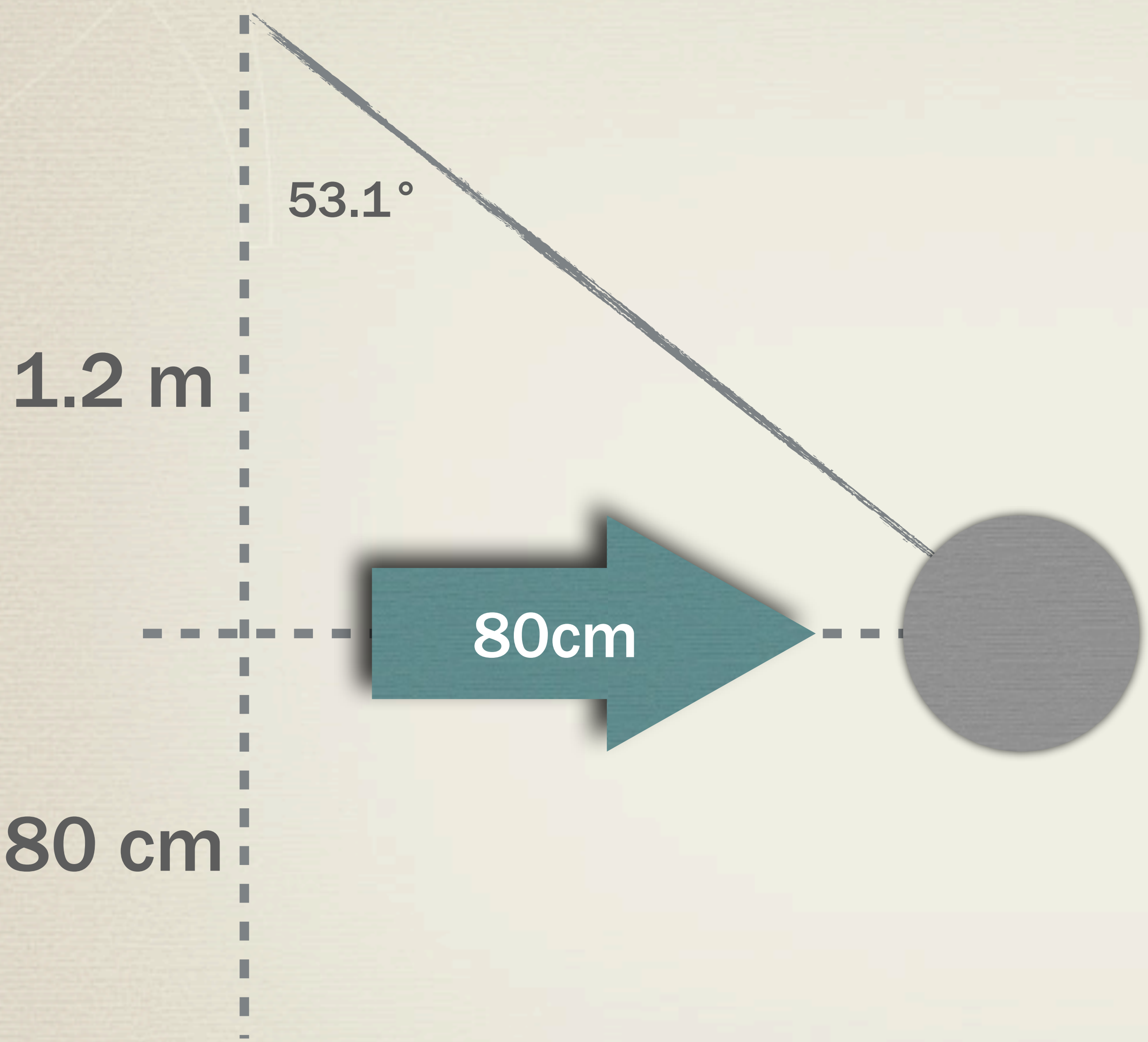


Find the Speed

A 100g pendulum bob on a 2m string is released from a height of 80cm.

What is the maximum velocity of the pendulum?

What is the speed at half the height?



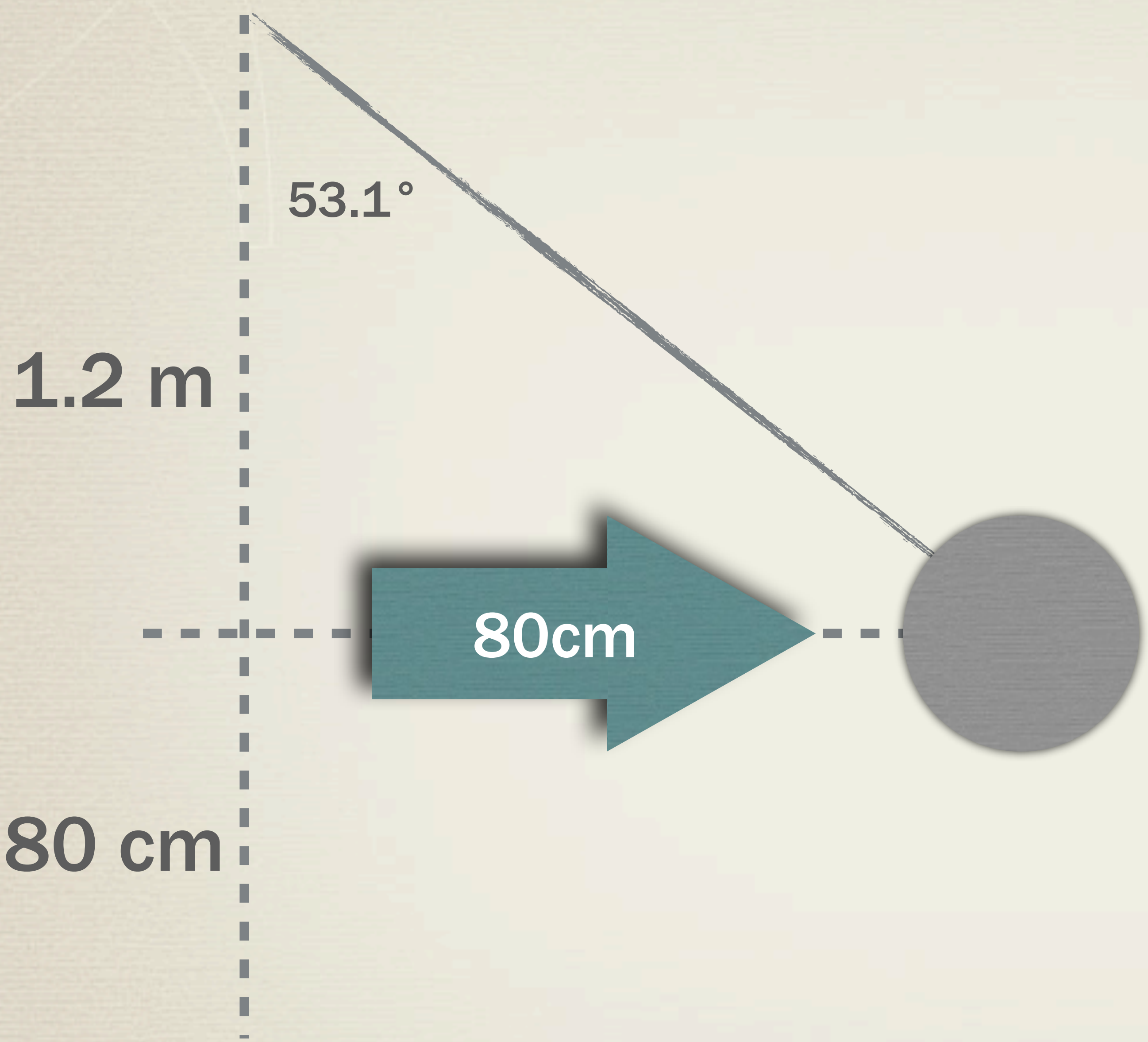
- Mass = 0.1 kg

Find the Speed

A 100g pendulum bob on a 2m string is released from a height of 80cm.

What is the maximum velocity of the pendulum?

What is the speed at half the height?



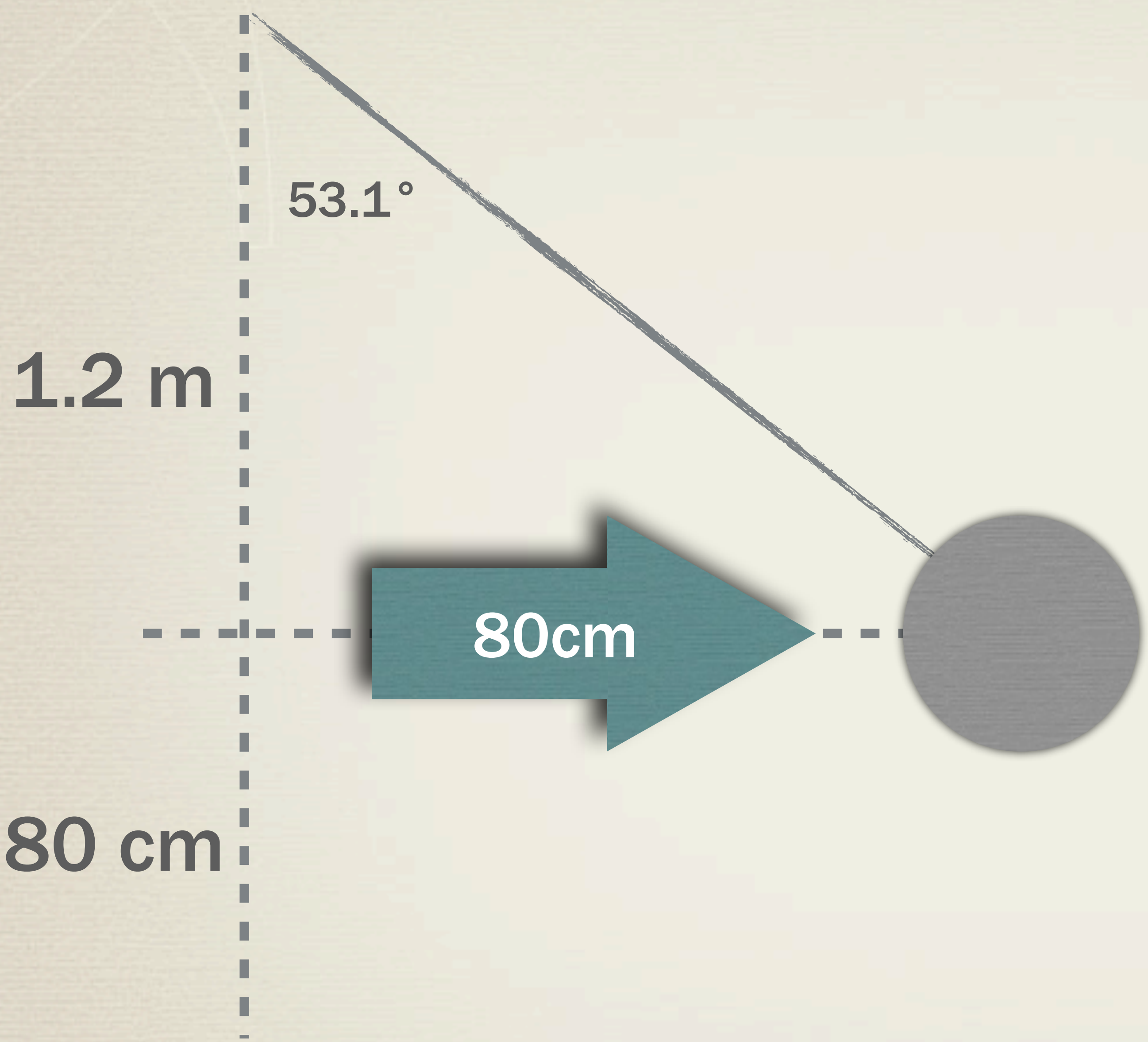
- Mass = 0.1 kg
- h = 0.8 m

Find the Speed

A 100g pendulum bob on a 2m string is released from a height of 80cm.

What is the maximum velocity of the pendulum?

What is the speed at half the height?



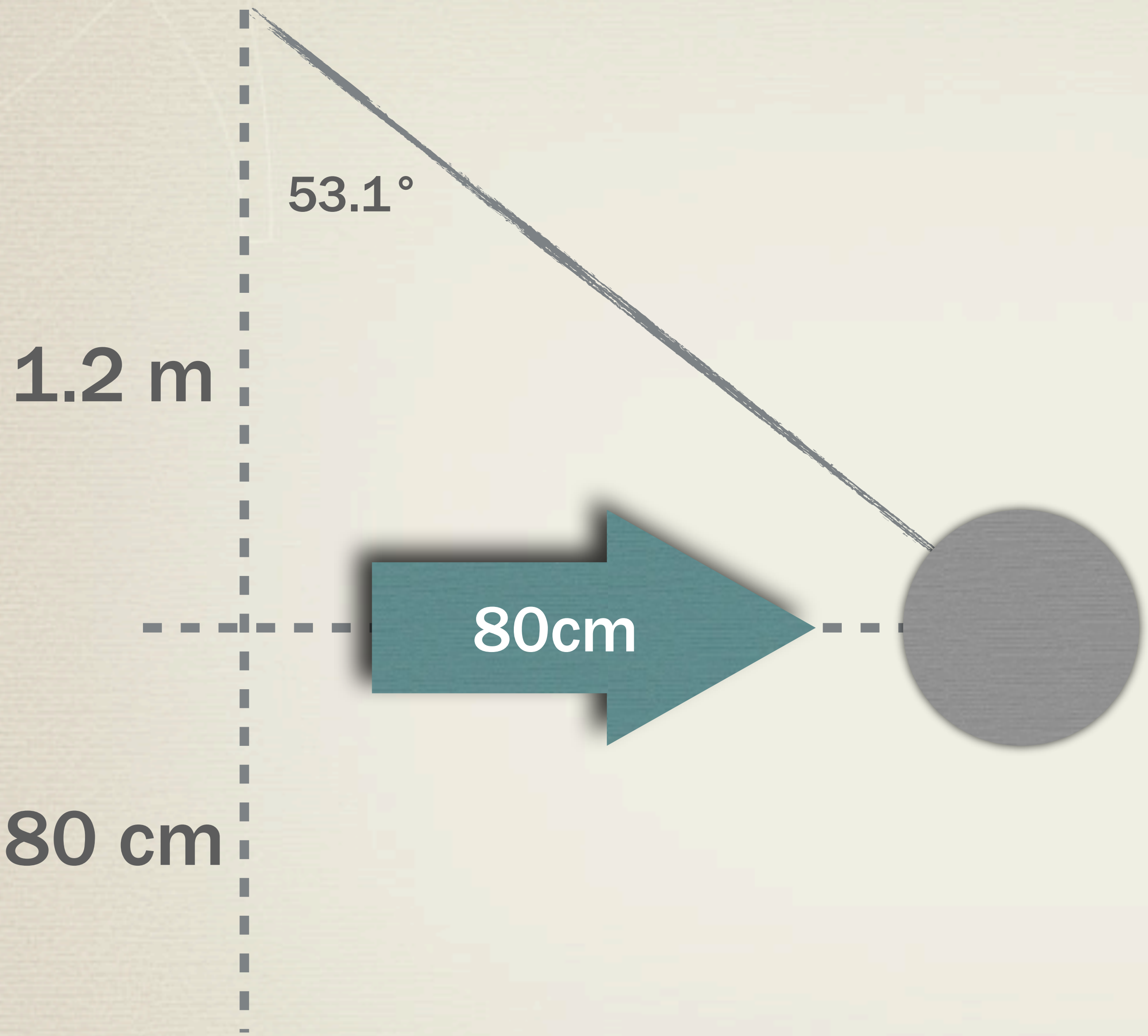
- Mass = 0.1 kg
- h = 0.8 m
- PE = mgh = 0.784J

Find the Speed

A 100g pendulum bob on a 2m string is released from a height of 80cm.

What is the maximum velocity of the pendulum?

What is the speed at half the height?



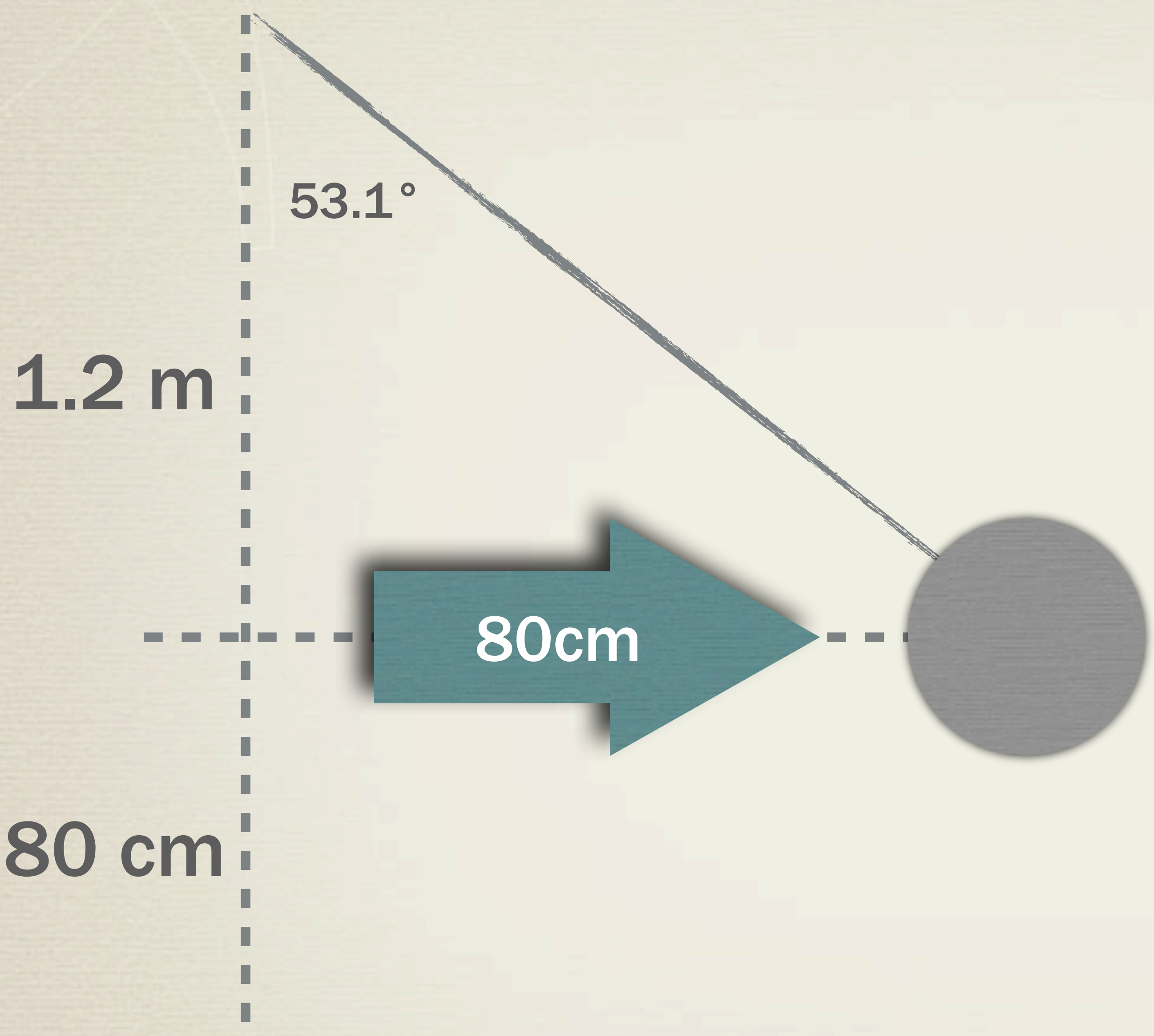
- Mass = 0.1 kg
- h = 0.8 m
- PE = mgh = 0.784J
- Velocity = 0 m/s

Find the Speed

A 100g pendulum bob on a 2m string is released from a height of 80cm.

What is the maximum velocity of the pendulum?

What is the speed at half the height?



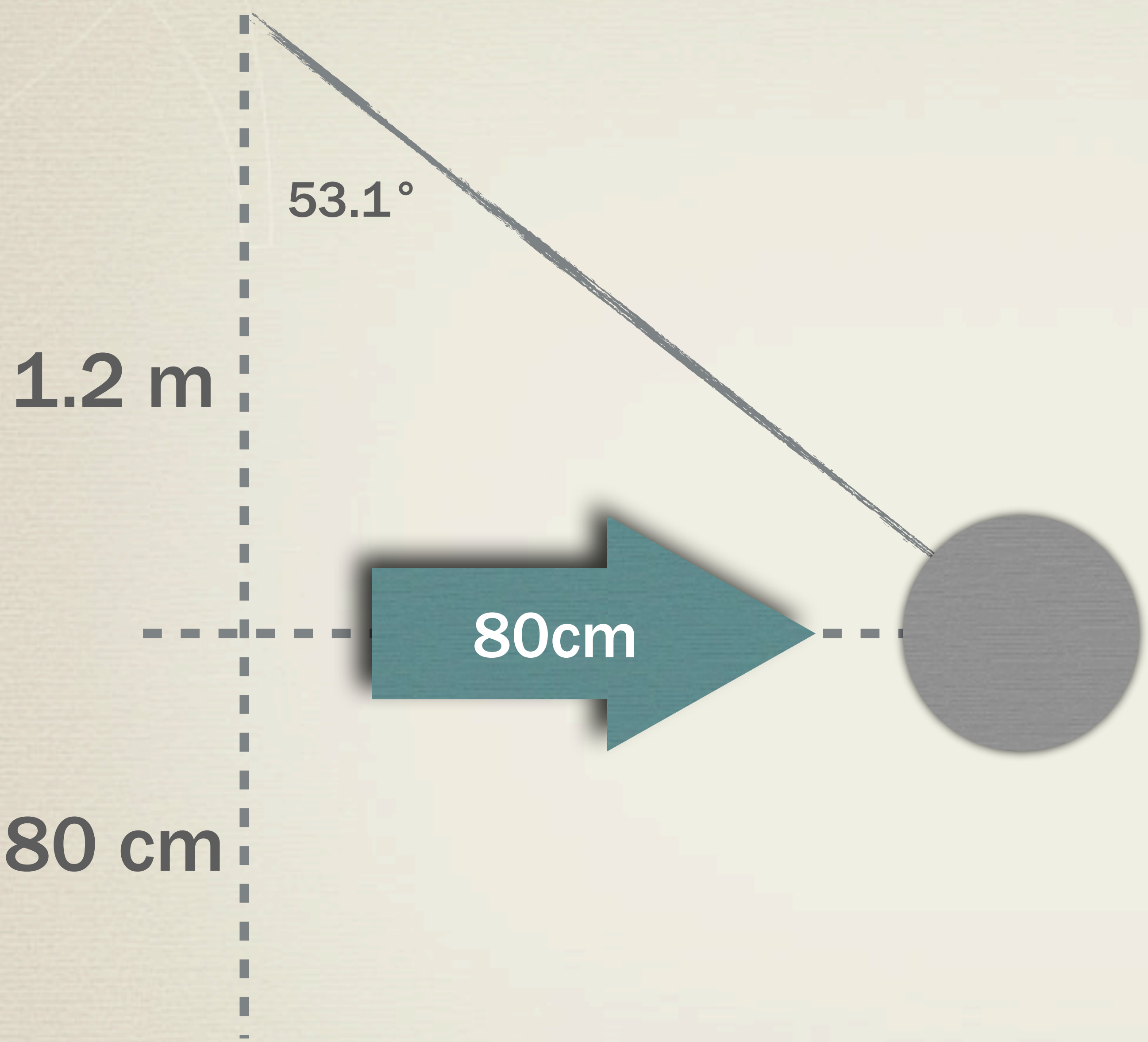
- Mass = 0.1 kg
- h = 0.8 m
- PE = mgh = 0.784J
- Velocity = 0 m/s
- KE = 0 J

Find the Speed

A 100g pendulum bob on a 2m string is released from a height of 80cm.

What is the maximum velocity of the pendulum?

What is the speed at half the height?



- Mass = 0.1 kg
- h = 0.8 m
- PE = mgh = 0.784J
- Velocity = 0 m/s
- KE = 0 J
- TE = 0.784J

Find the Speed

A 100g pendulum bob on a 2m string is released from a height of 80cm.

What is the maximum velocity of the pendulum?

What is the speed at half the height?

80cm

- PE = 0.784J
- KE = 0 J
- TE = 0.784J

Find the Speed

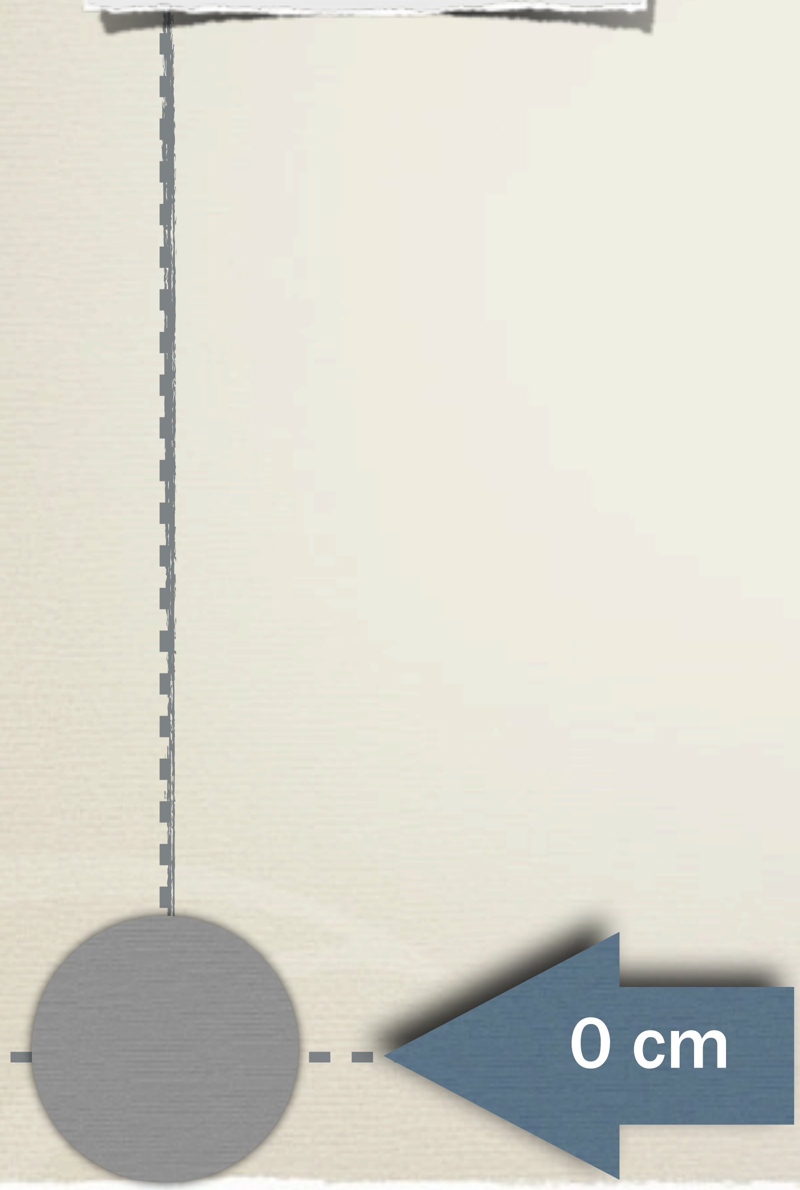
A 100g pendulum bob on a 2m string is released from a height of 80cm.

What is the maximum velocity of the pendulum?

What is the speed at half the height?

80cm

- PE = 0.784J
- KE = 0 J
- TE = 0.784J



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What is the maximum velocity of the pendulum?
What is the speed at half the height?

80cm

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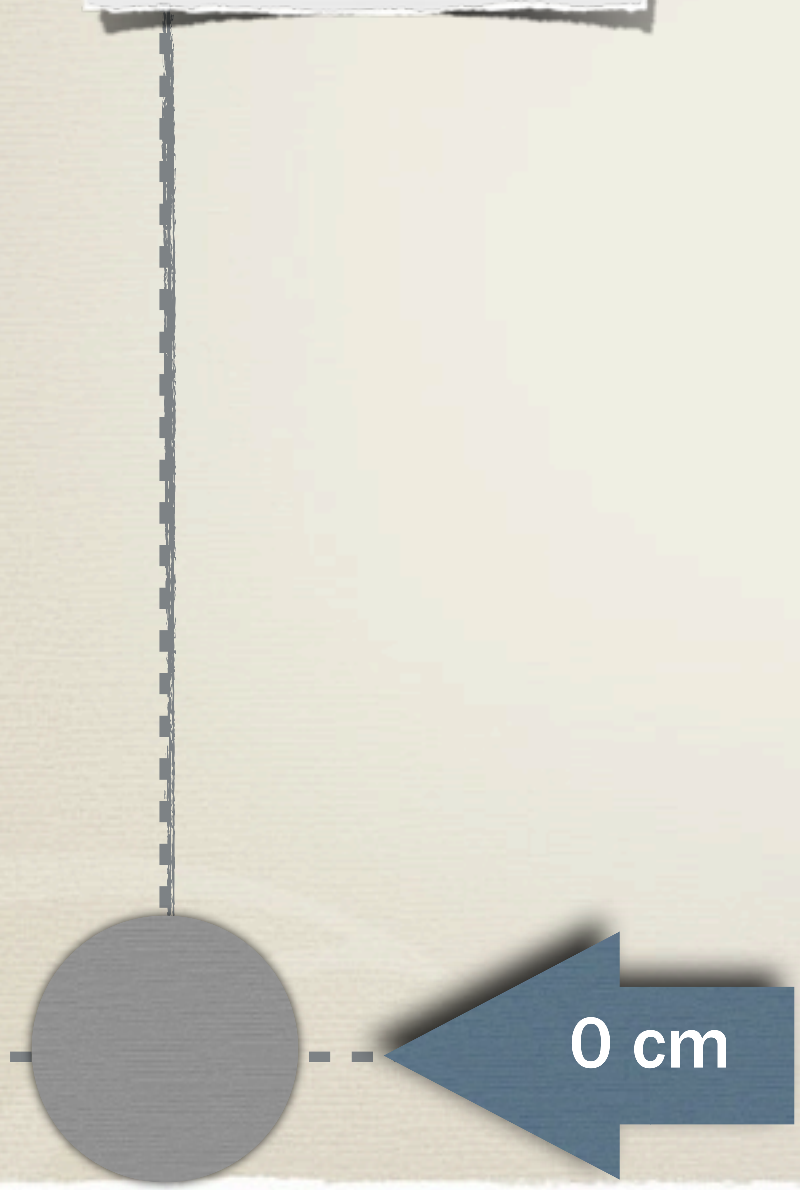
- KE = 0 J
- TE = 0.784J



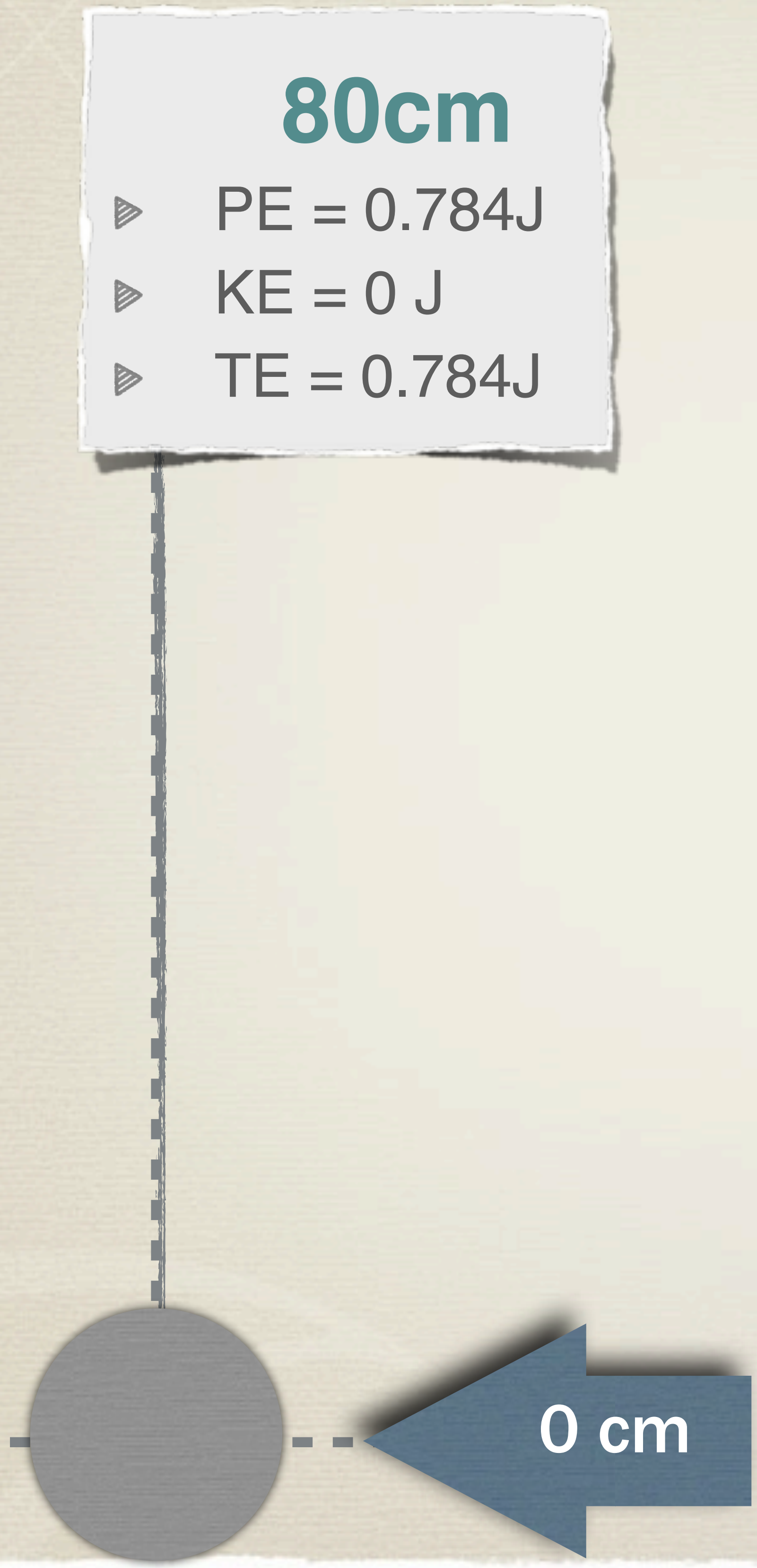
- Given Info:
  - Mass = 0.1 kg
  - TE = 0.784J
  - h = 0.0 m

Find the Speed

A 100g pendulum bob on a 2m string is released from a height of 80cm.

What is the maximum velocity of the pendulum?

What is the speed at half the height?



- Given Info:
  - Mass = 0.1 kg
  - TE = 0.784J
  - h = 0.0 m
- PE = mgh = 0 J

Find the Speed

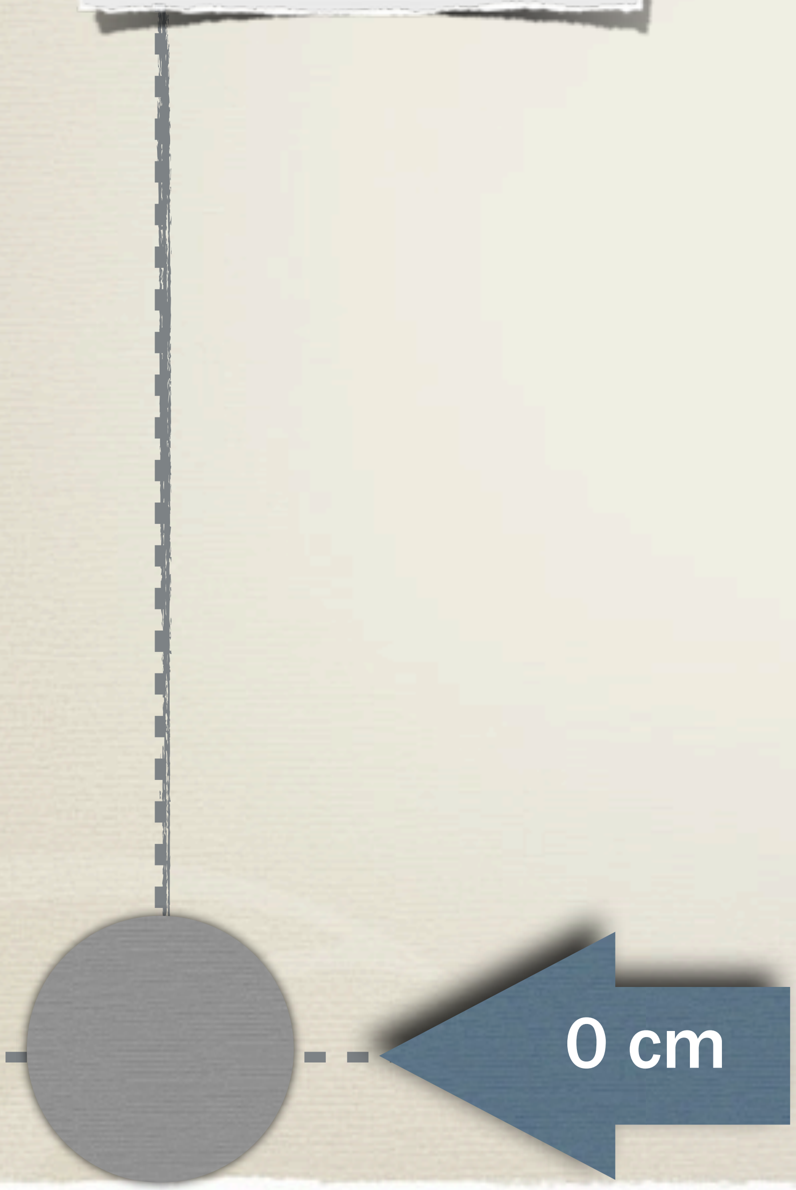
A 100g pendulum bob on a 2m string is released from a height of 80cm.

What is the maximum velocity of the pendulum?

What is the speed at half the height?

80cm

- PE = 0.784J
- KE = 0 J
- TE = 0.784J



- Given Info:
  - Mass = 0.1 kg
  - TE = 0.784J
  - h = 0.0 m
- PE = mgh = 0 J
- KE = 0.784 J = $\frac{1}{2}(mv^2)$

Find the Speed

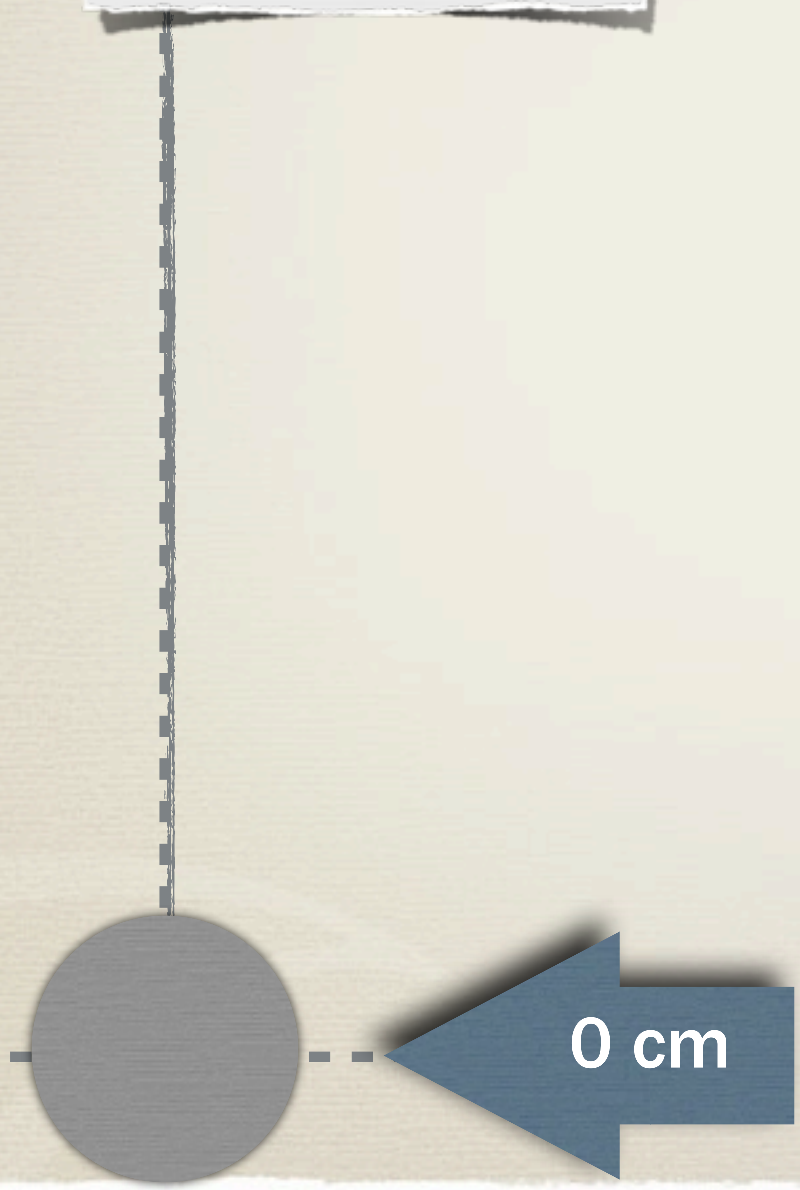
A 100g pendulum bob on a 2m string is released from a height of 80cm.

What is the maximum velocity of the pendulum?

What is the speed at half the height?

80cm

- PE = 0.784J
- KE = 0 J
- TE = 0.784J



- Given Info:
  - Mass = 0.1 kg
  - TE = 0.784J
  - h = 0.0 m
- PE = mgh = 0 J
- KE = 0.784 J = $\frac{1}{2}(mv^2)$
- 0.784 J = $\frac{1}{2}(0.1)(v^2)$

Find the Speed

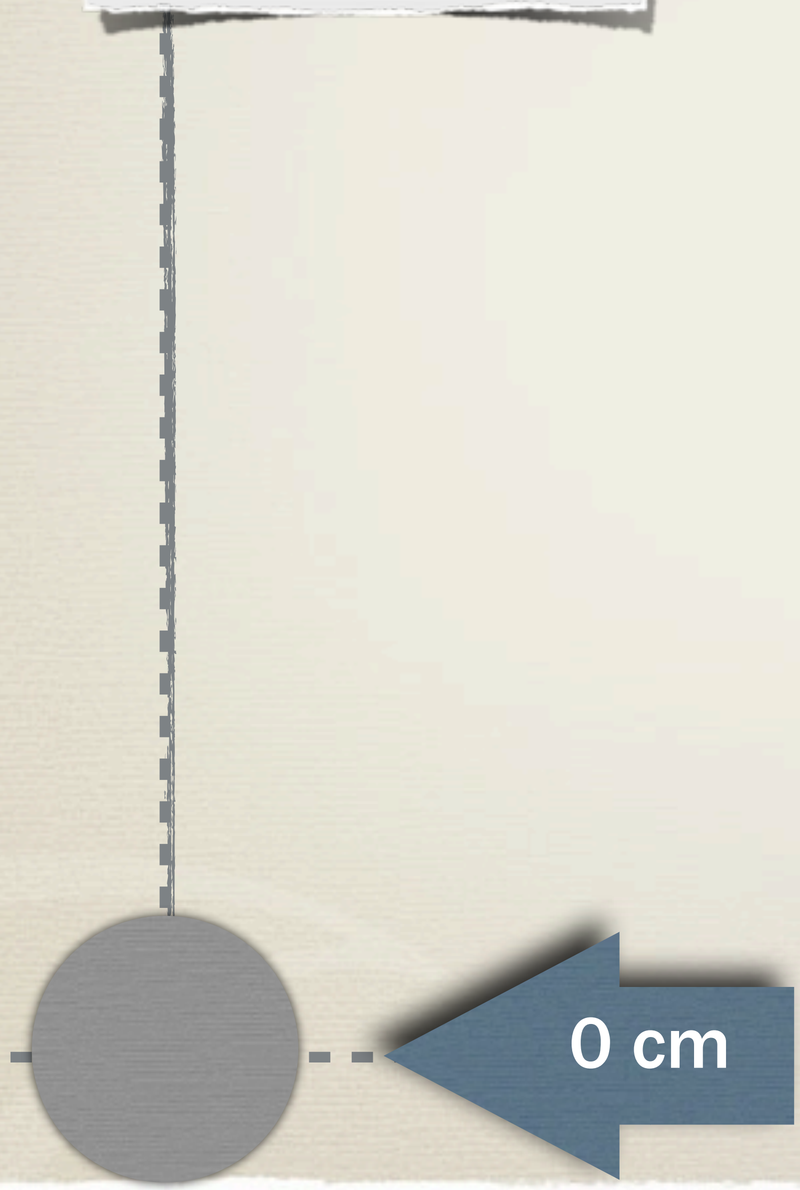
A 100g pendulum bob on a 2m string is released from a height of 80cm.

What is the maximum velocity of the pendulum?

What is the speed at half the height?

80cm

- PE = 0.784J
- KE = 0 J
- TE = 0.784J



- Given Info:
  - Mass = 0.1 kg
  - TE = 0.784J
  - h = 0.0 m
- PE = mgh = 0 J
- KE = 0.784 J = $\frac{1}{2}(mv^2)$
- 0.784 J = $\frac{1}{2}(0.1)(v^2)$
- v = 3.96 m/s

Find the Speed

A 100g pendulum bob on a 2m string is released from a height of 80cm.

What is the maximum velocity of the pendulum?

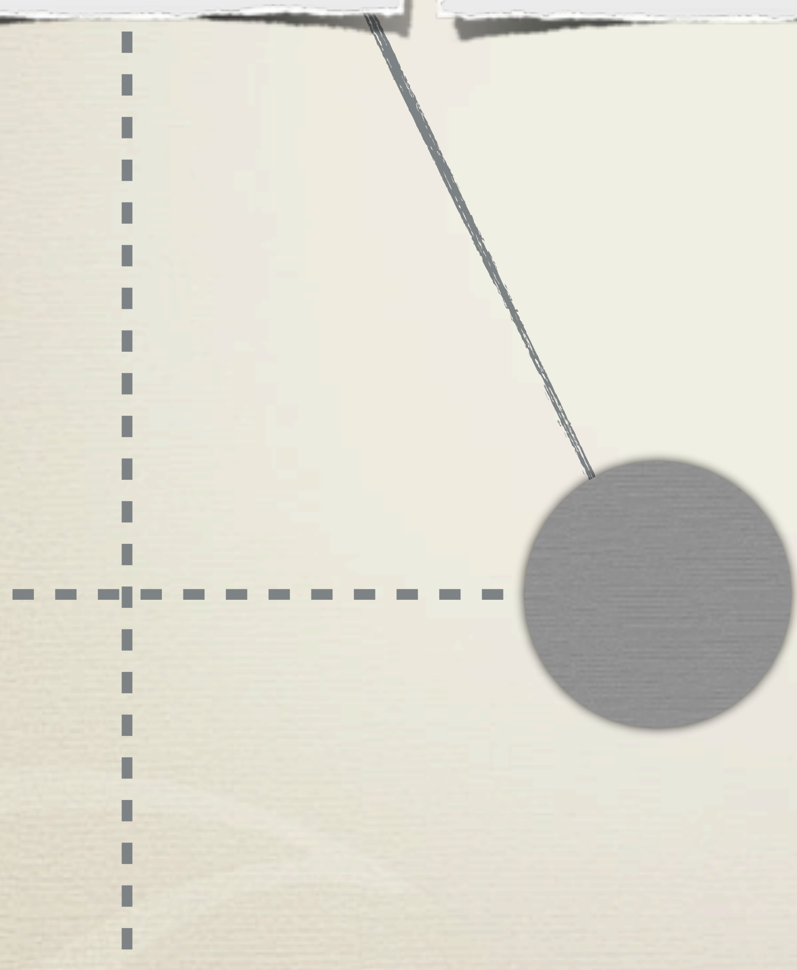
What is the speed at half the height?

80cm

- PE = 0.784J
- KE = 0 J
- TE = 0.784J
- v = 0.0 m/s

0cm

- PE = 0 J
- KE = 0.784J
- TE = 0.784J
- v = 3.96 m/s



Find the Speed

A 100g pendulum bob on a 2m string is released from a height of 80cm.

What is the maximum velocity of the pendulum?

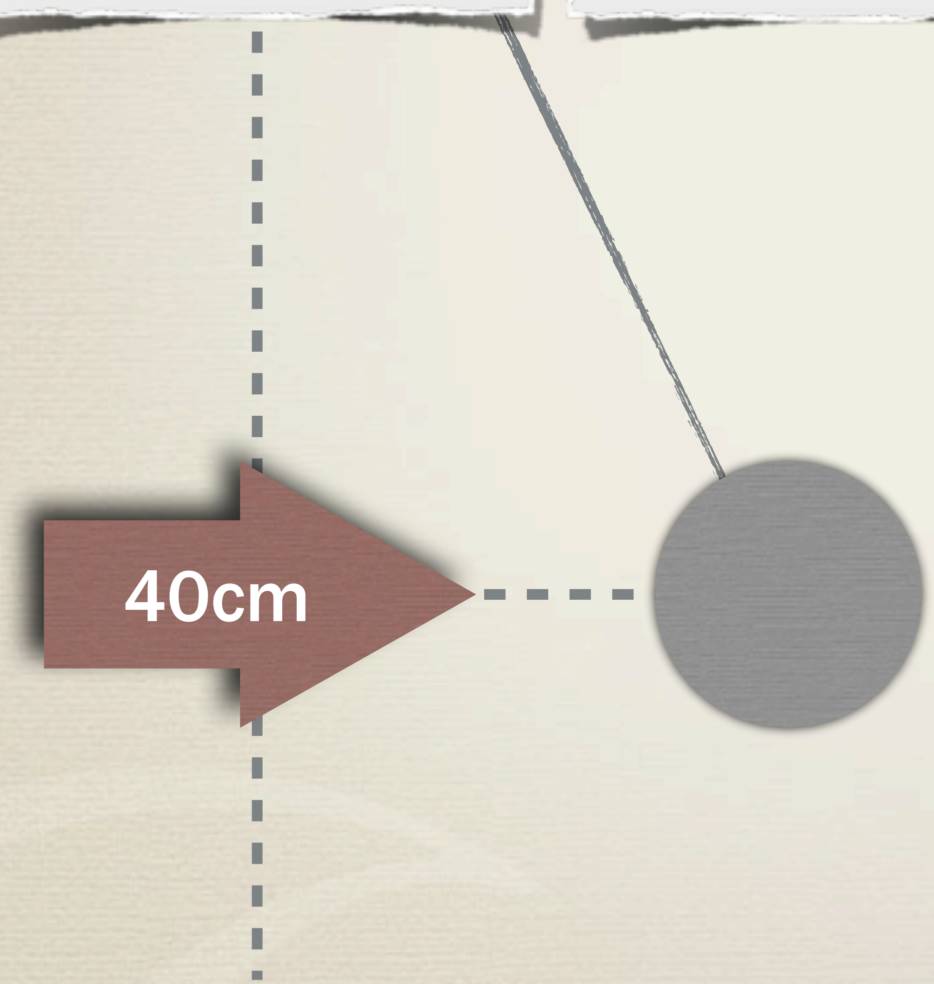
What is the speed at half the height?

80cm

- PE = 0.784J
- KE = 0 J
- TE = 0.784J
- v = 0.0 m/s

0cm

- PE = 0 J
- KE = 0.784J
- TE = 0.784J
- v = 3.96 m/s



Find the Speed

A 100g pendulum bob on a 2m string is released from a height of 80cm.

What is the maximum velocity of the pendulum?

What is the speed at half the height?

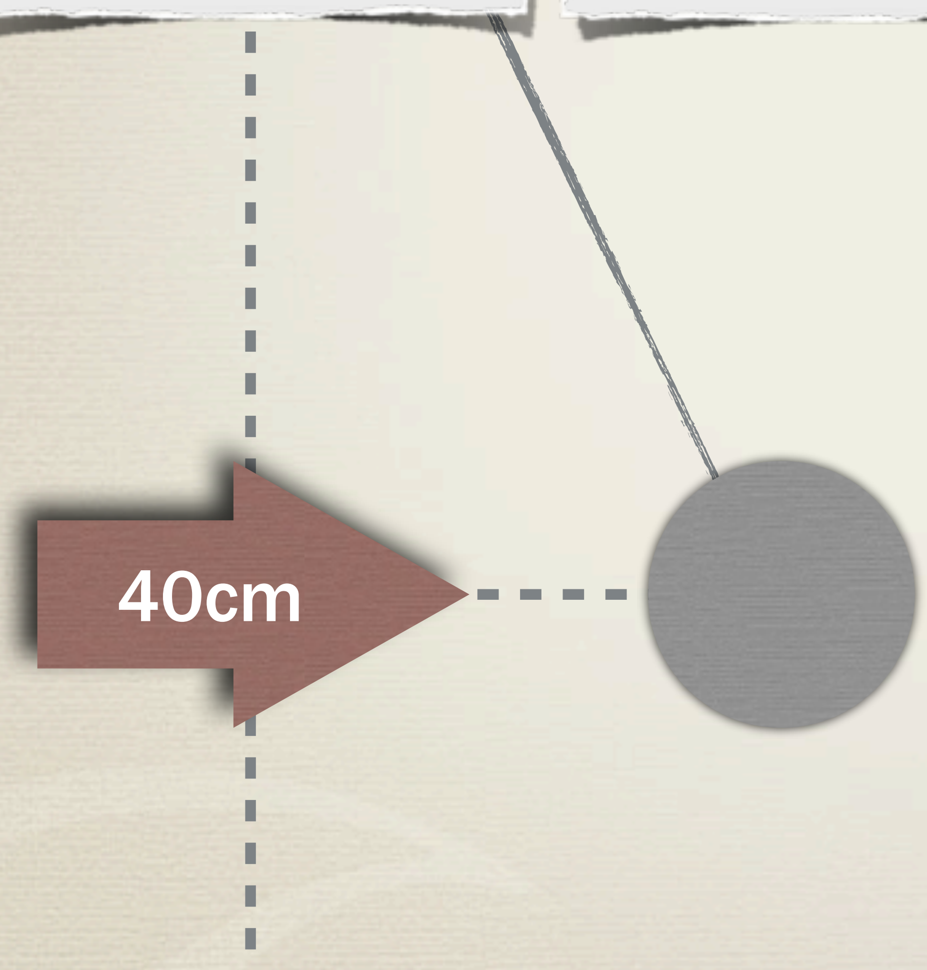
80cm

- PE = 0.784J
- KE = 0 J
- TE = 0.784J
- v = 0.0 m/s

0cm

- PE = 0 J
- KE = 0.784J
- TE = 0.784J
- v = 3.96 m/s

- Given Info:
  - m = 0.1 kg
  - TE = 0.784J
  - h = 0.4 m



Find the Speed

A 100g pendulum bob on a 2m string is released from a height of 80cm.

What is the maximum velocity of the pendulum?

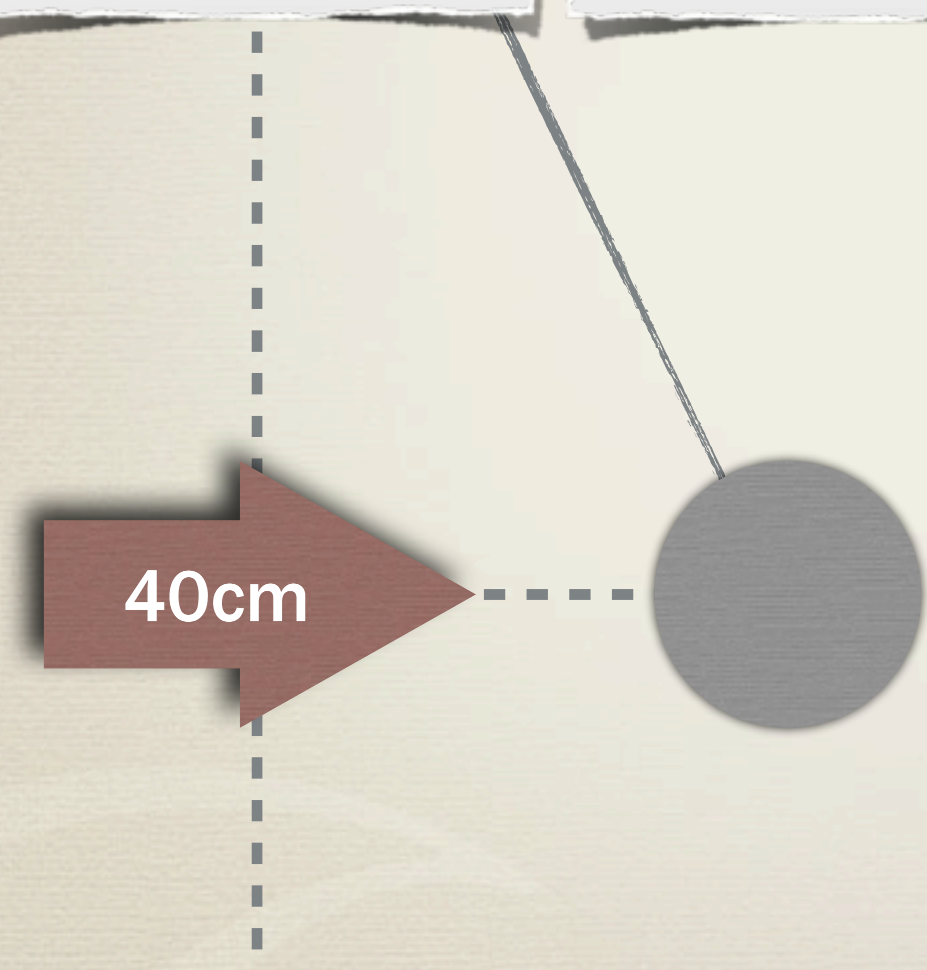
What is the speed at half the height?

80cm

- PE = 0.784J
- KE = 0 J
- TE = 0.784J
- v = 0.0 m/s

0cm

- PE = 0 J
- KE = 0.784J
- TE = 0.784J
- v = 3.96 m/s



- Given Info:
  - m = 0.1 kg
  - TE = 0.784J
  - h = 0.4 m
- PE = mgh = 0.392 J

Find the Speed

A 100g pendulum bob on a 2m string is released from a height of 80cm.

What is the maximum velocity of the pendulum?

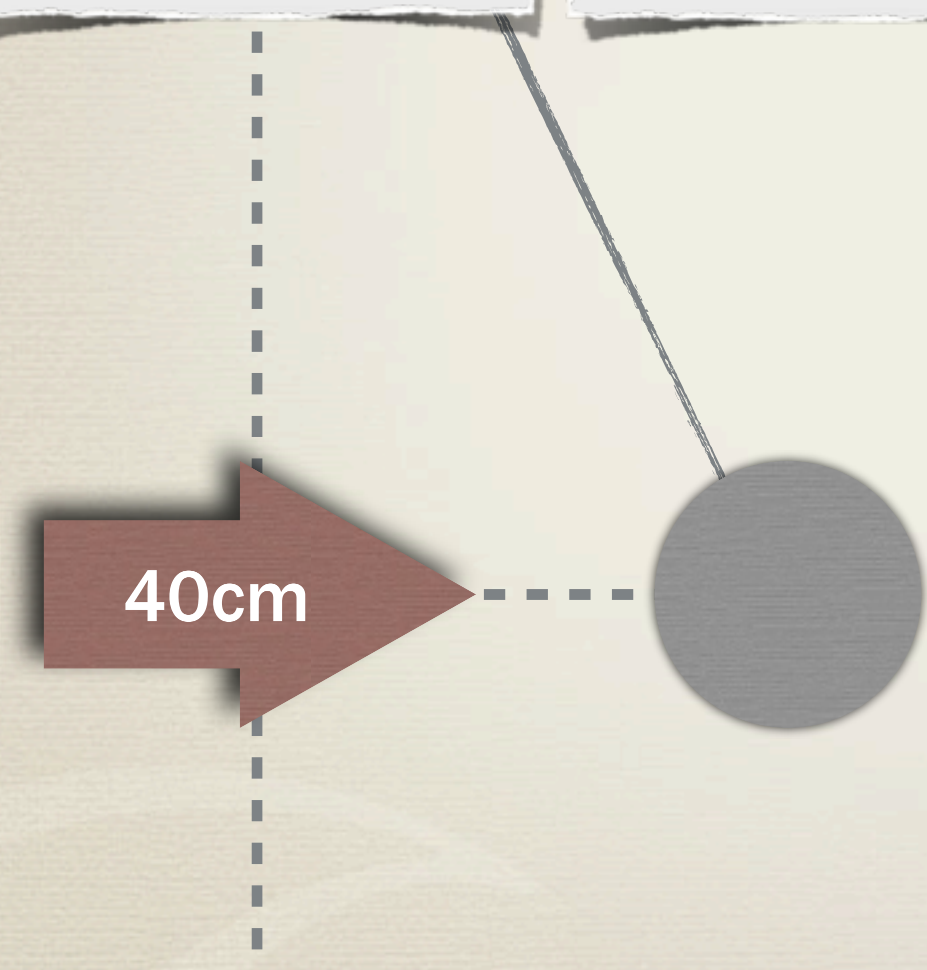
What is the speed at half the height?

80cm

- PE = 0.784J
- KE = 0 J
- TE = 0.784J
- v = 0.0 m/s

0cm

- PE = 0 J
- KE = 0.784J
- TE = 0.784J
- v = 3.96 m/s



- Given Info:
  - m = 0.1 kg
  - TE = 0.784J
  - h = 0.4 m
- PE = mgh = 0.392 J
- KE = 0.392 J = $\frac{1}{2}(mv^2)$

Find the Speed

A 100g pendulum bob on a 2m string is released from a height of 80cm.

What is the maximum velocity of the pendulum?

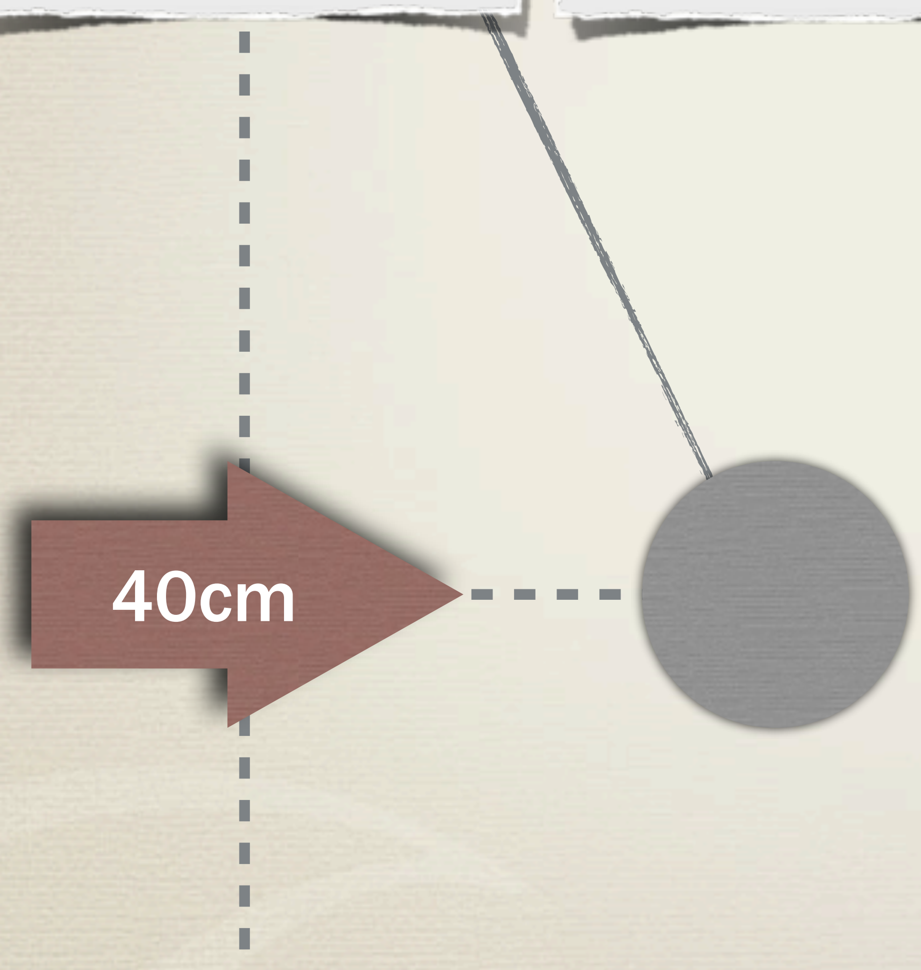
What is the speed at half the height?

80cm

- PE = 0.784J
- KE = 0 J
- TE = 0.784J
- v = 0.0 m/s

0cm

- PE = 0 J
- KE = 0.784J
- TE = 0.784J
- v = 3.96 m/s



- Given Info:
  - m = 0.1 kg
  - TE = 0.784J
  - h = 0.4 m
- PE = mgh = 0.392 J
- KE = 0.392 J = $\frac{1}{2}(mv^2)$
- 0.392 J = $\frac{1}{2}(0.1)(v^2)$

Find the Speed

A 100g pendulum bob on a 2m string is released from a height of 80cm.

What is the maximum velocity of the pendulum?

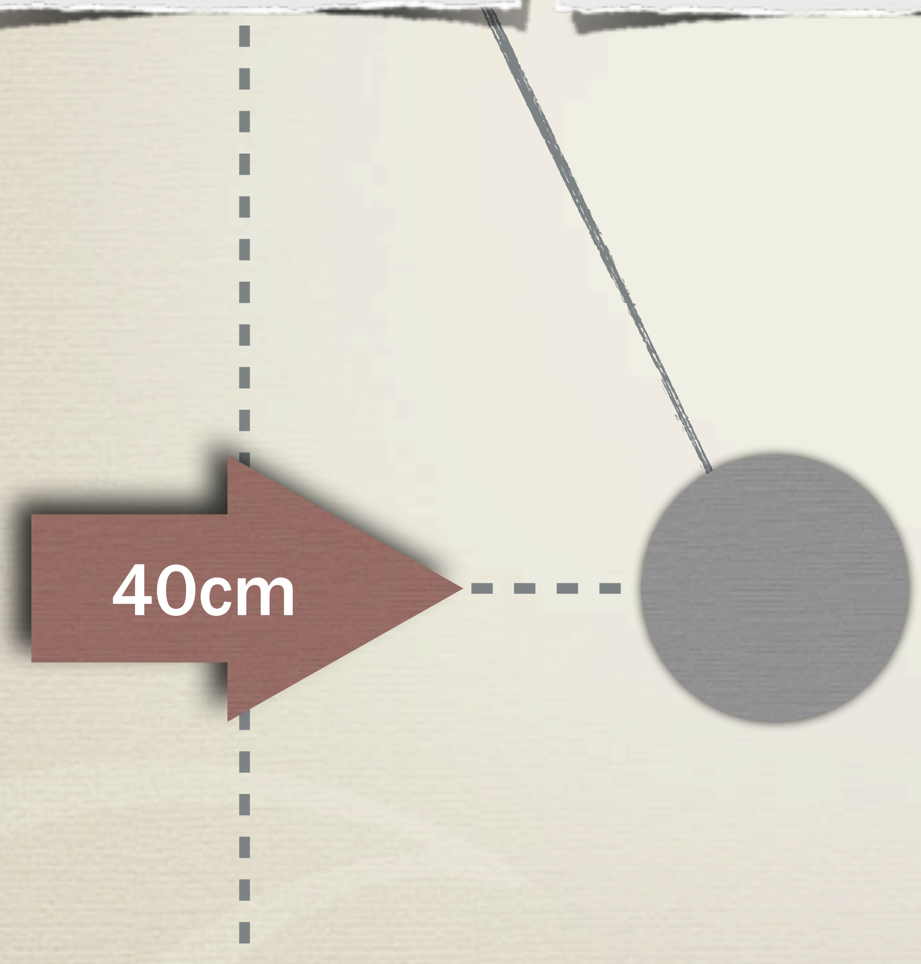
What is the speed at half the height?

80cm

- PE = 0.784J
- KE = 0 J
- TE = 0.784J
- v = 0.0 m/s

0cm

- PE = 0 J
- KE = 0.784J
- TE = 0.784J
- v = 3.96 m/s



- Given Info:
  - m = 0.1 kg
  - TE = 0.784J
  - h = 0.4 m
- PE = mgh = 0.392 J
- KE = 0.392 J = $\frac{1}{2}(mv^2)$
- 0.392 J = $\frac{1}{2}(0.1)(v^2)$
- $v^2 = 7.84$

Find the Speed

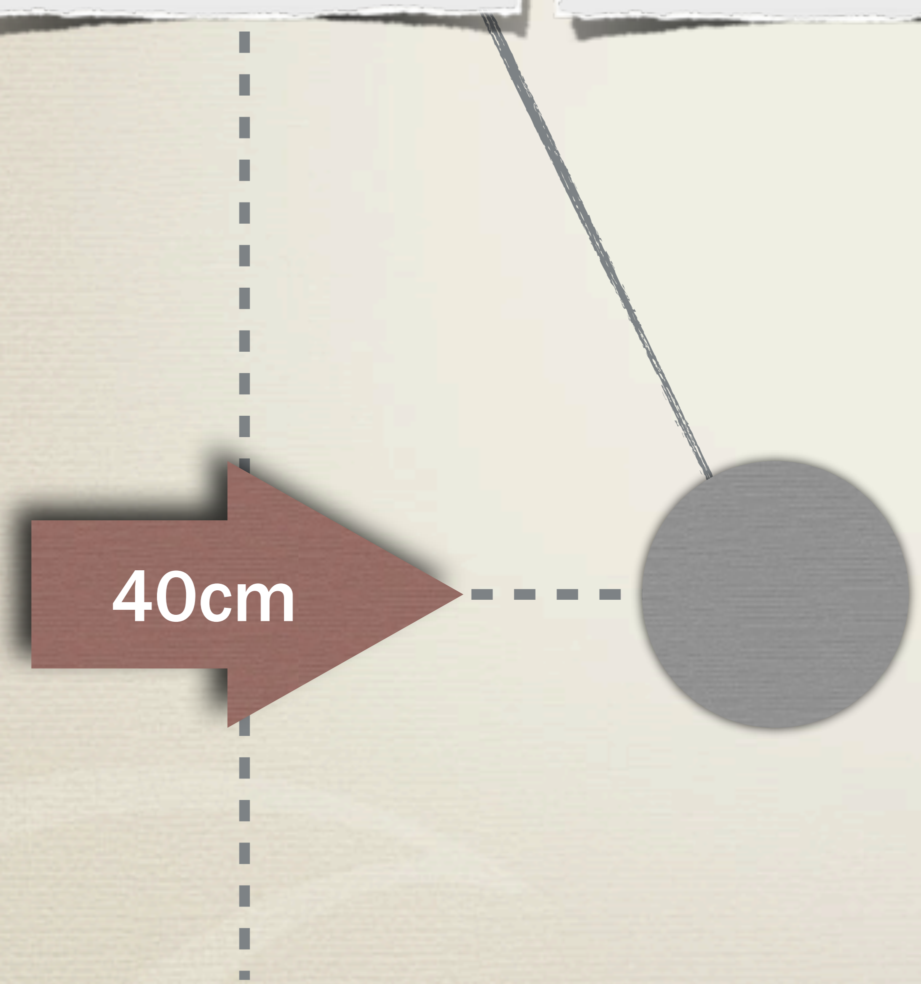
A 100g pendulum bob on a 2m string is released from a height of 80cm.
What is the maximum velocity of the pendulum?
What is the speed at half the height?

80cm

- PE = 0.784J
- KE = 0 J
- TE = 0.784J
- v = 0.0 m/s

0cm

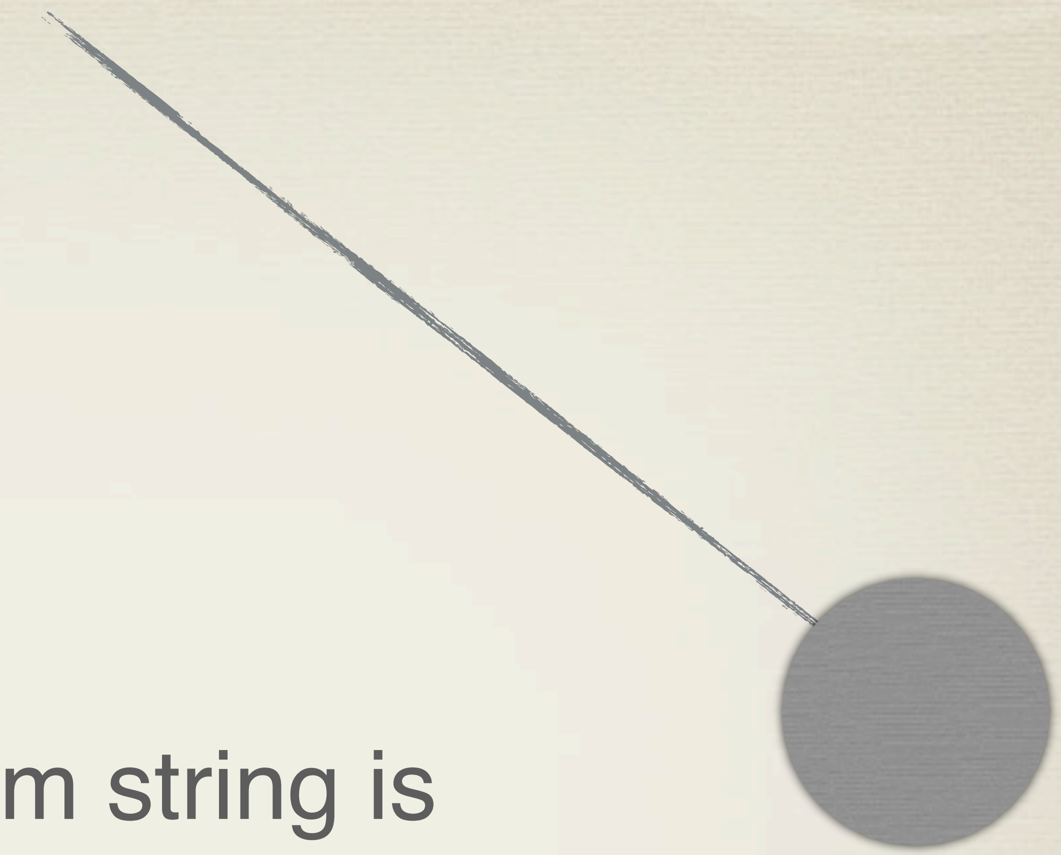
- PE = 0 J
- KE = 0.784J
- TE = 0.784J
- v = 3.96 m/s



- Given Info:
  - m = 0.1 kg
  - TE = 0.784J
  - h = 0.4 m
- PE = mgh = 0.392 J
- KE = 0.392 J = $\frac{1}{2}(mv^2)$
- 0.392 J = $\frac{1}{2}(0.1)(v^2)$
- $v^2 = 7.84$
- v = 2.8 m/s
  - *(not half the maximum speed)*

Find the Speed

honors style



- A 250g pendulum bob on a 2m string is released from an angle of 60°.
- What is the speed when the string forms a 20°angle with the vertical

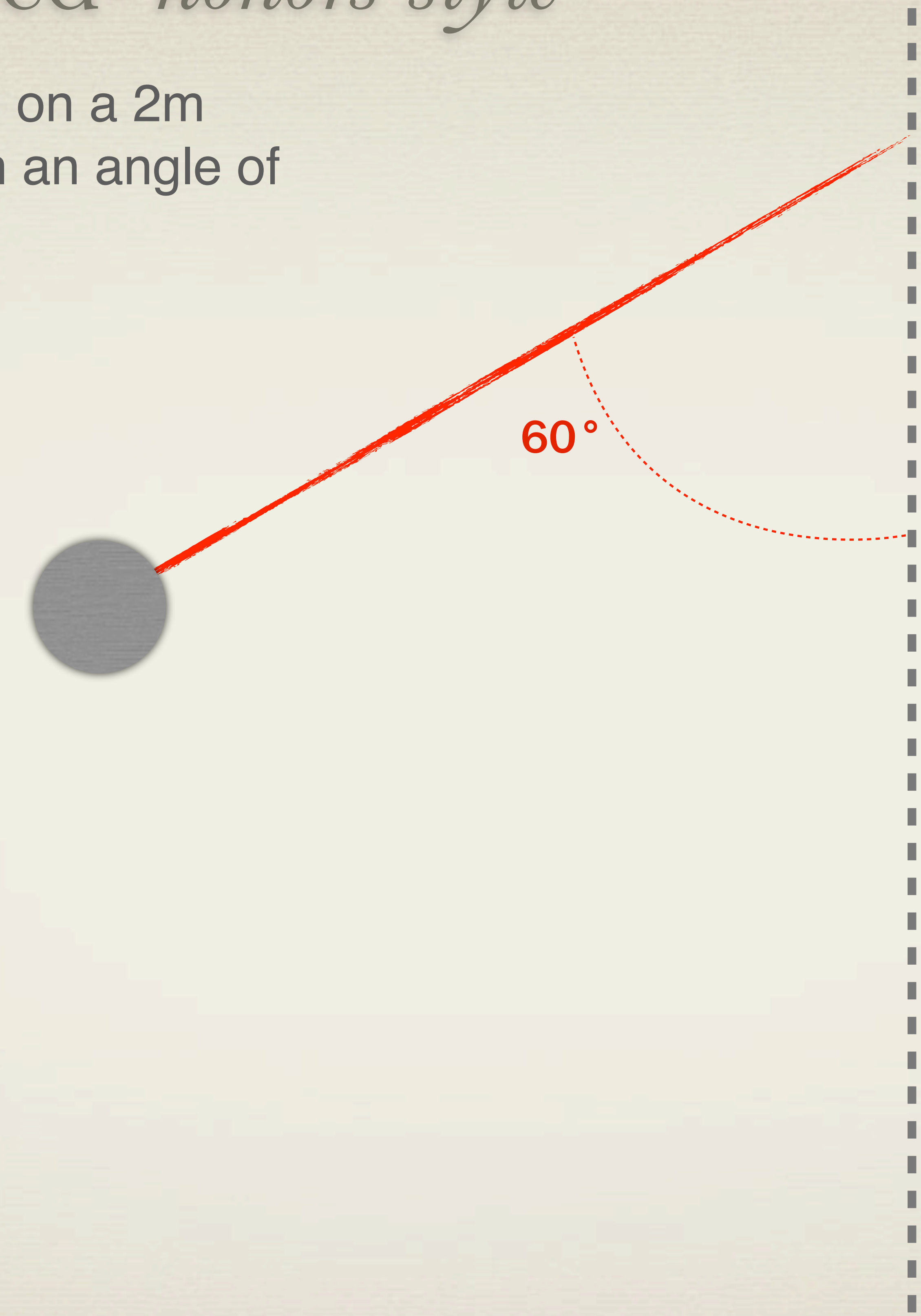
Find the Speed- *honors style*

Find the Speed- *honors style*

A 250g pendulum bob on a 2m string is released from an angle of 60° with the vertical.

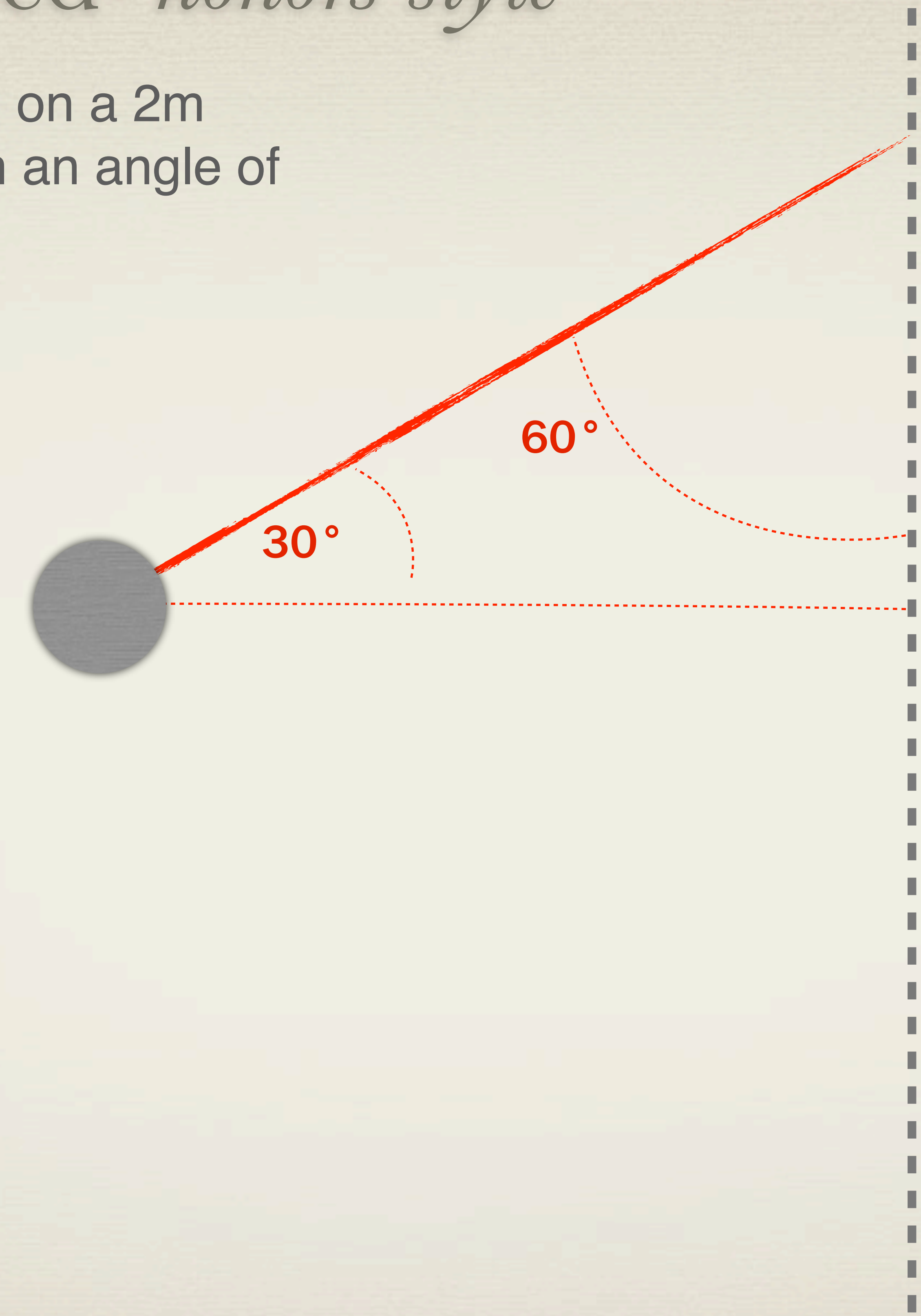
Find the Speed- *honors style*

A 250g pendulum bob on a 2m string is released from an angle of 60° with the vertical.



Find the Speed- *honors style*

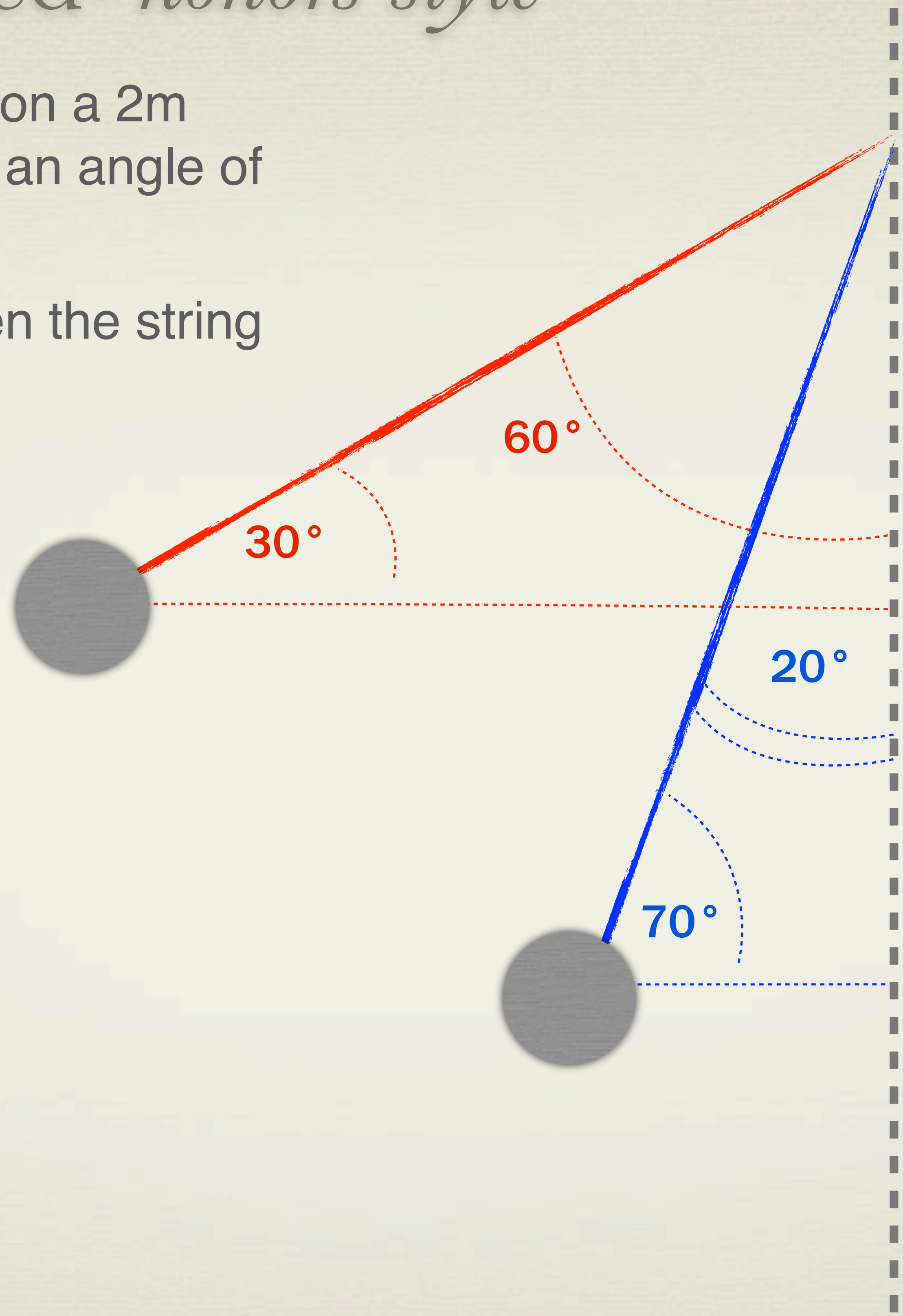
A 250g pendulum bob on a 2m string is released from an angle of 60° with the vertical.



Find the Speed- *honors style*

A 250g pendulum bob on a 2m string is released from an angle of 60° with the vertical.

What is the speed when the string forms a 20°angle?



Find the Speed- *honors style*

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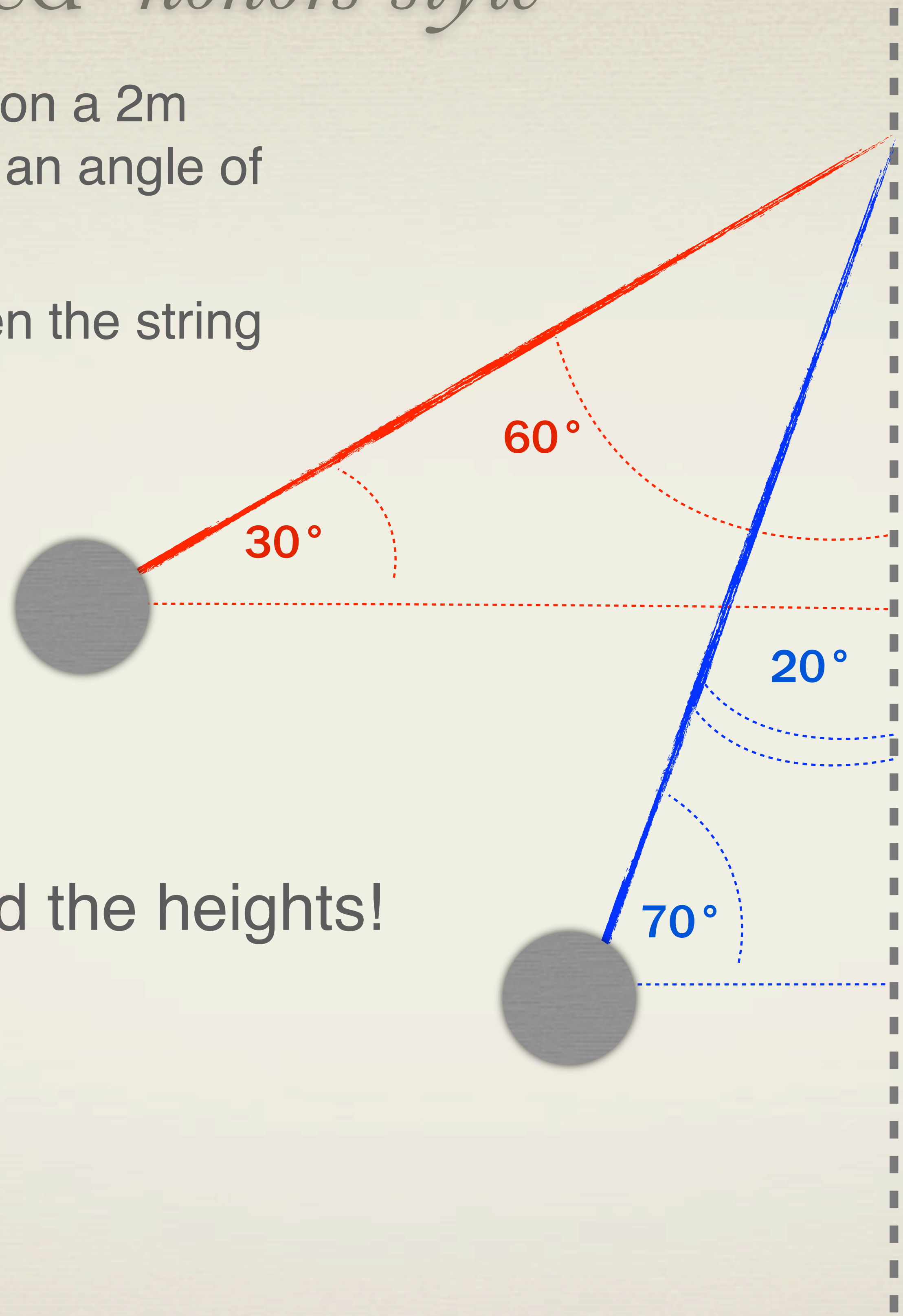
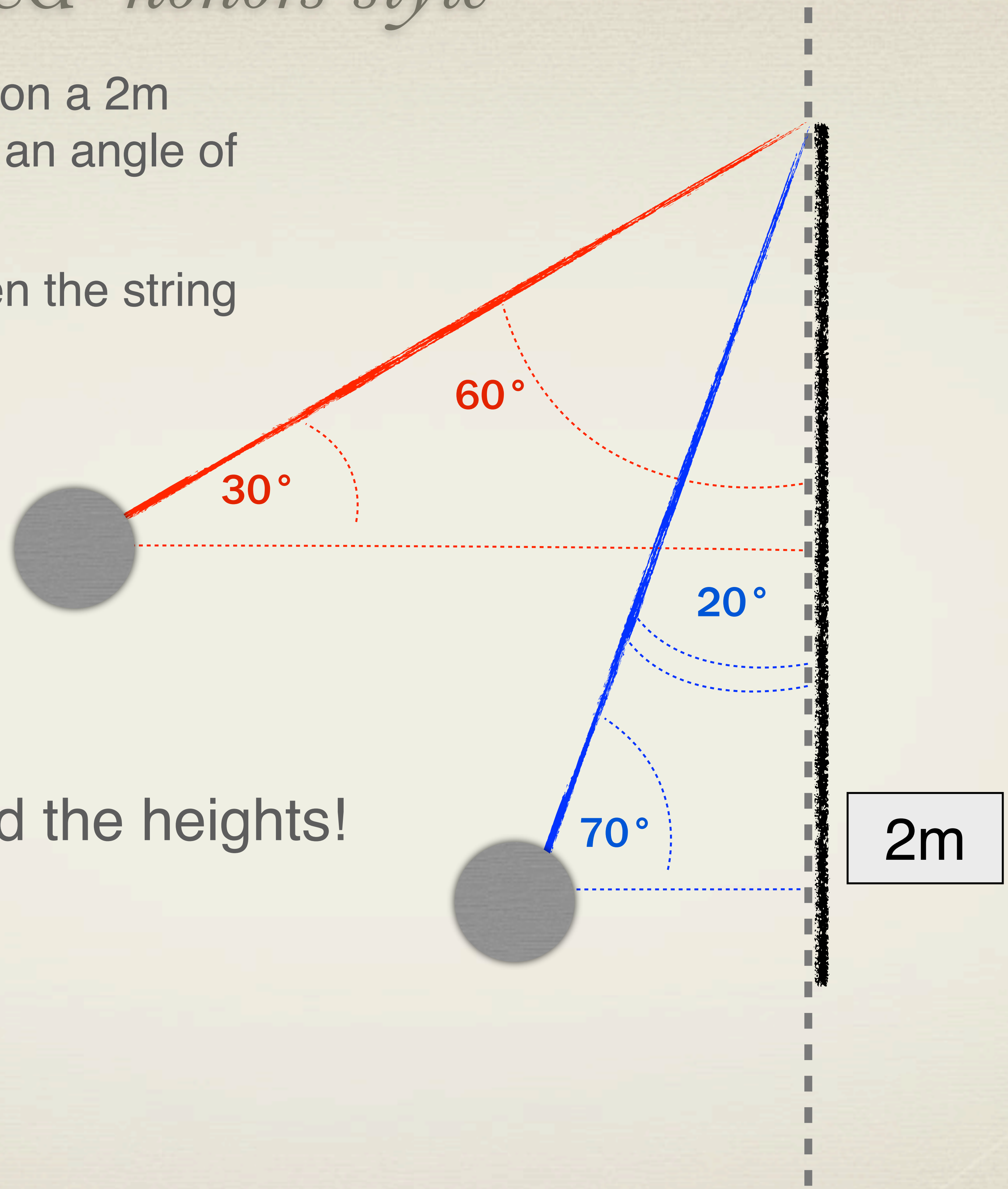


So, you need to find the heights!

Find the Speed- *honors style*

A 250g pendulum bob on a 2m string is released from an angle of 60° with the vertical.

What is the speed when the string forms a 20°angle?



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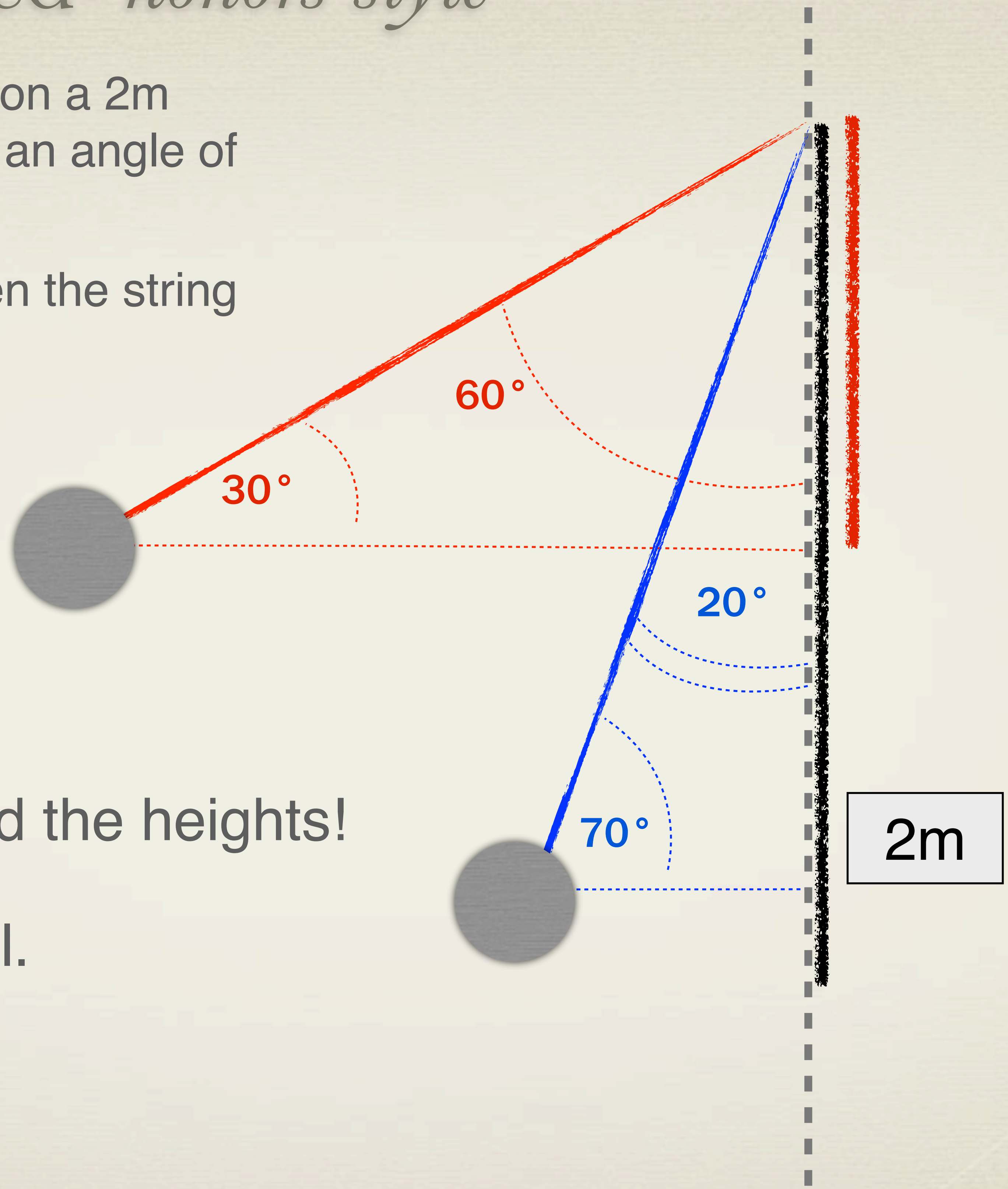


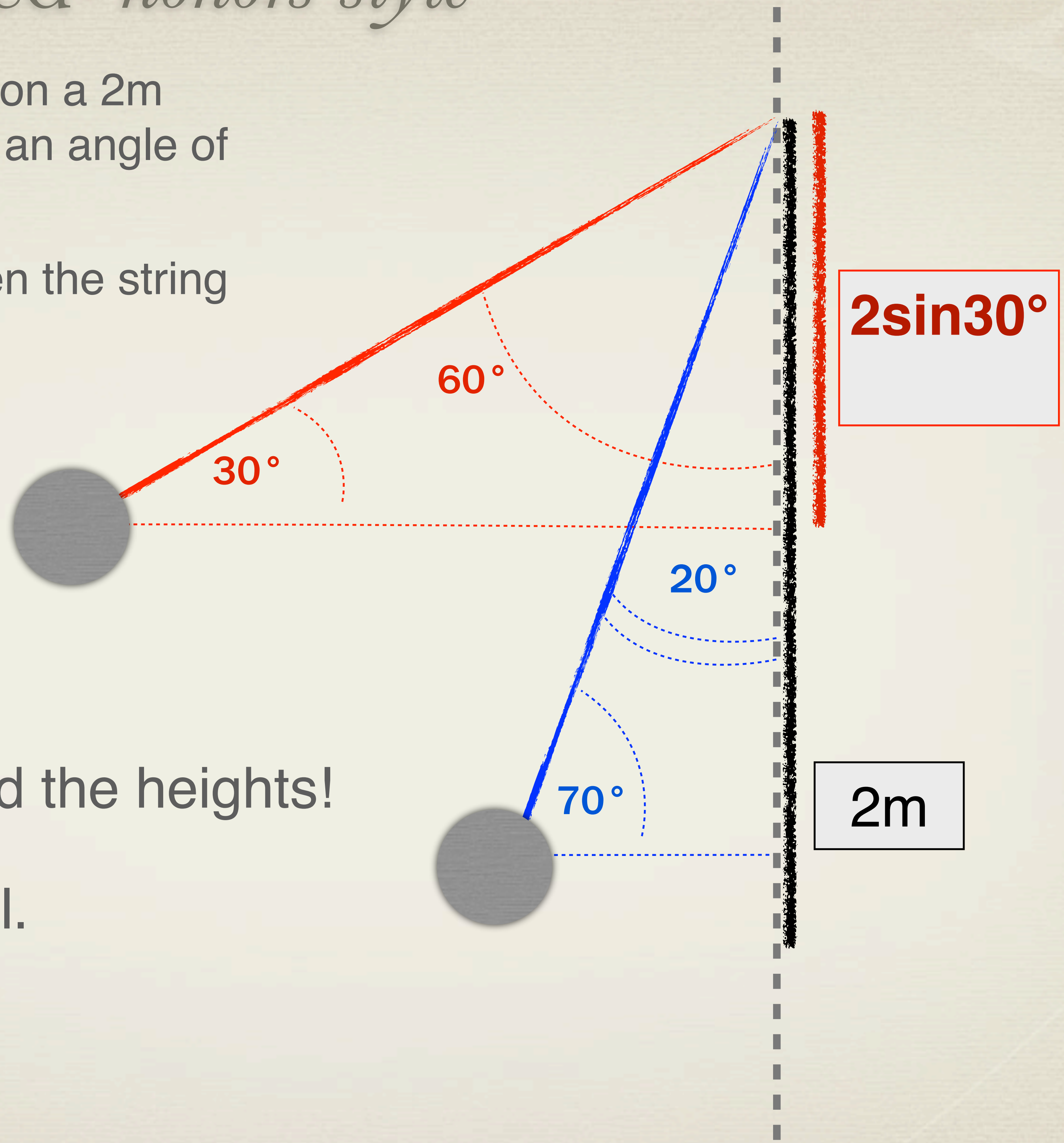
So, you need to find the heights!

60° with the vertical.

Find the Speed- *honors style*

A 250g pendulum bob on a 2m string is released from an angle of 60° with the vertical.

What is the speed when the string forms a 20°angle?



So, you need to find the heights!

60° with the vertical.

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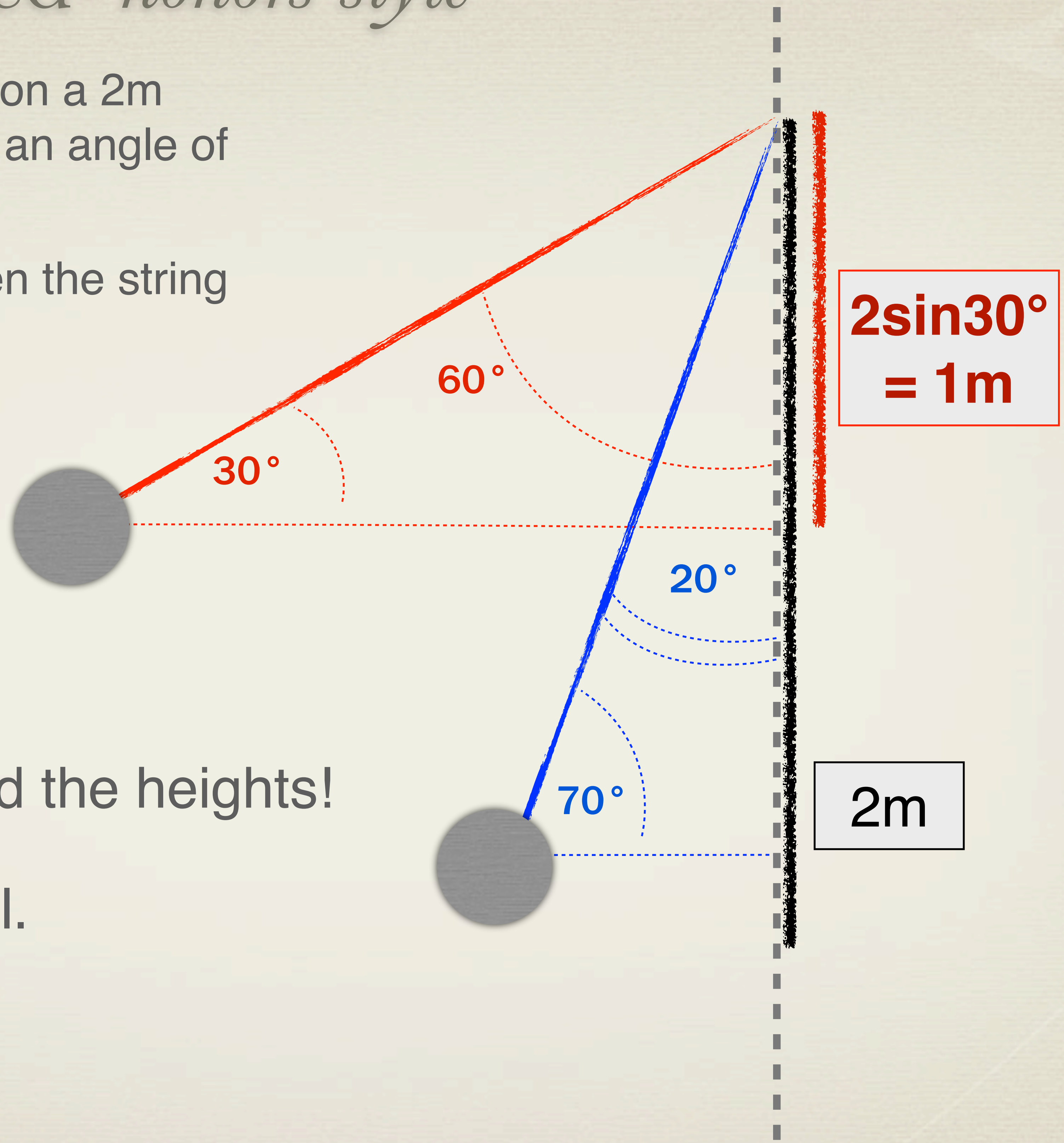

So, you need to find the heights!

60° with the vertical.

Find the Speed- *honors style*

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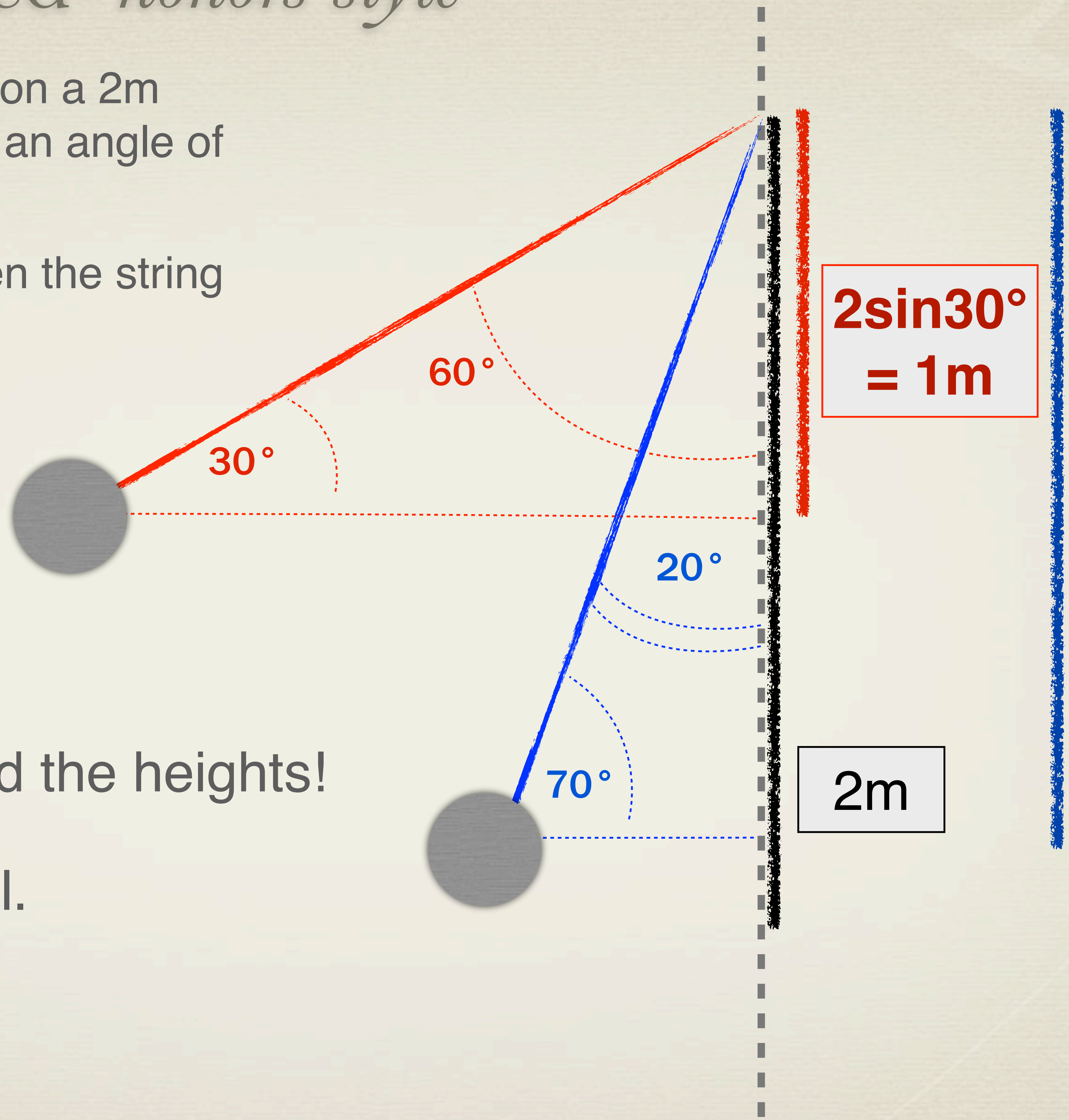


So, you need to find the heights!

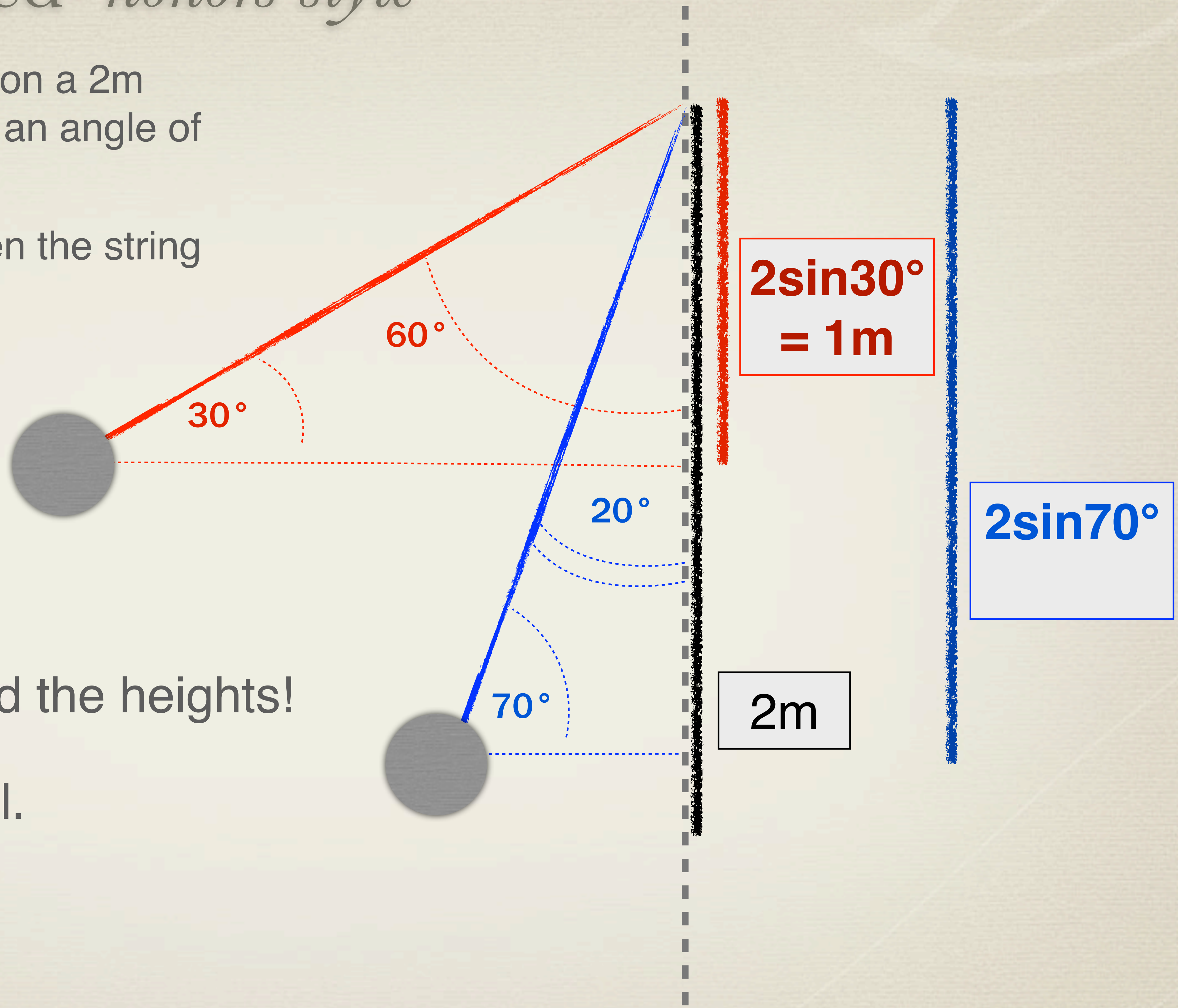
60° with the vertical.

20°angle?

Find the Speed- *honors style*

A 250g pendulum bob on a 2m string is released from an angle of 60° with the vertical.

What is the speed when the string forms a 20°angle?



So, you need to find the heights!

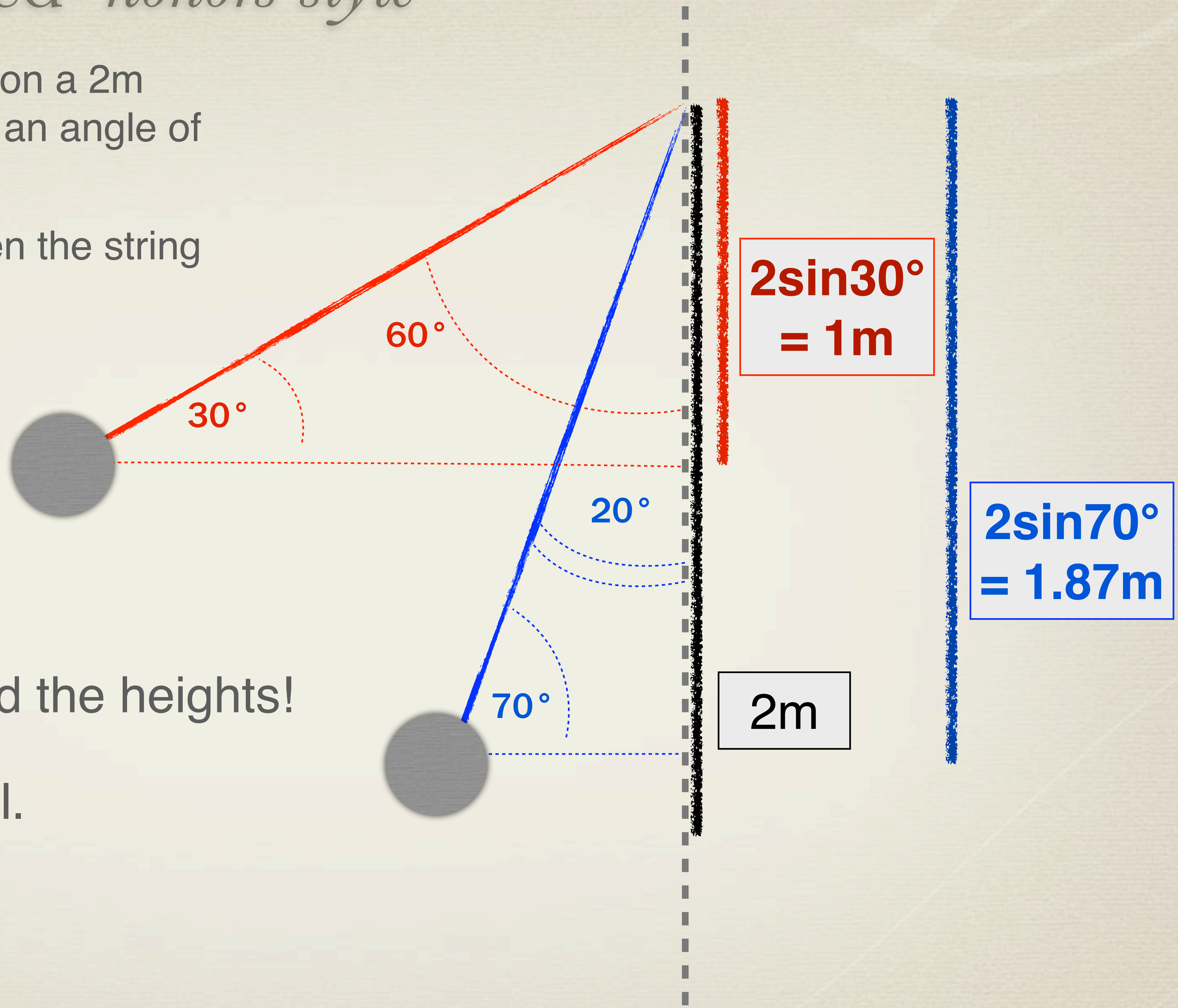
60° with the vertical.

20°angle?

Find the Speed- *honors style*

A 250g pendulum bob on a 2m string is released from an angle of 60° with the vertical.

What is the speed when the string forms a 20°angle?



So, you need to find the heights!

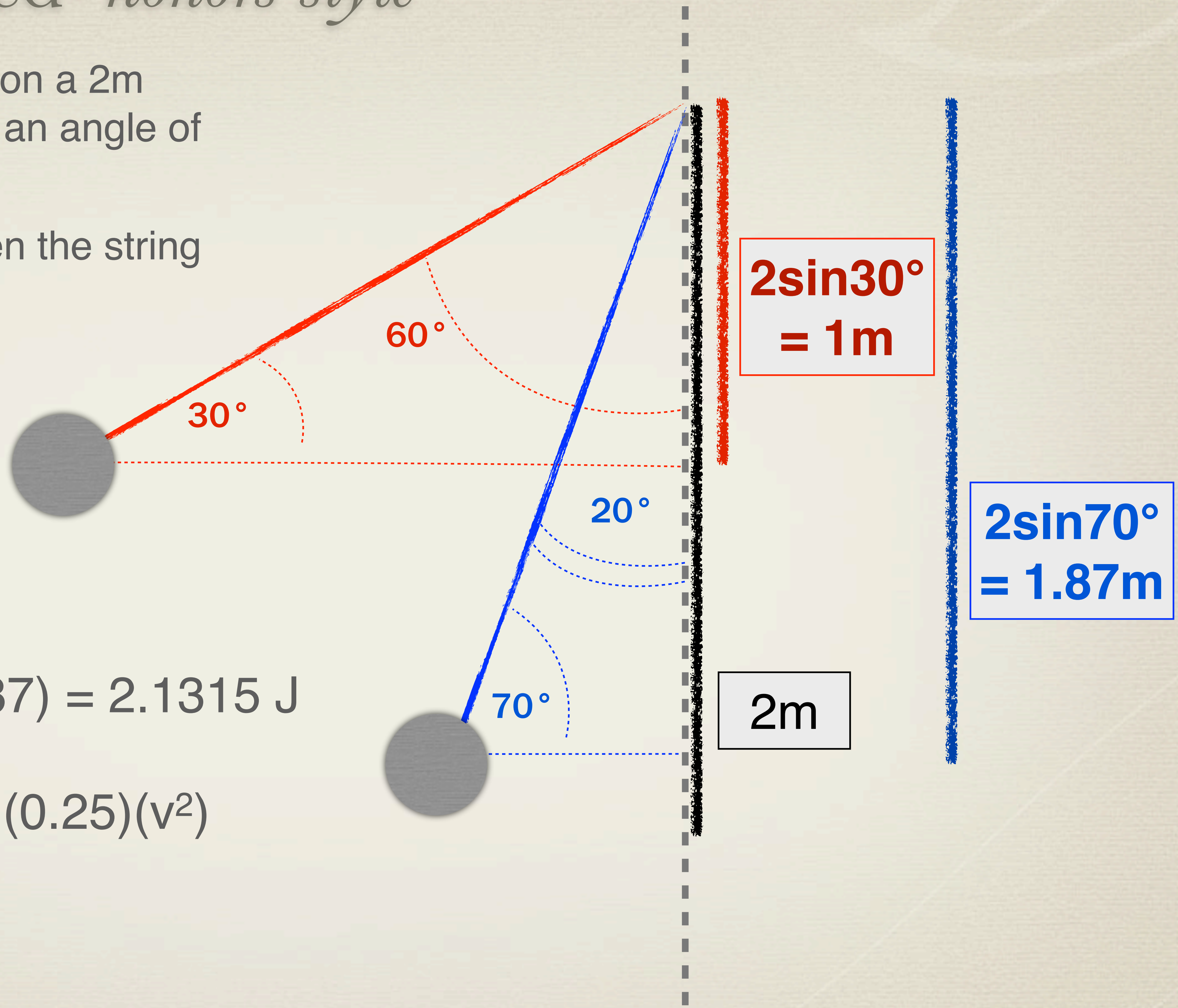
60° with the vertical.

20°angle?

Find the Speed- *honors style*

A 250g pendulum bob on a 2m string is released from an angle of 60° with the vertical.

What is the speed when the string forms a 20°angle?



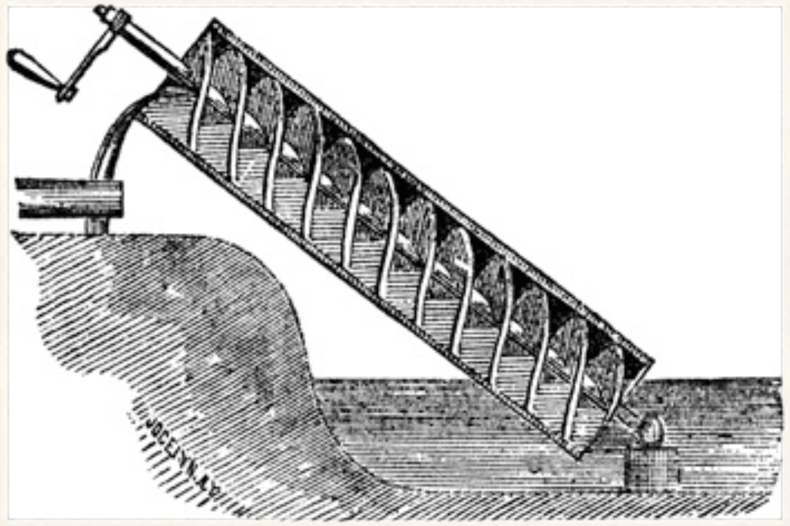
PE= (0.25)(9.8)(0.87) = 2.1315 J

KE = 2.1315 J = ½(0.25)(v^2)

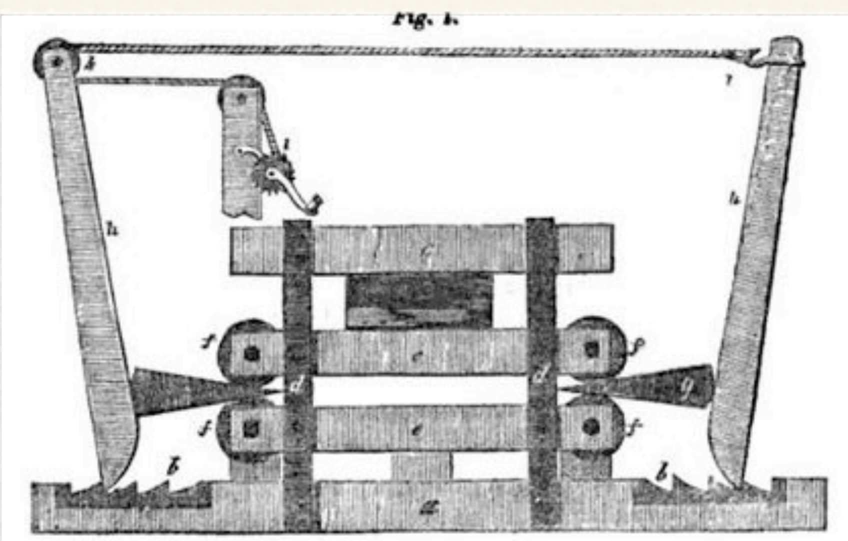
v = 4.13 m/s

SIMPLE MACHINES

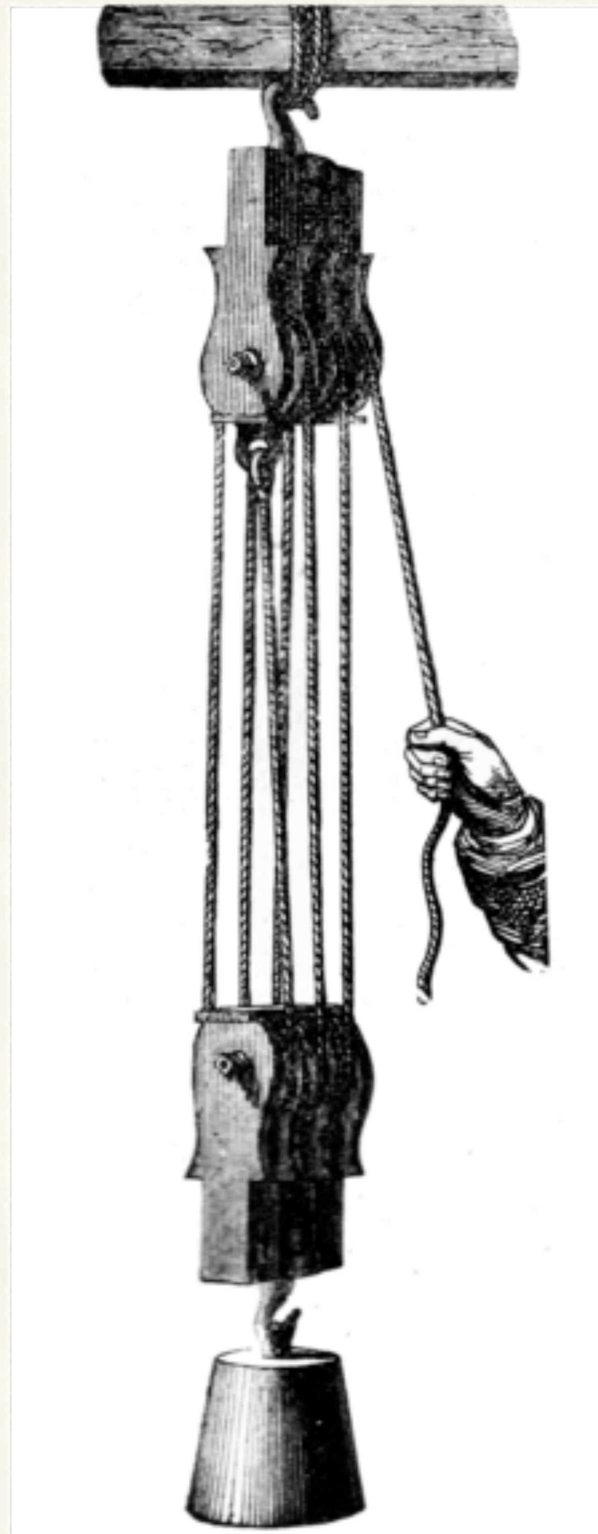
Simple Machines



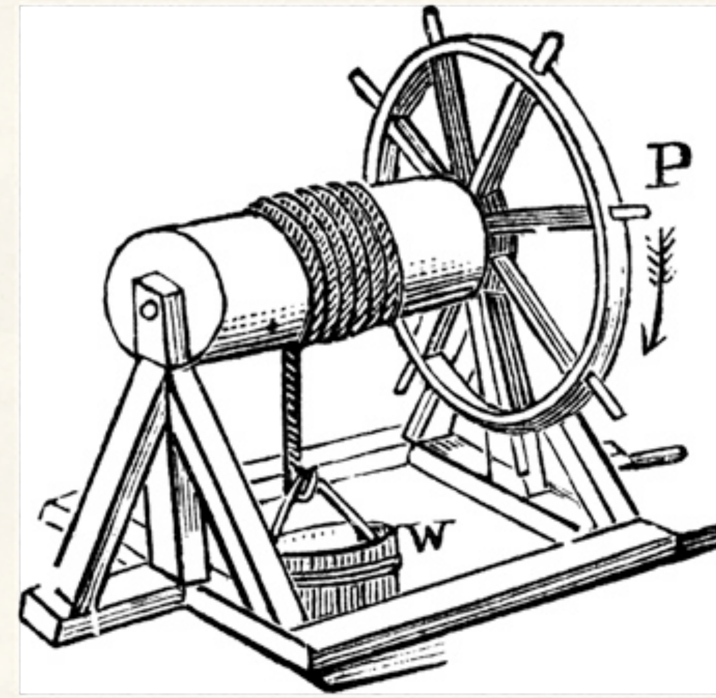
File:Archimedes screw.JPG - Wikimedia Foundation



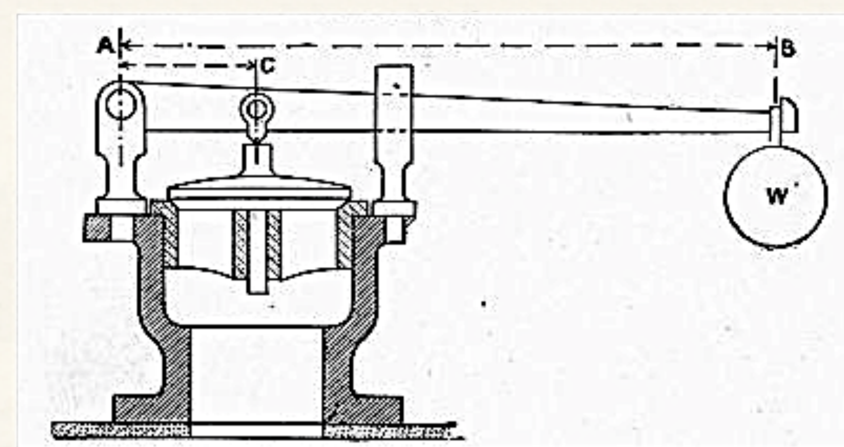
File:19th century knowledge mechanisms wedge lever press.jpg - Wikimedia Foundation



File:Opfindelsernes bog3 fig043.png - Wikimedia Foundation



File:Wheelaxle quackenbos.gif - Wikimedia Foundation



File:Lever safety valve (Heat Engines, 1913).jpg - Wikimedia Foundation

Simple Machines

Simple Machines

- IMA - the Ideal Mechanical Advantage
  - based on the geometry of the system

Simple Machines

- IMA - the Ideal Mechanical Advantage
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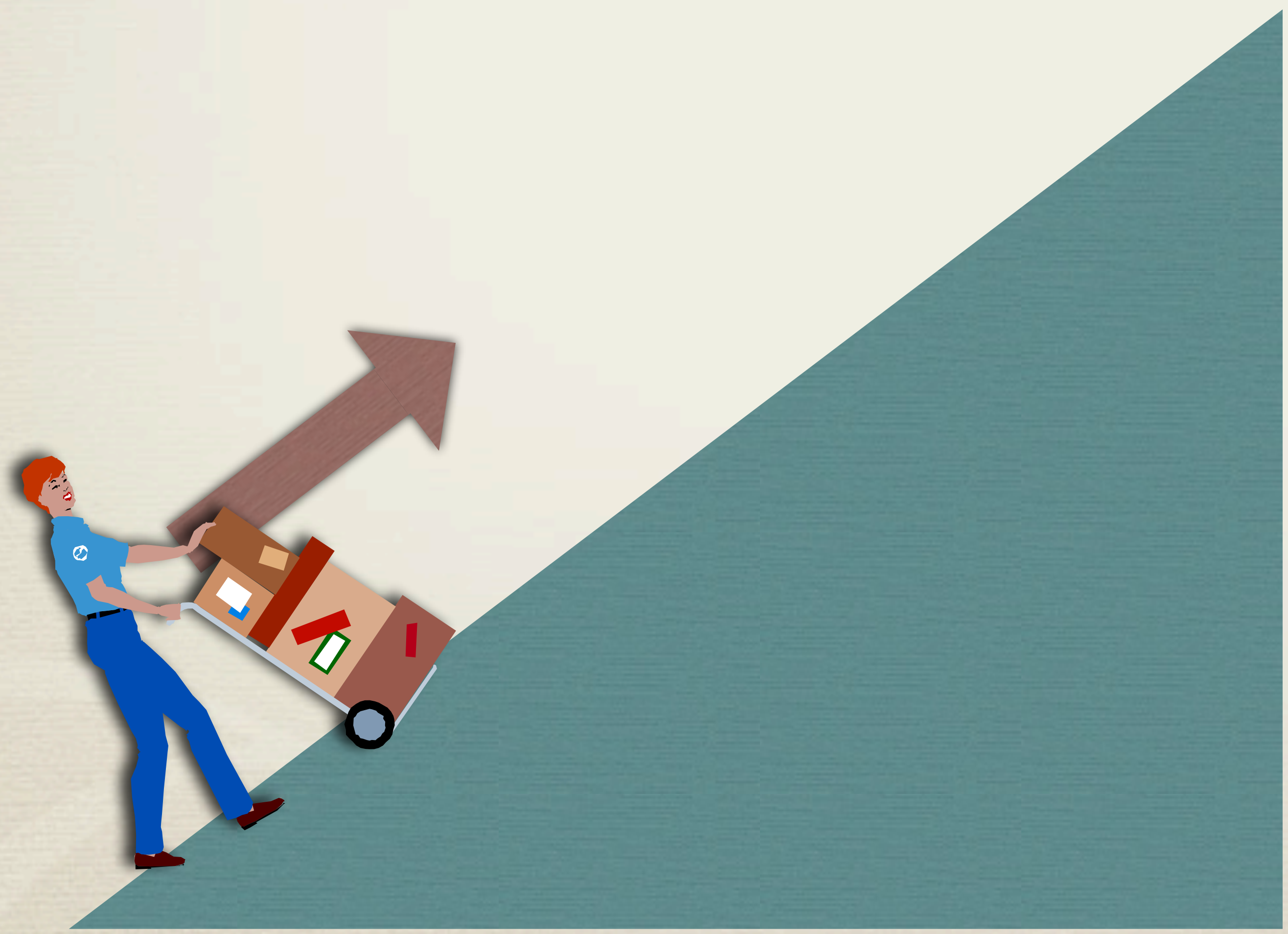
- Efficiency = Work Output / Work Input
  - Efficiency = Wo / Wi = AMA / IMA

Laura lifts some boxes up 3m by pushing the 60 kg cart up a 12 m ramp. She uses a force of 200 N and takes 30 seconds to travel.

Find; the work input, the work output, the IMA and AMA, the efficiency of the ramp, energy wasted by friction, her power



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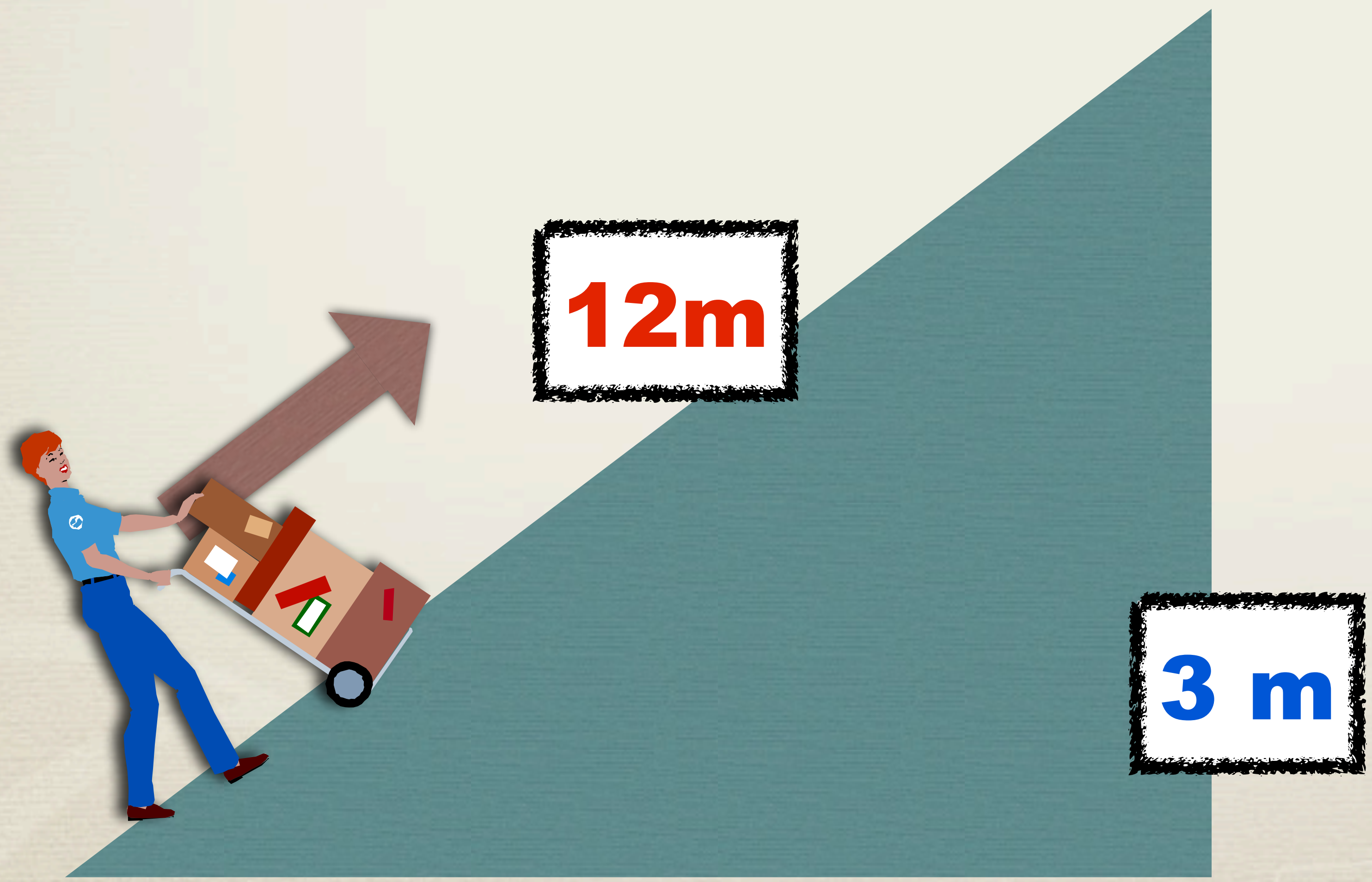

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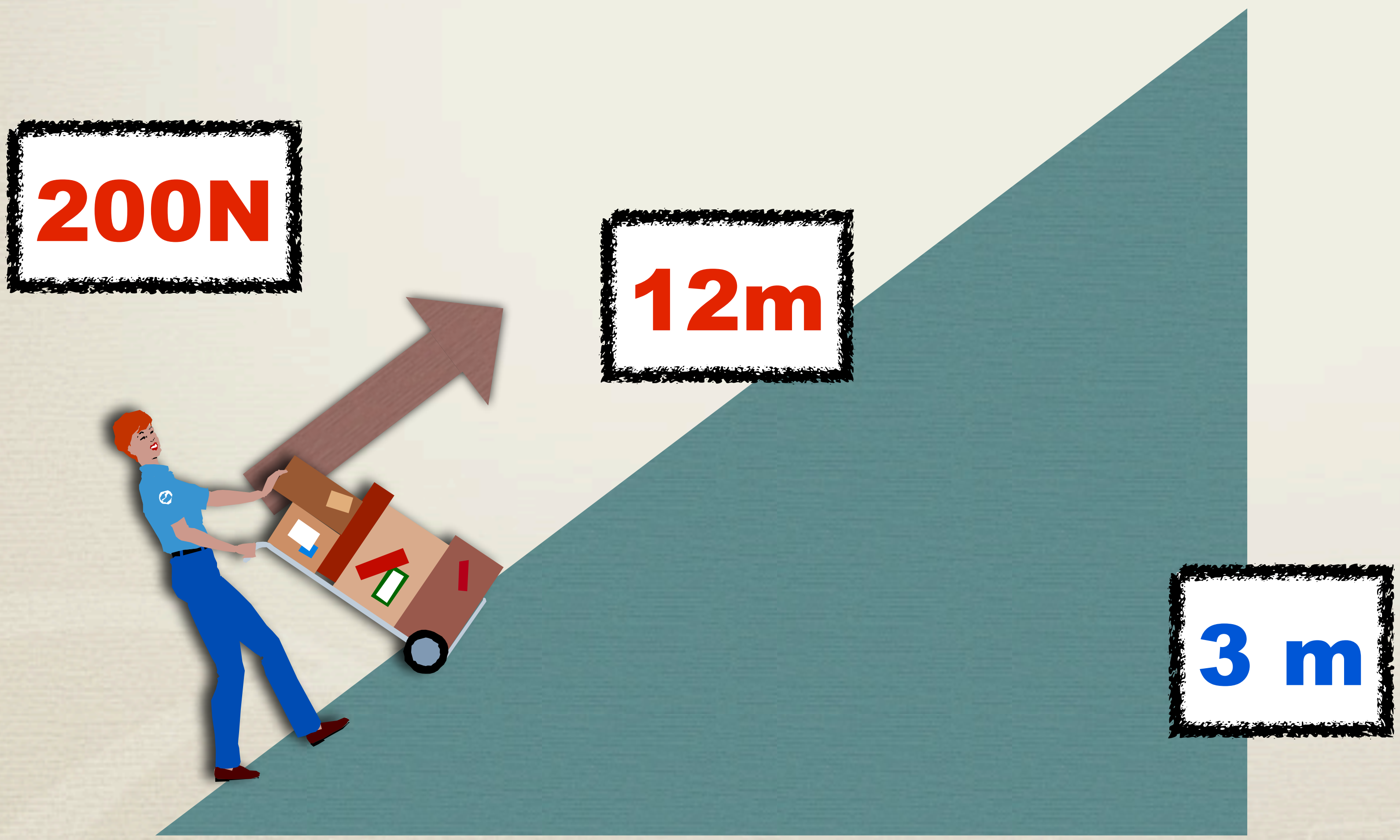

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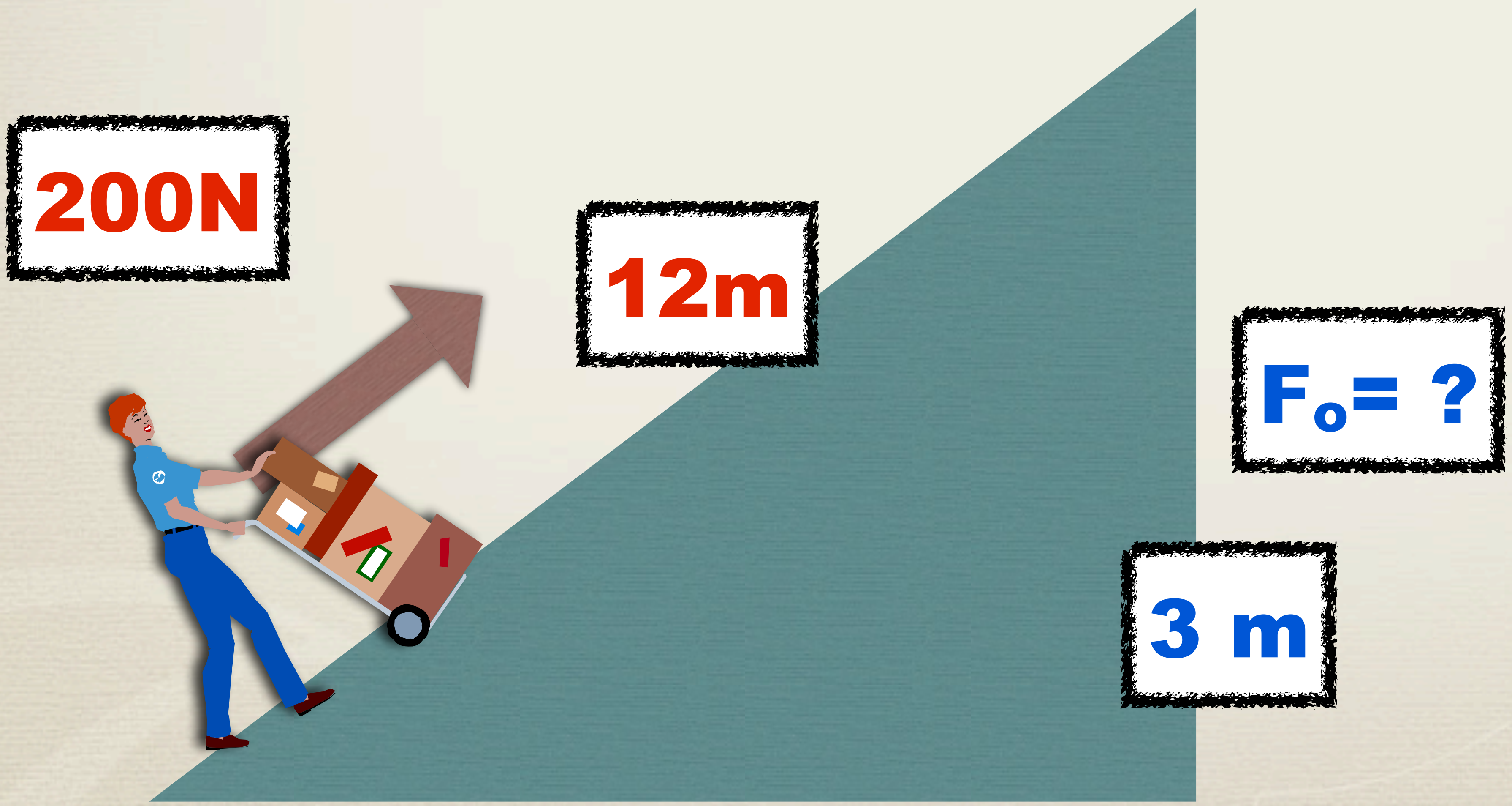

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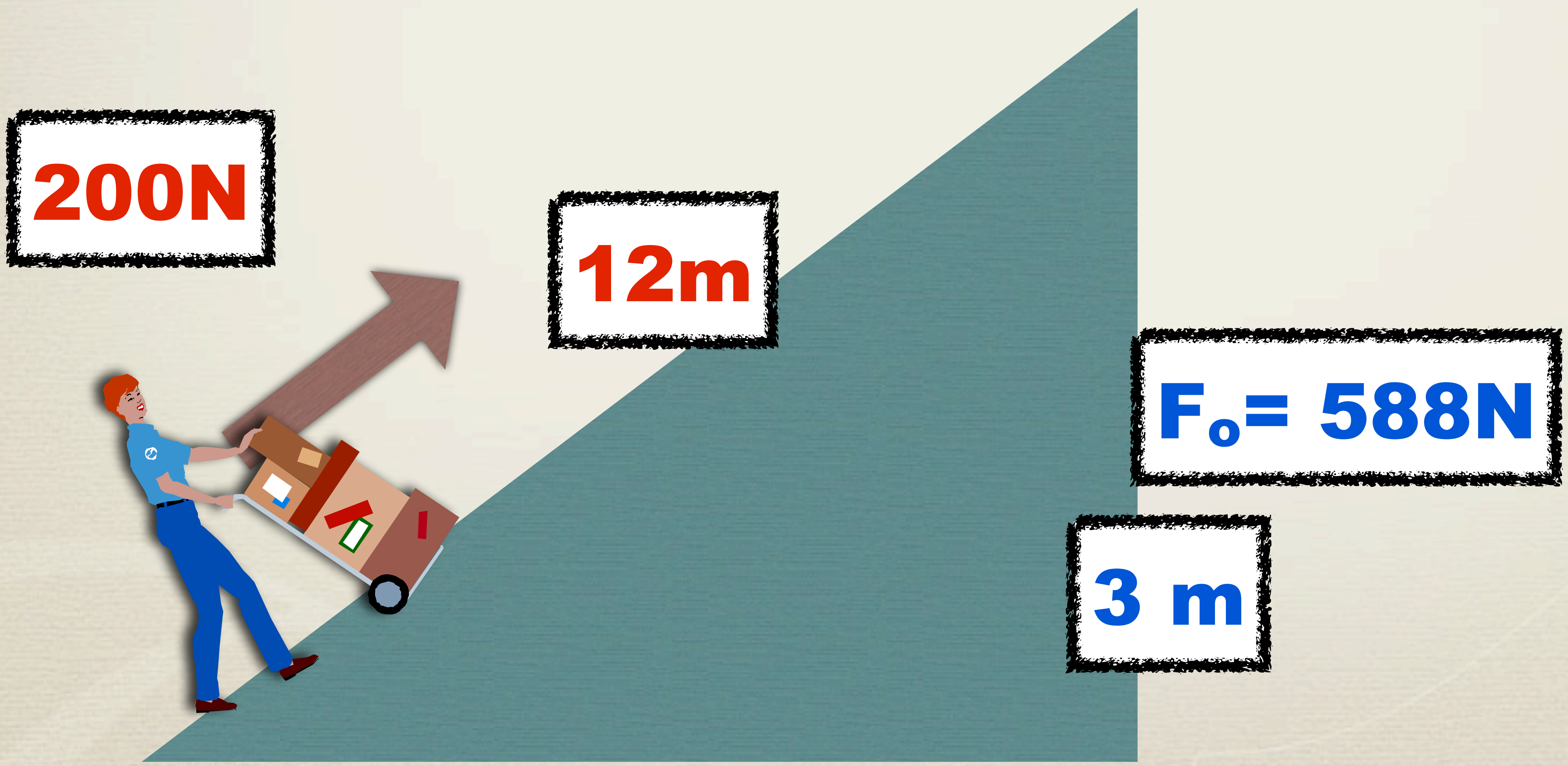

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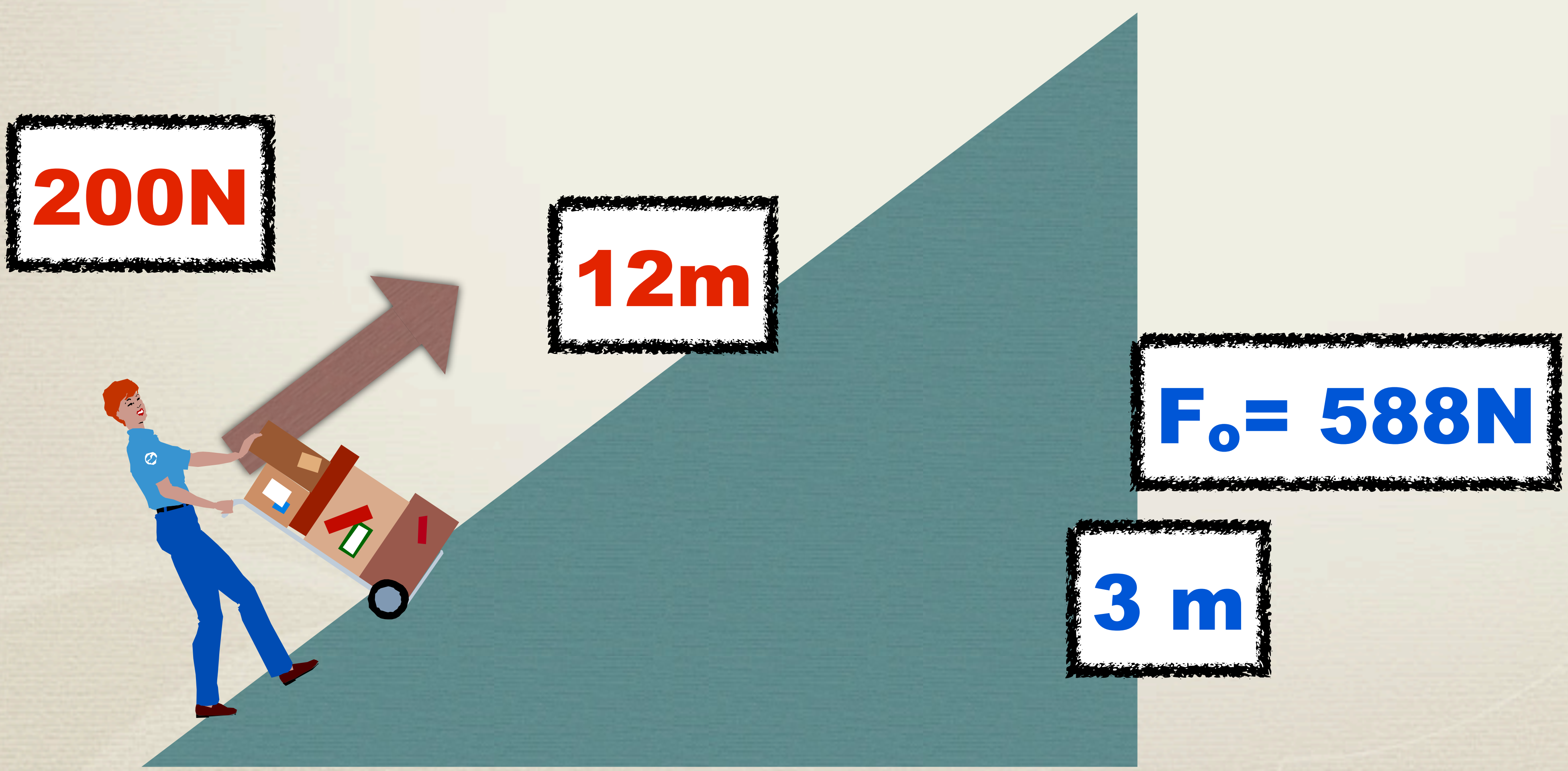

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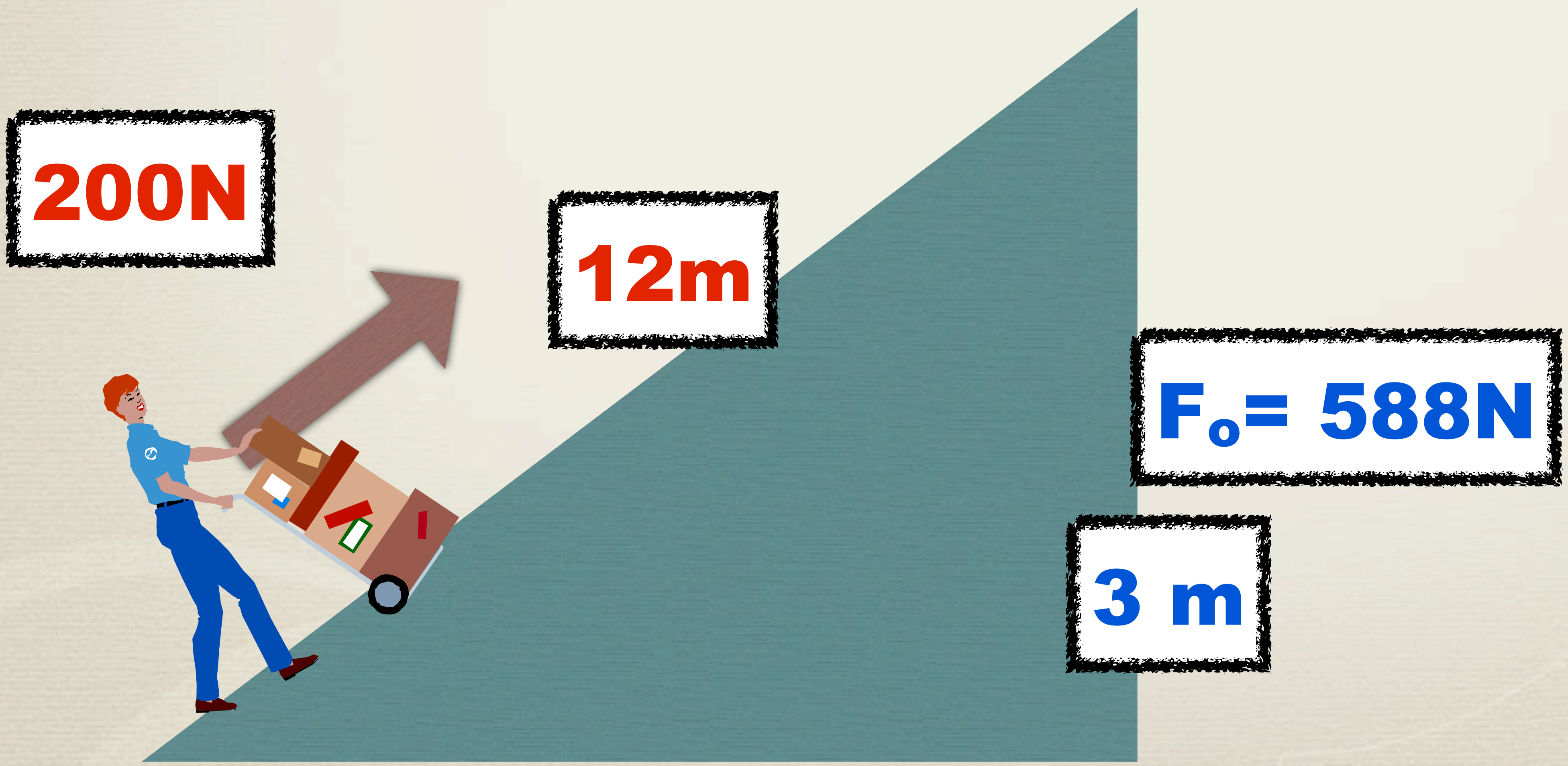
$W_i = F\ d$



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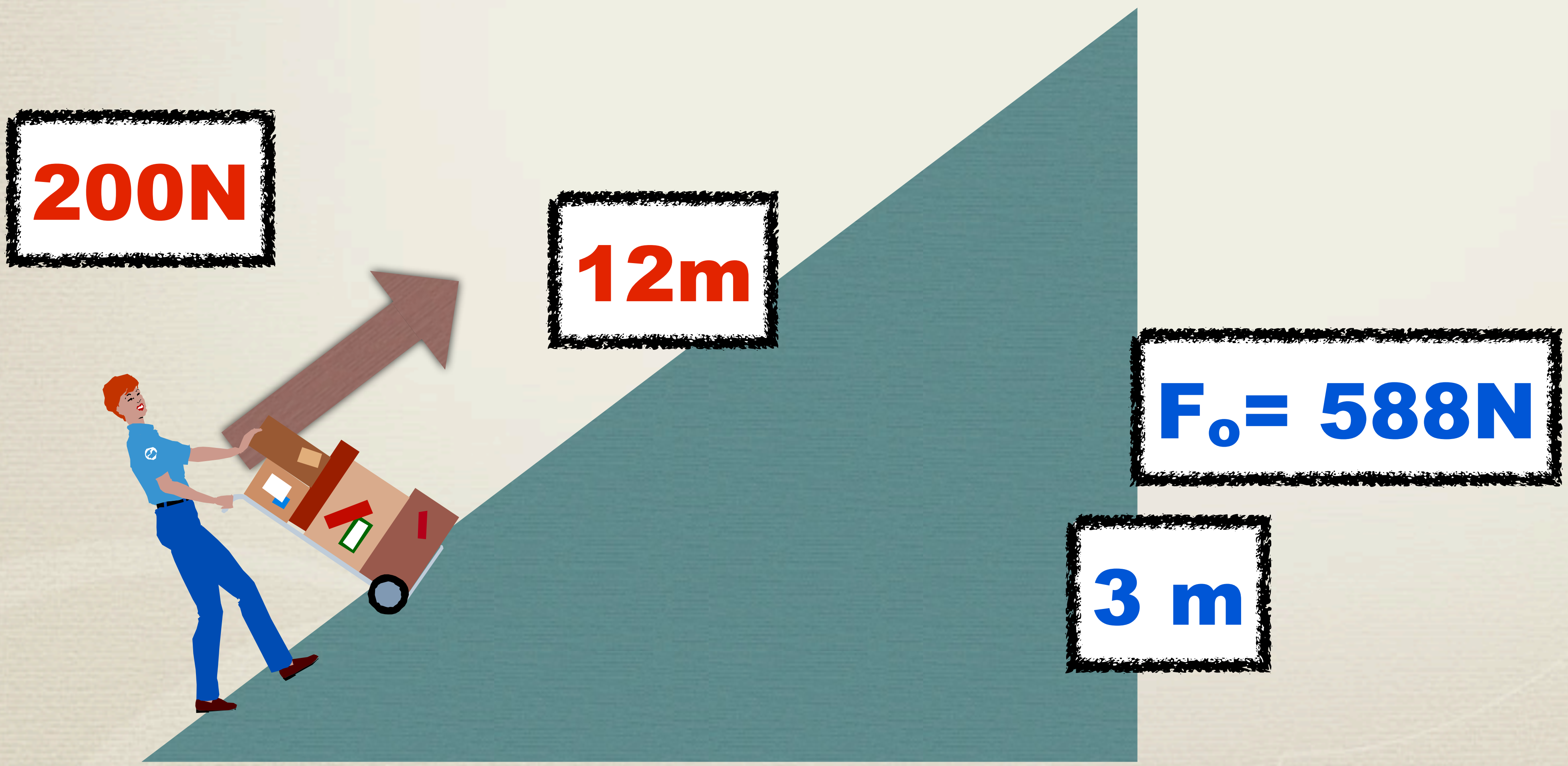
Find; the work input, the work output, the IMA and AMA, the efficiency of the ramp, energy wasted by friction, her power

$$W_i = F\ d$$
$$W_i = (200\ \mathrm{N})\ (12\mathrm{m})$$



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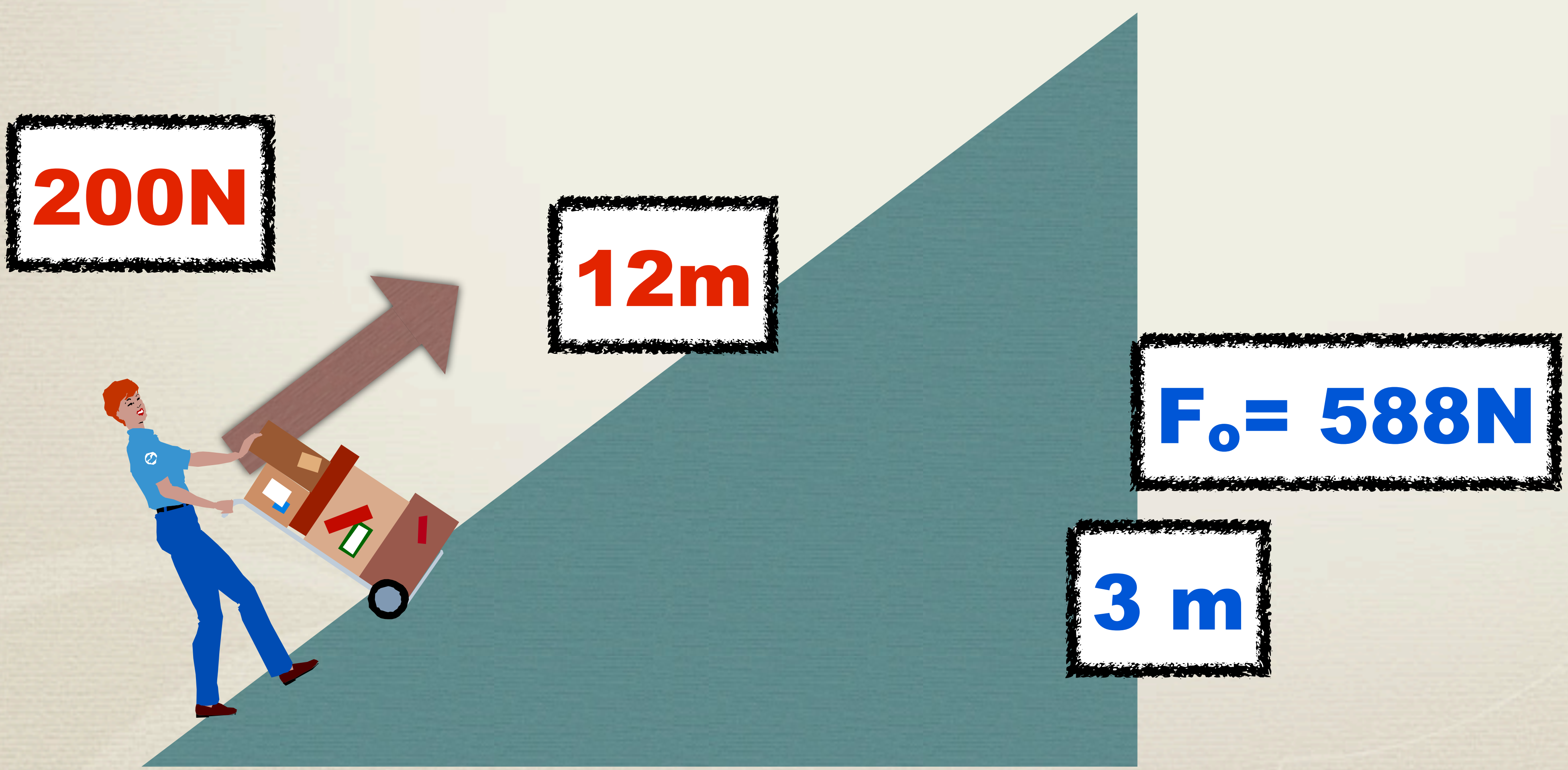
Find; the work input, the work output, the IMA and AMA, the efficiency of the ramp, energy wasted by friction, her power

$$W_i = F\ d$$
$$W_i = (200\ N)\ (12m)$$
$$W_i = 2400\ J$$



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Find; the work input, the work output, the IMA and AMA, the efficiency of the ramp, energy wasted by friction, her power

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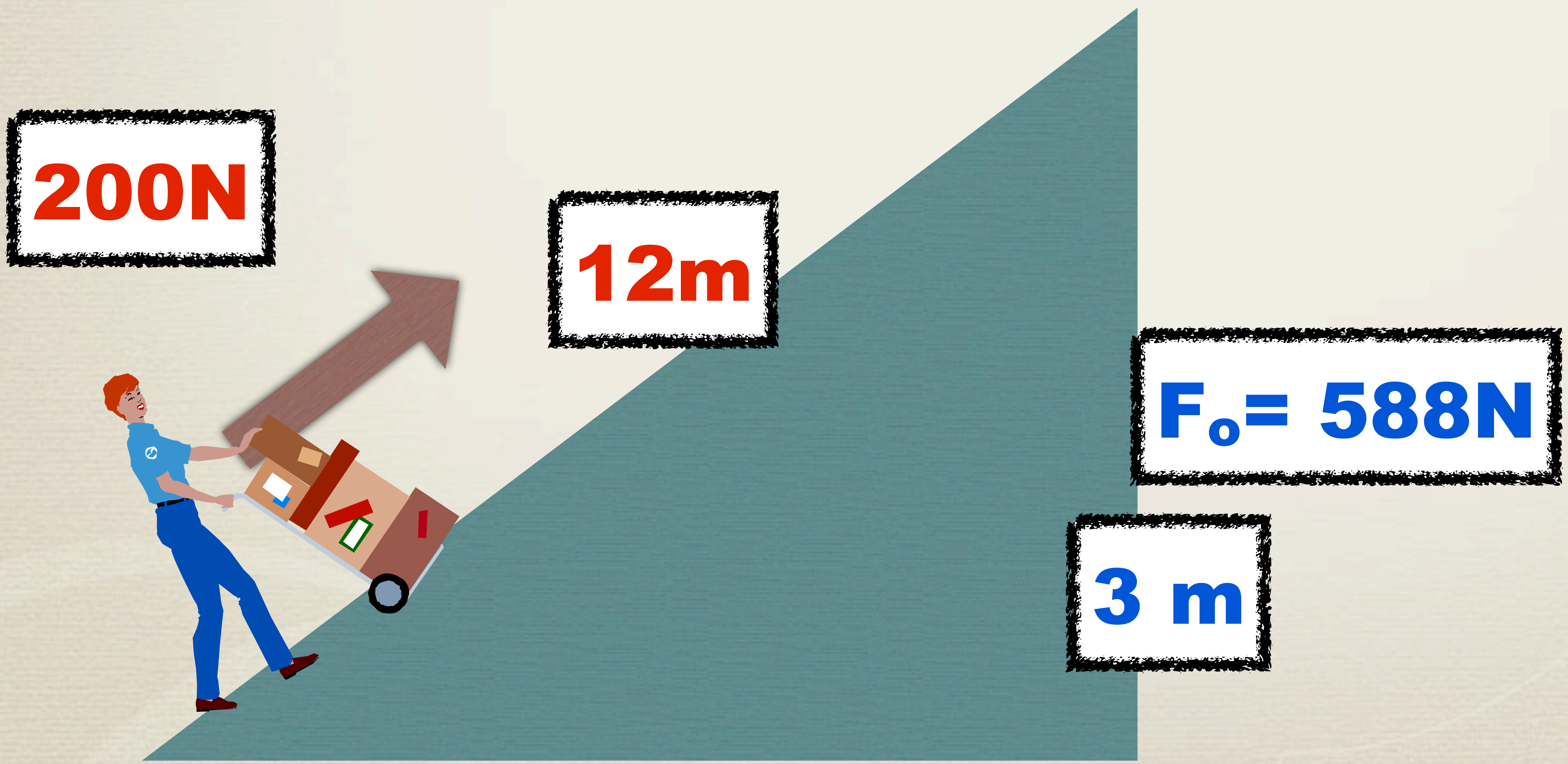
$$W_i = (200\ N)\ (12m)$$
$$W_i = 2400\ J$$

$$W_o = F\ d$$



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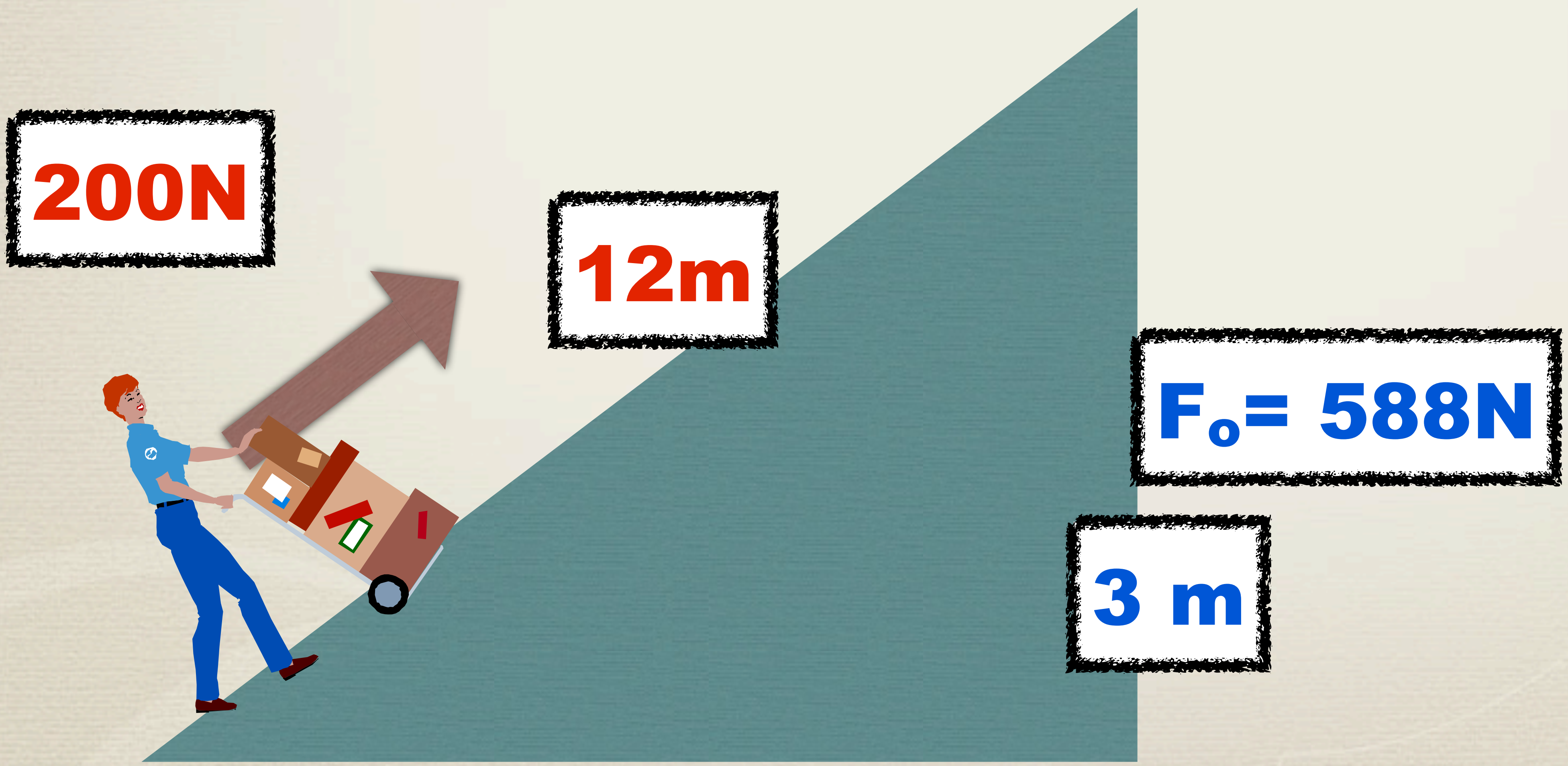
Find; the work input, the work output, the IMA and AMA, the efficiency of the ramp, energy wasted by friction, her power

$$W_i = F\ d$$
$$W_i = (200\ N)\ (12m)$$
$$W_i = 2400\ J$$

$$W_o = F\ d$$
$$W_o = (588\ N)\ (3m)$$



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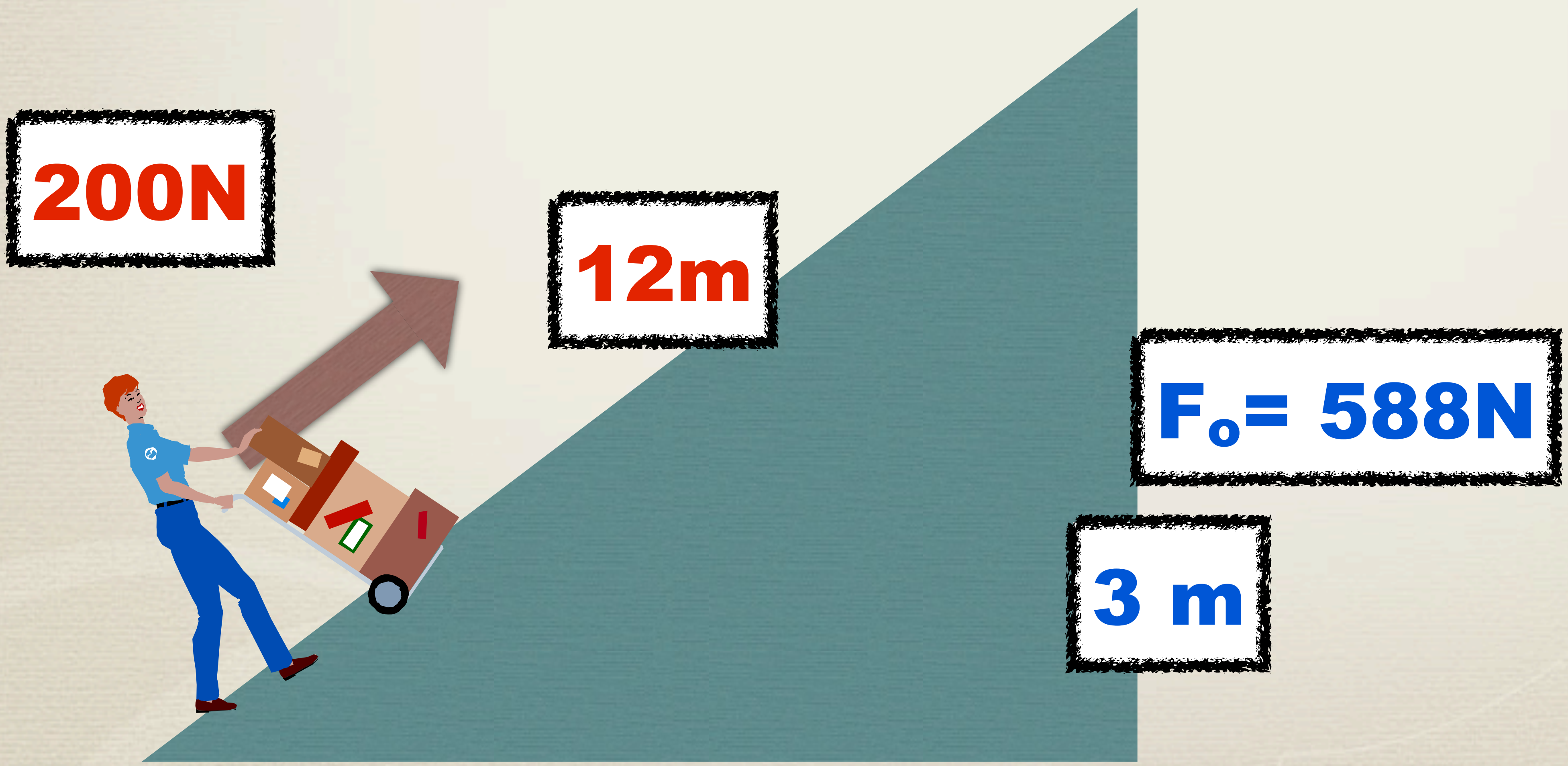
$W_i = F\ d$
$W_i = (200\ N)\ (12m)$
$W_i = 2400\ J$

$W_o = F\ d$
$W_o = (588\ N)\ (3m)$
$W_o = 1764\ J$



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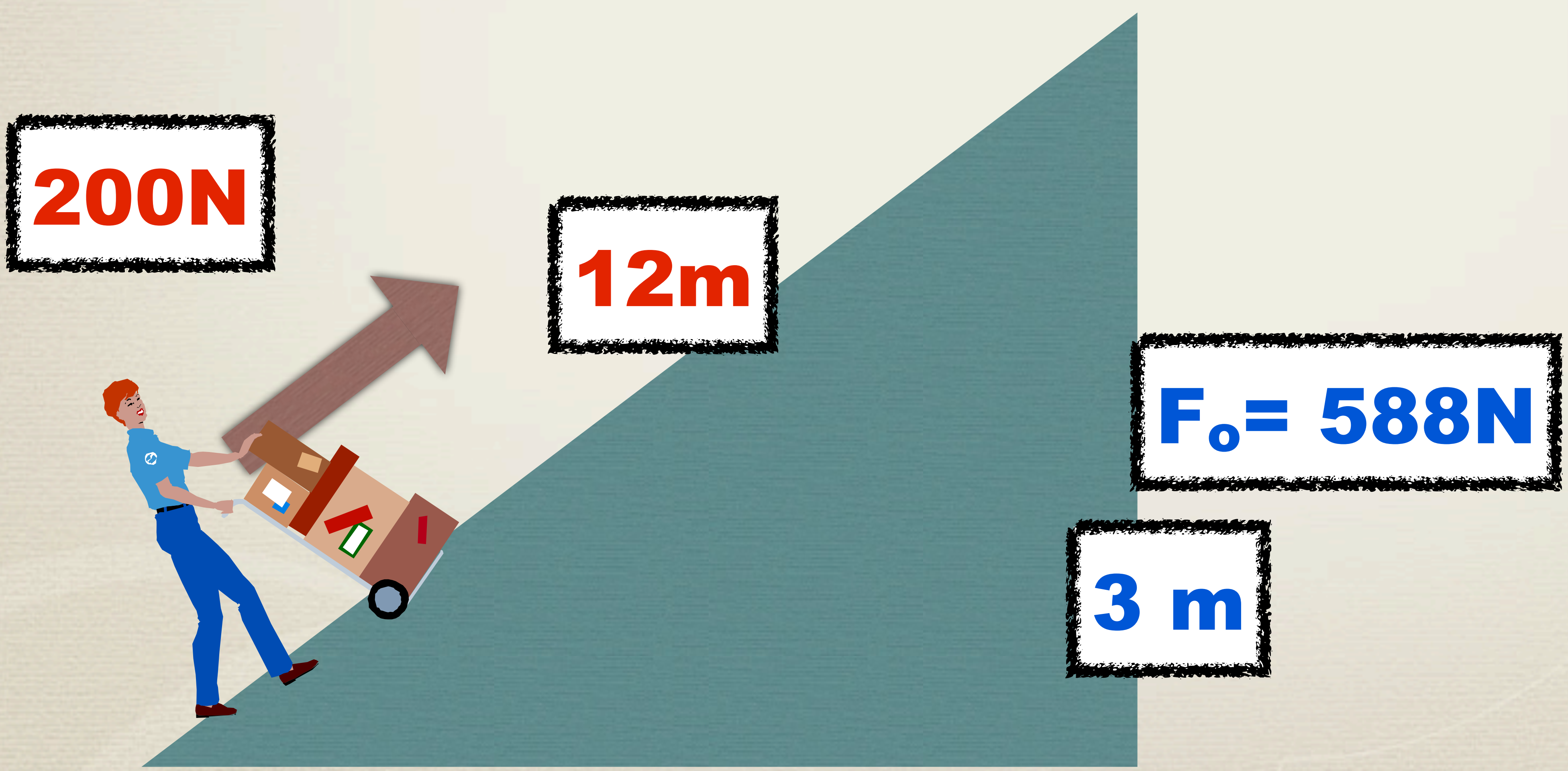

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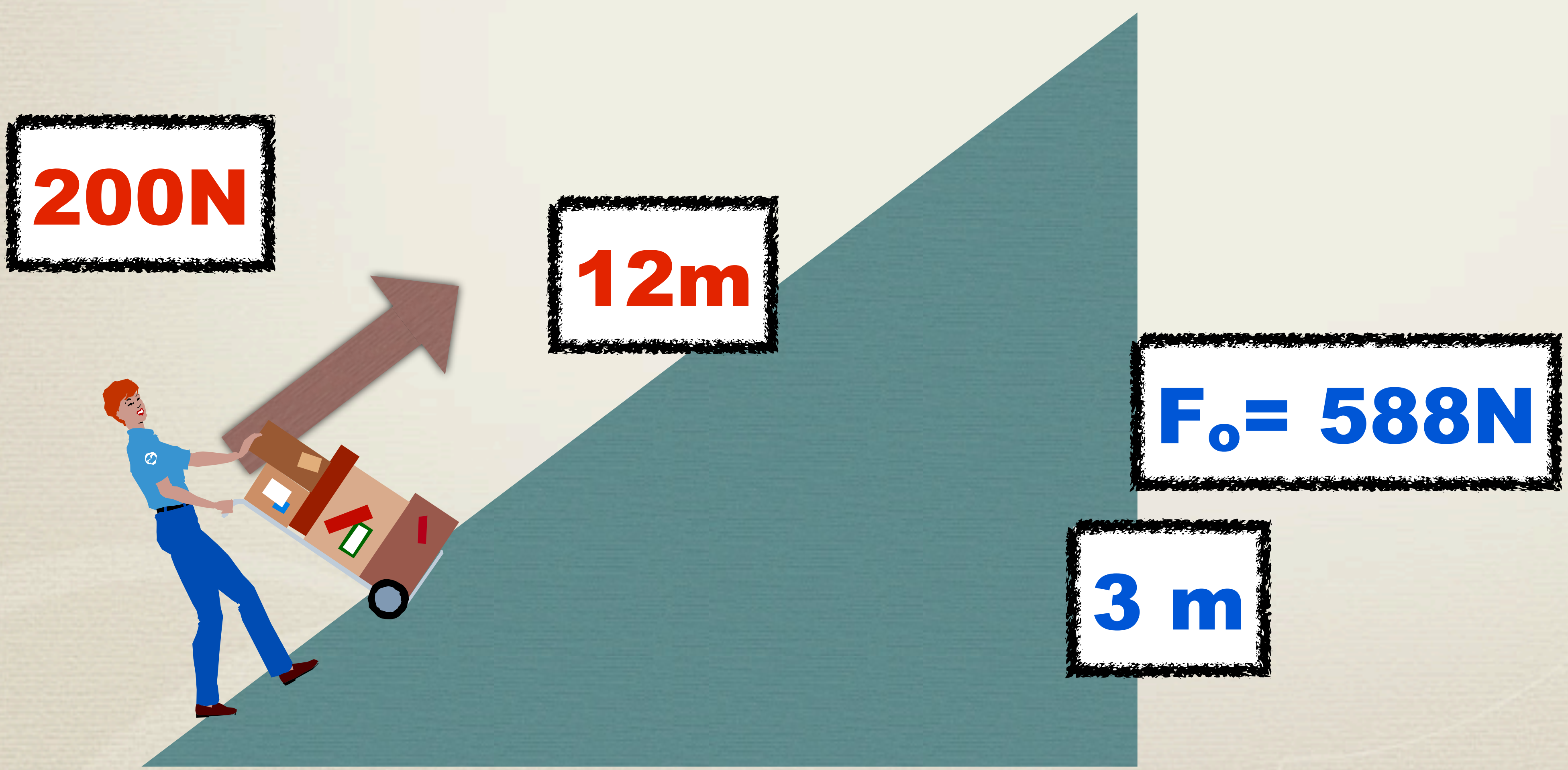
$IMA = D_i / D_o$



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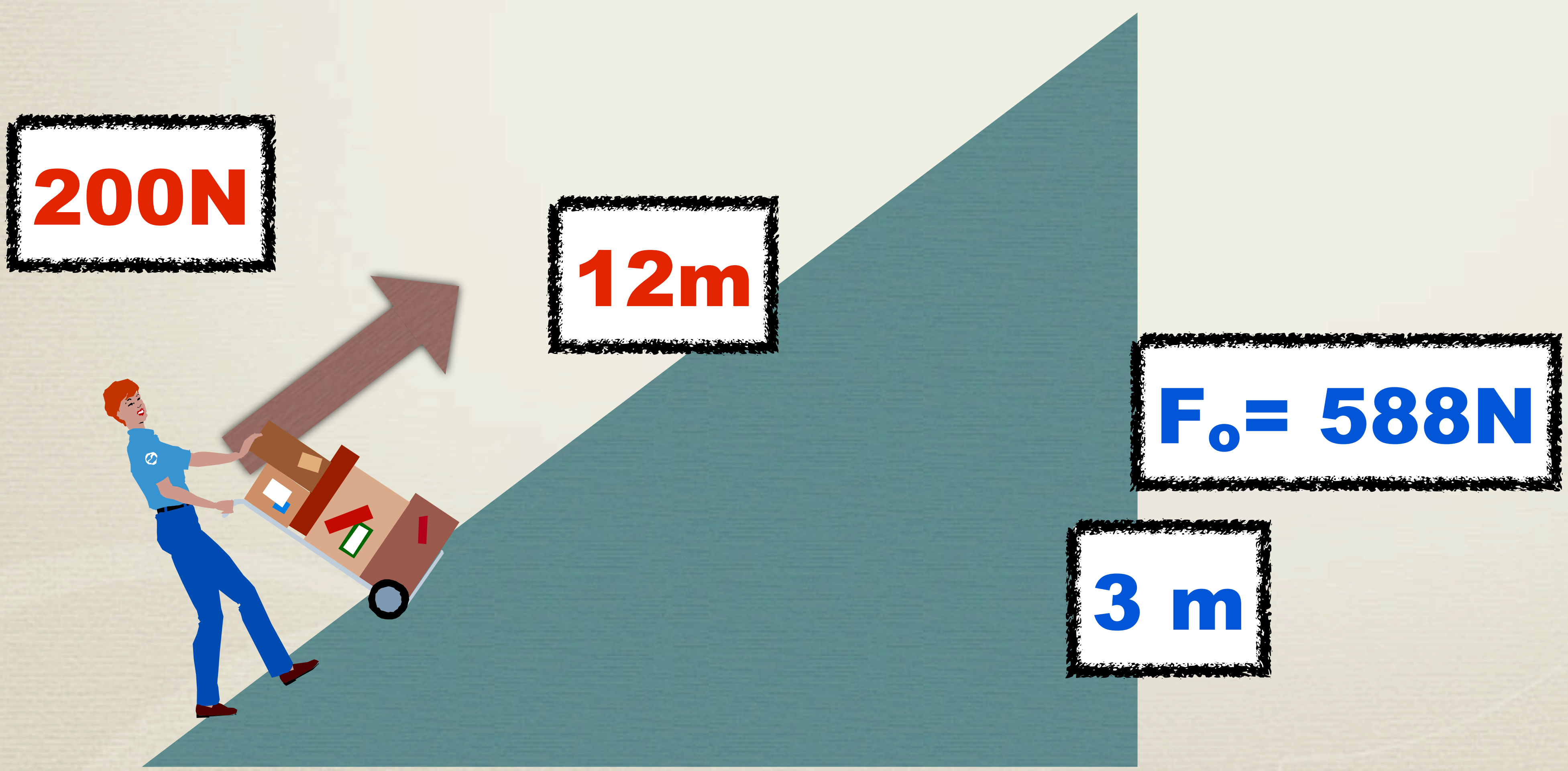
Find; the work input, the work output, the IMA and AMA, the efficiency of the ramp, energy wasted by friction, her power

$$IMA = D_i / D_o$$

$$\mathbf{IMA = 12 / 3 = 4}$$



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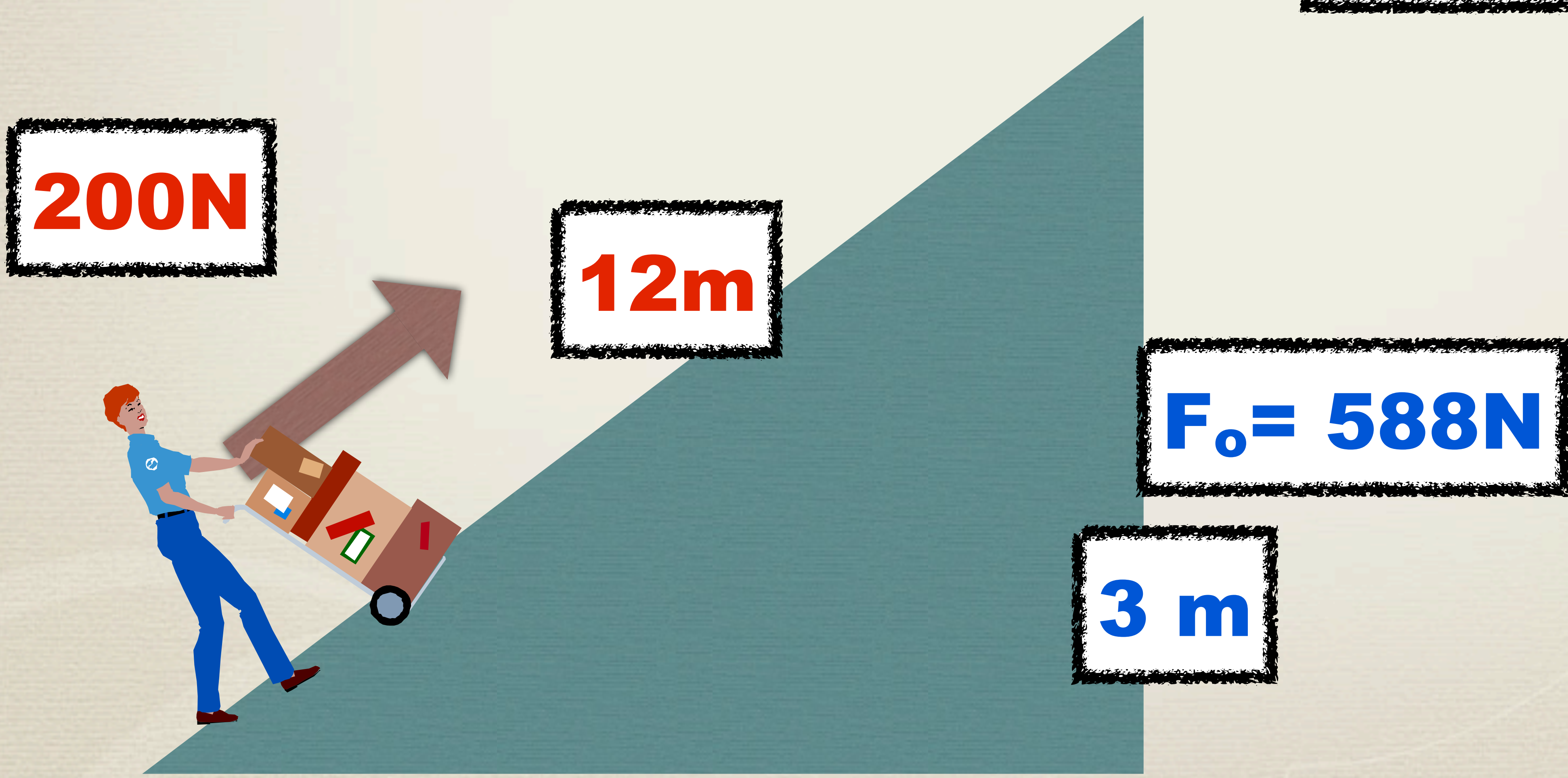
Find; the work input, the work output, the IMA and AMA, the efficiency of the ramp, energy wasted by friction, her power

$IMA = D_i / D_o$

$\mathbf{IMA = 12 / 3 = 4}$

$AMA = F_o / F_i$



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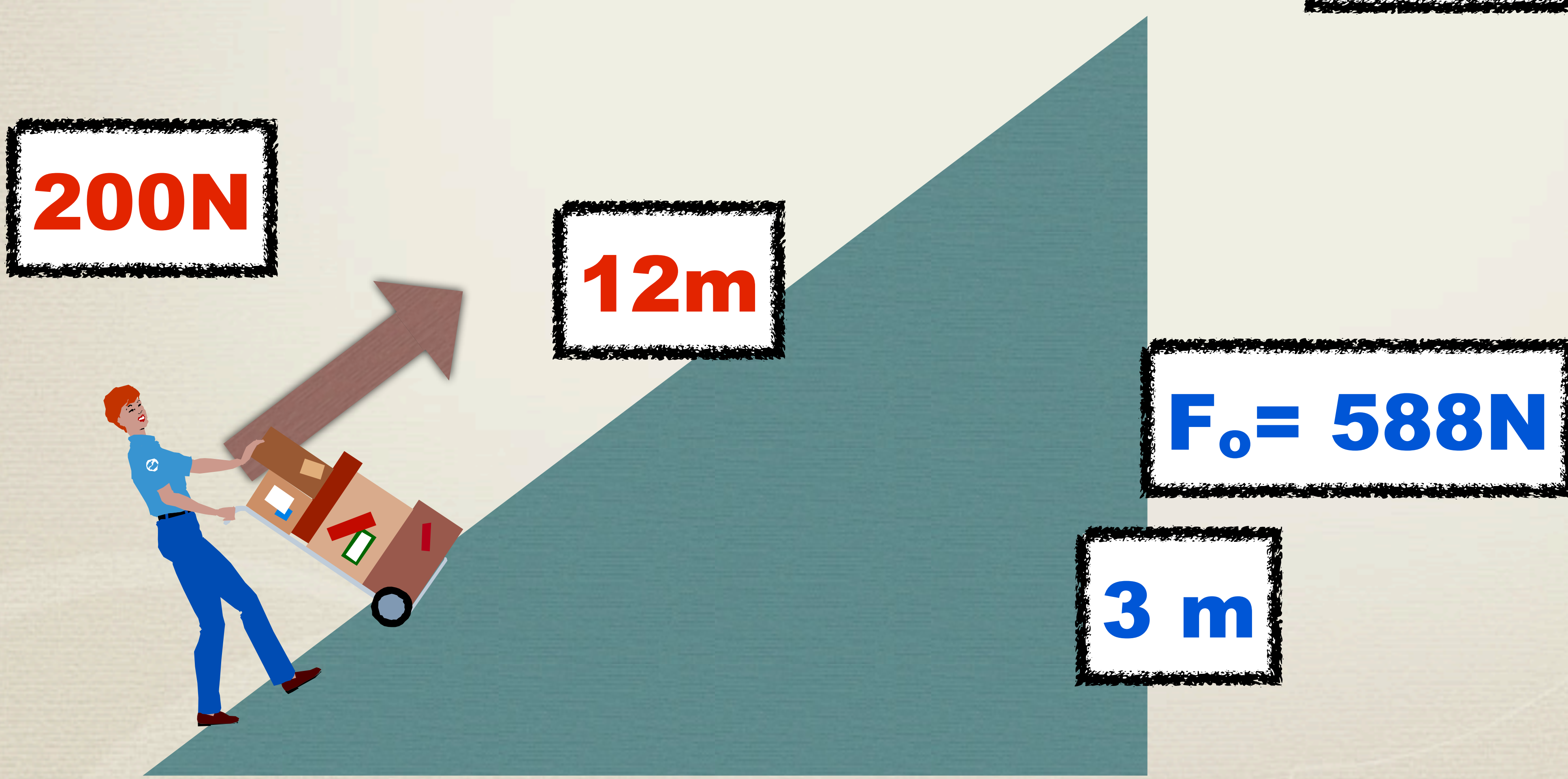
Find; the work input, the work output, the IMA and AMA, the efficiency of the ramp, energy wasted by friction, her power

$IMA = D_i / D_o$

$IMA = 12 / 3 = 4$

$AMA = F_o / F_i$

$AMA = 588/200$



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Find; the work input, the work output, the IMA and AMA, the efficiency of the ramp, energy wasted by friction, her power

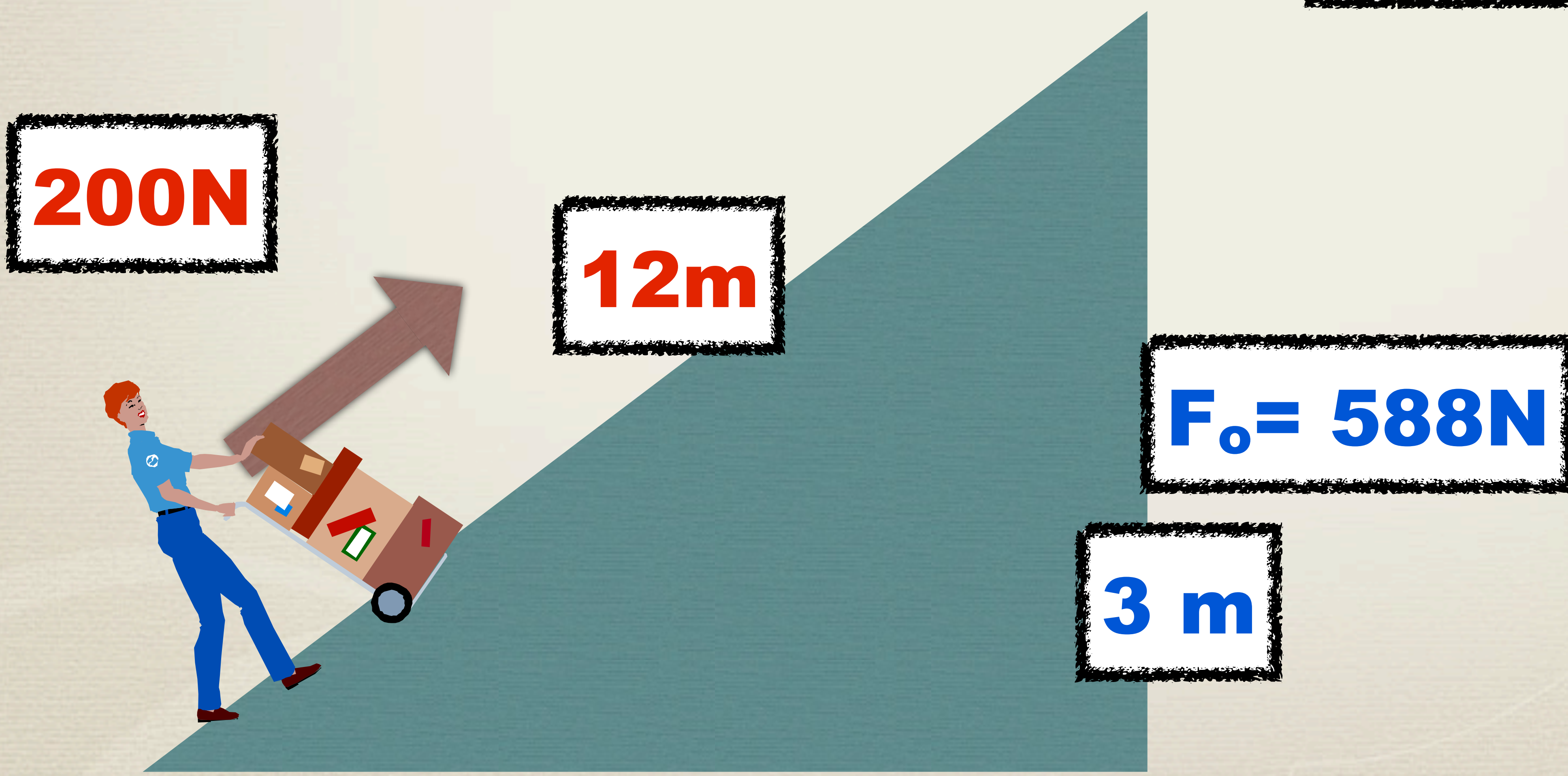
$IMA = D_i / D_o$

IMA = 12 / 3 = 4

$AMA = F_o / F_i$

AMA = 588/200

AMA = 2.94



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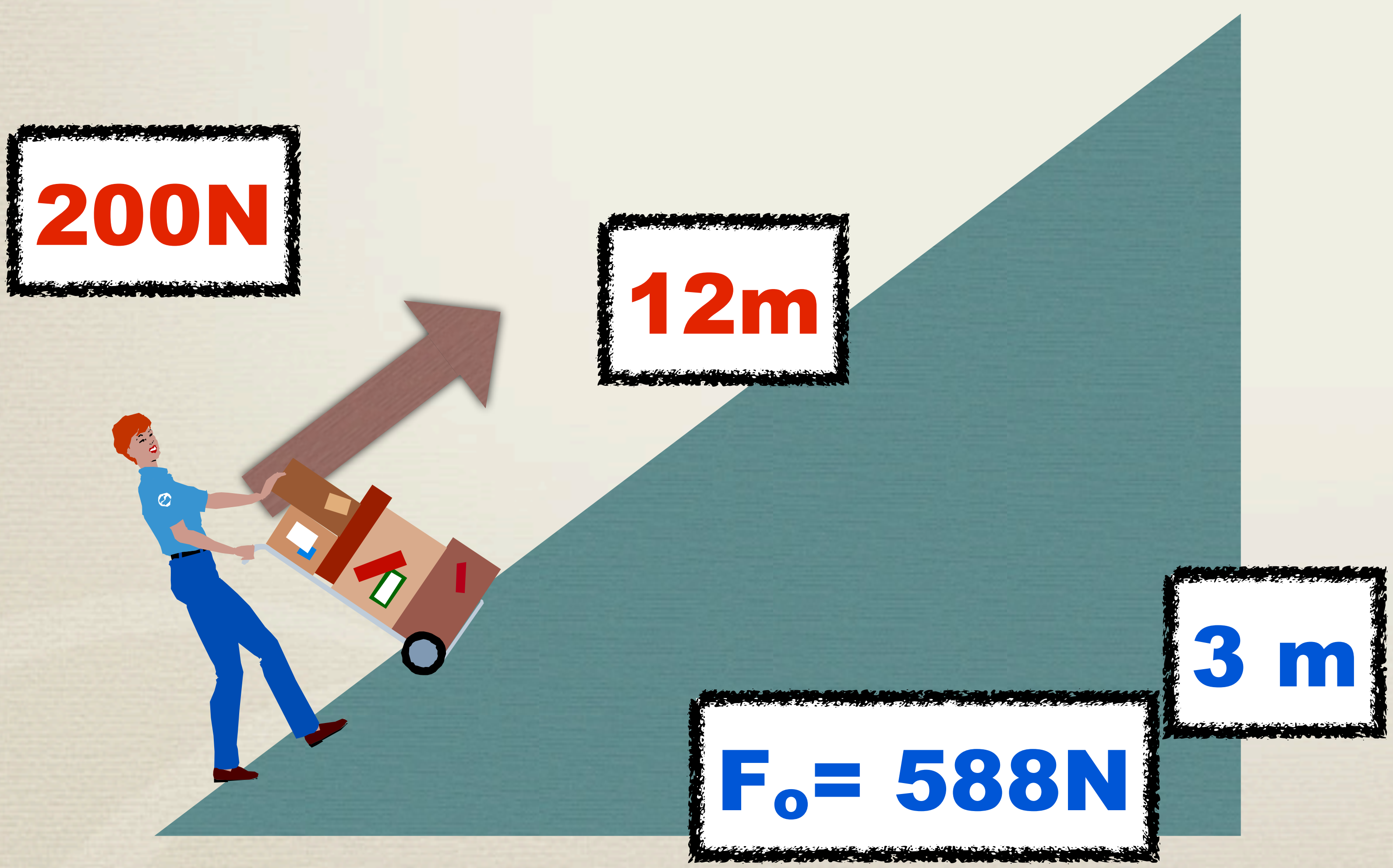

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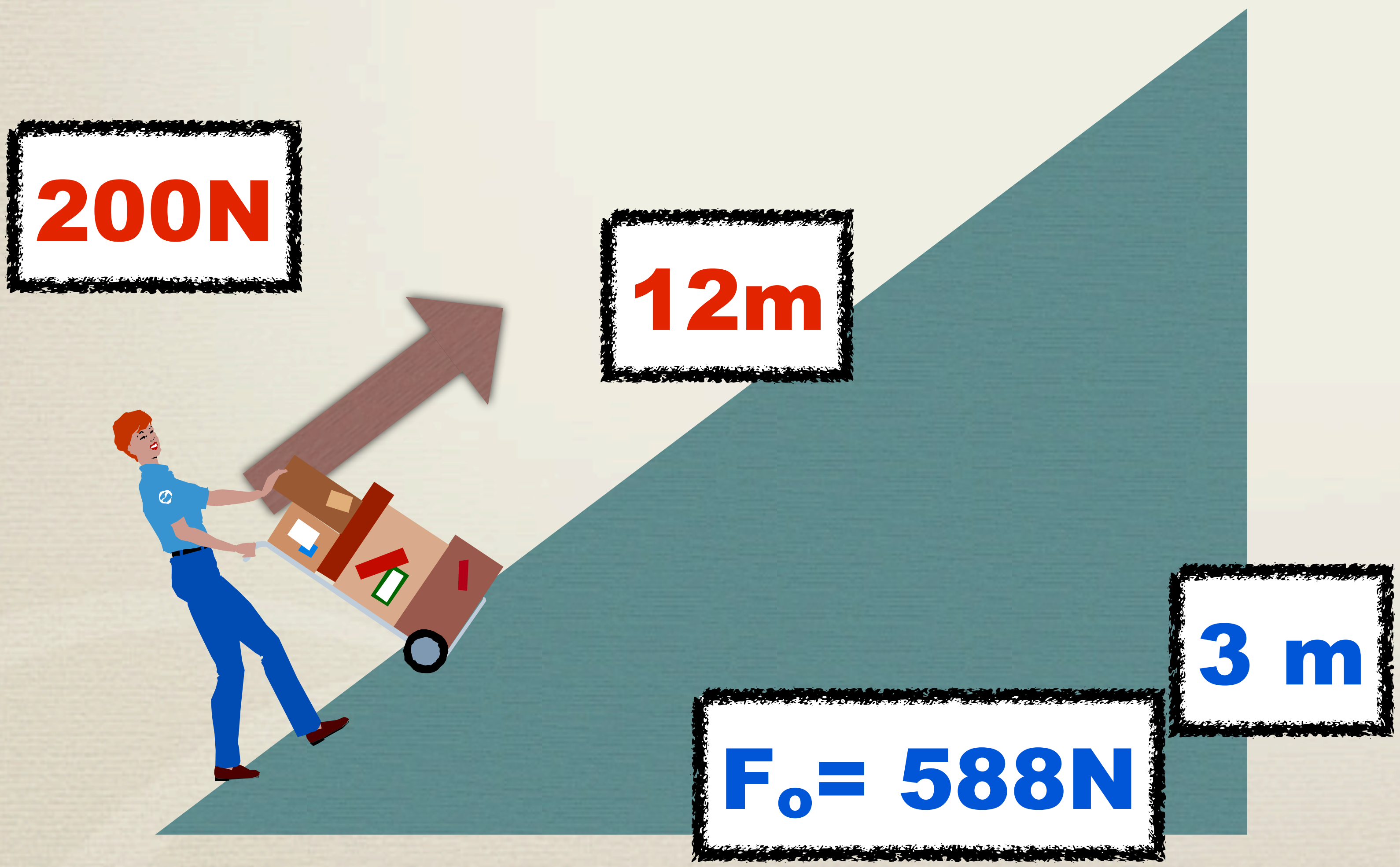
Efficiency



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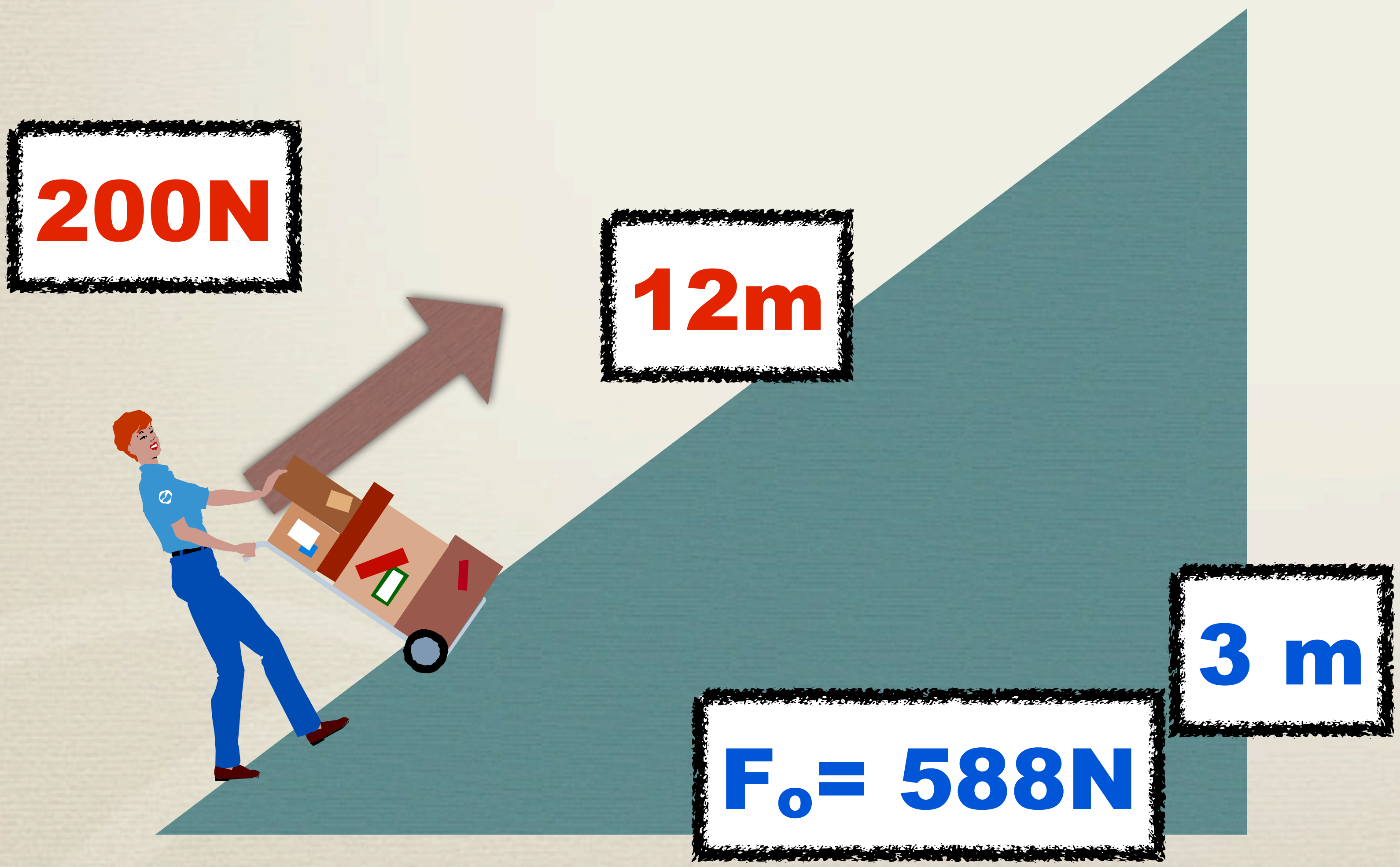
Find; the work input, the work output, the IMA and AMA, the efficiency of the ramp, energy wasted by friction, her power

Efficiency
= W_o / W_i



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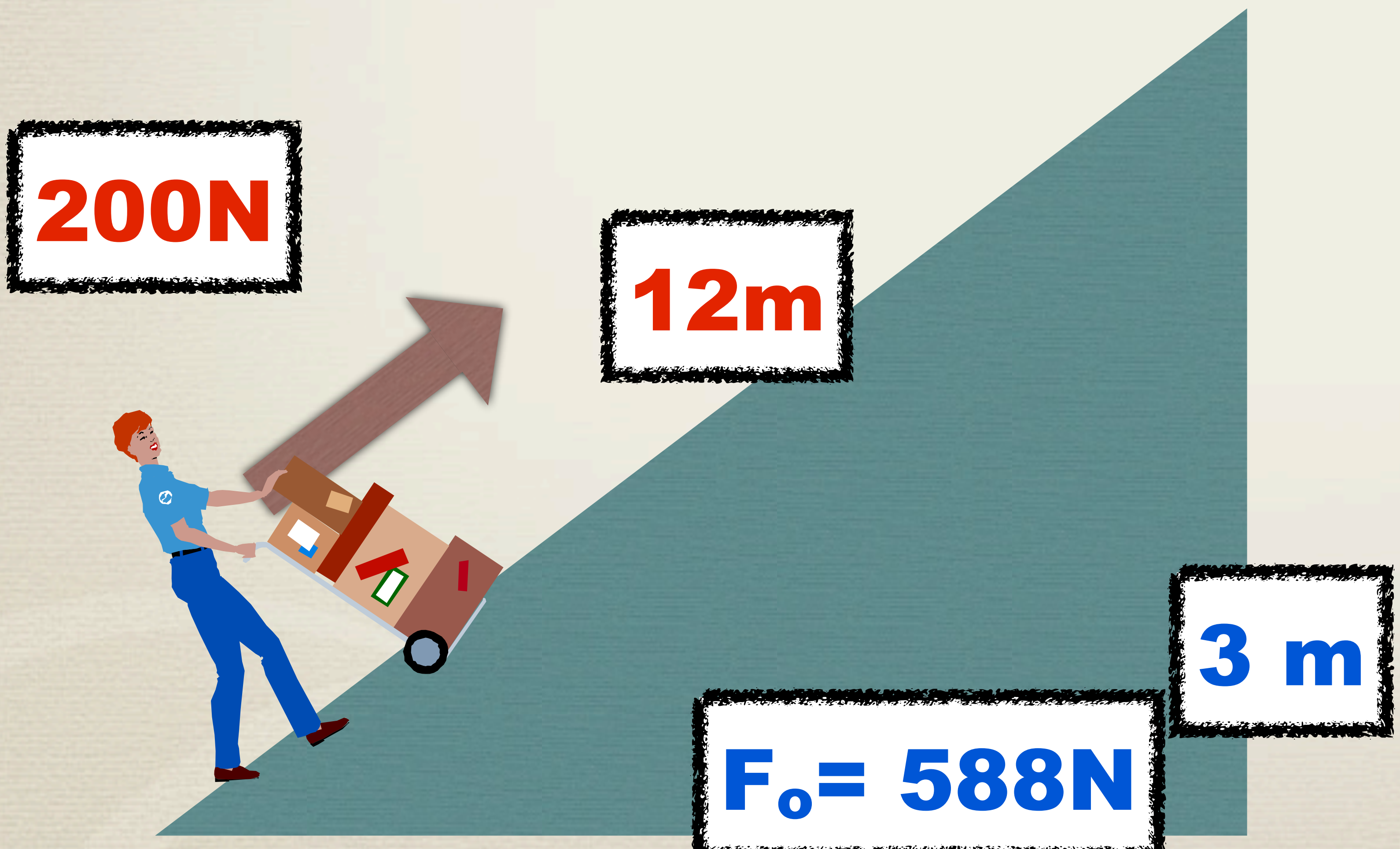
Efficiency
$= W_o / W_i$
= AMA / IMA



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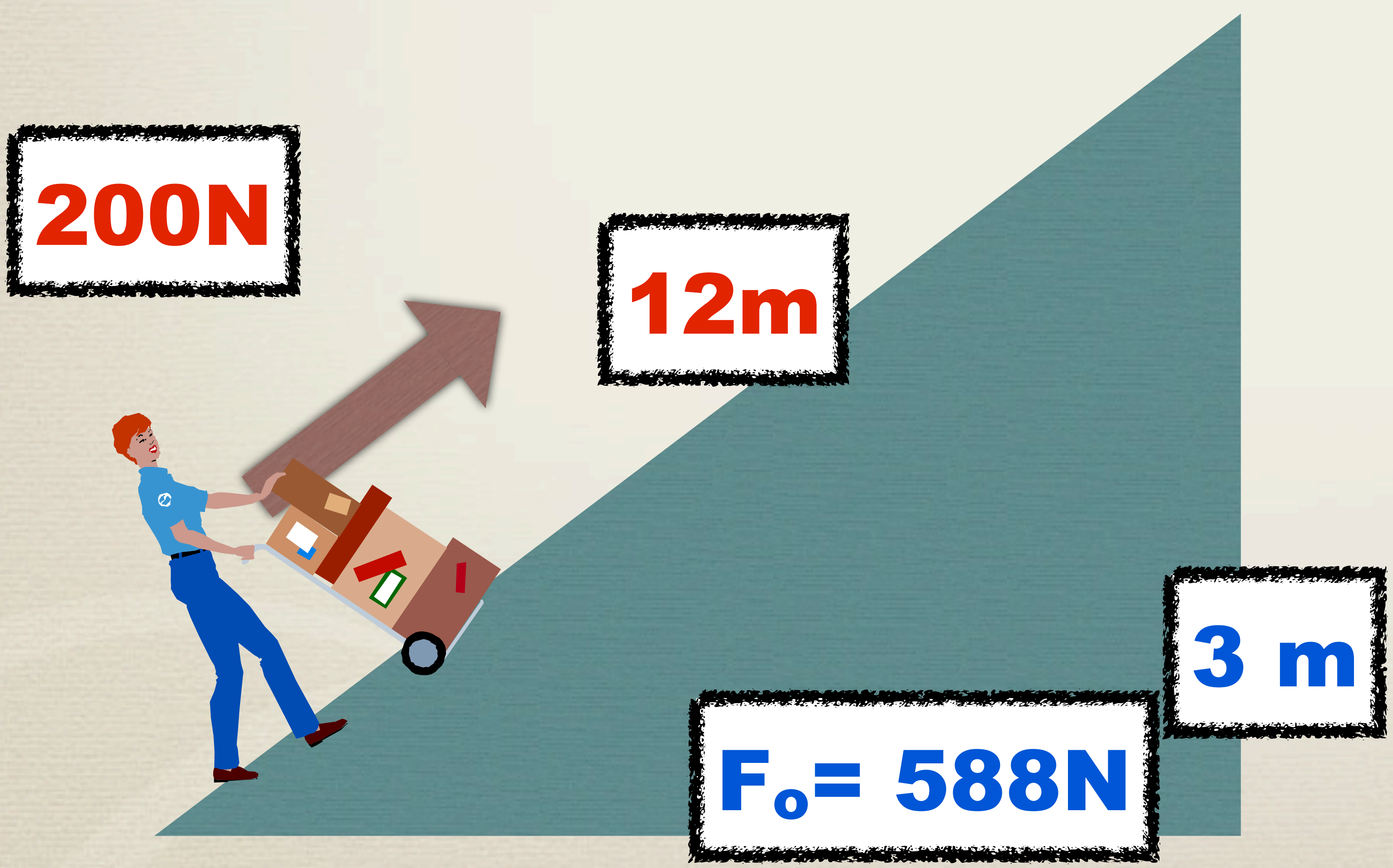
Find; the work input, the work output, the IMA and AMA, the efficiency of the ramp, energy wasted by friction, her power

Efficiency

$= W_o / W_i$

$= AMA / IMA$

Eff = 73.5%



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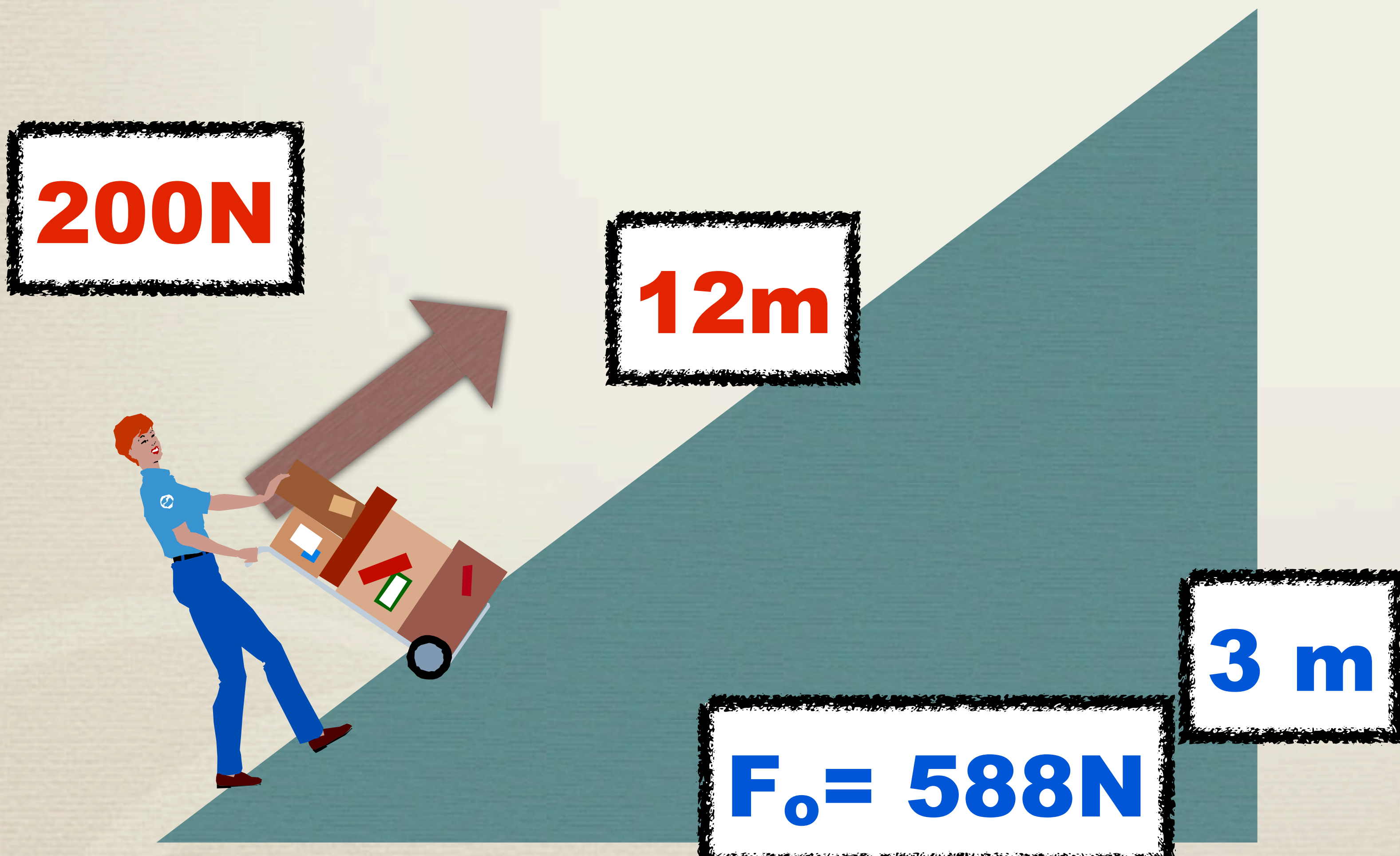
$= W_o / W_i$

= AMA / IMA

Eff = 73.5%

Lost Energy to Friction



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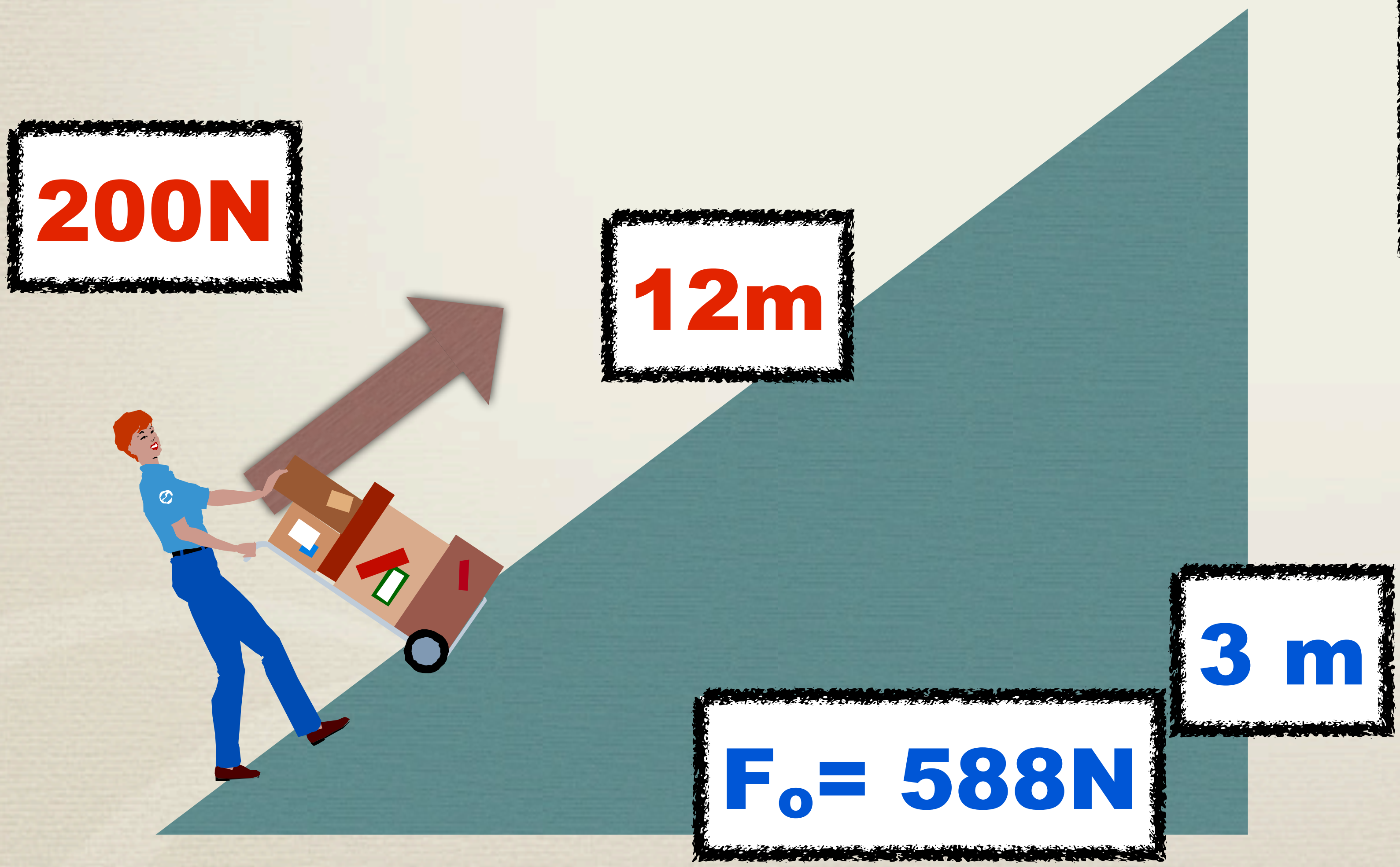
Find; the work input, the work output, the IMA and AMA, the efficiency of the ramp, energy wasted by friction, her power

Efficiency
$= W_o / W_i$
= AMA / IMA
Eff = 73.5%

Lost Energy to Friction
2400J - 1764J



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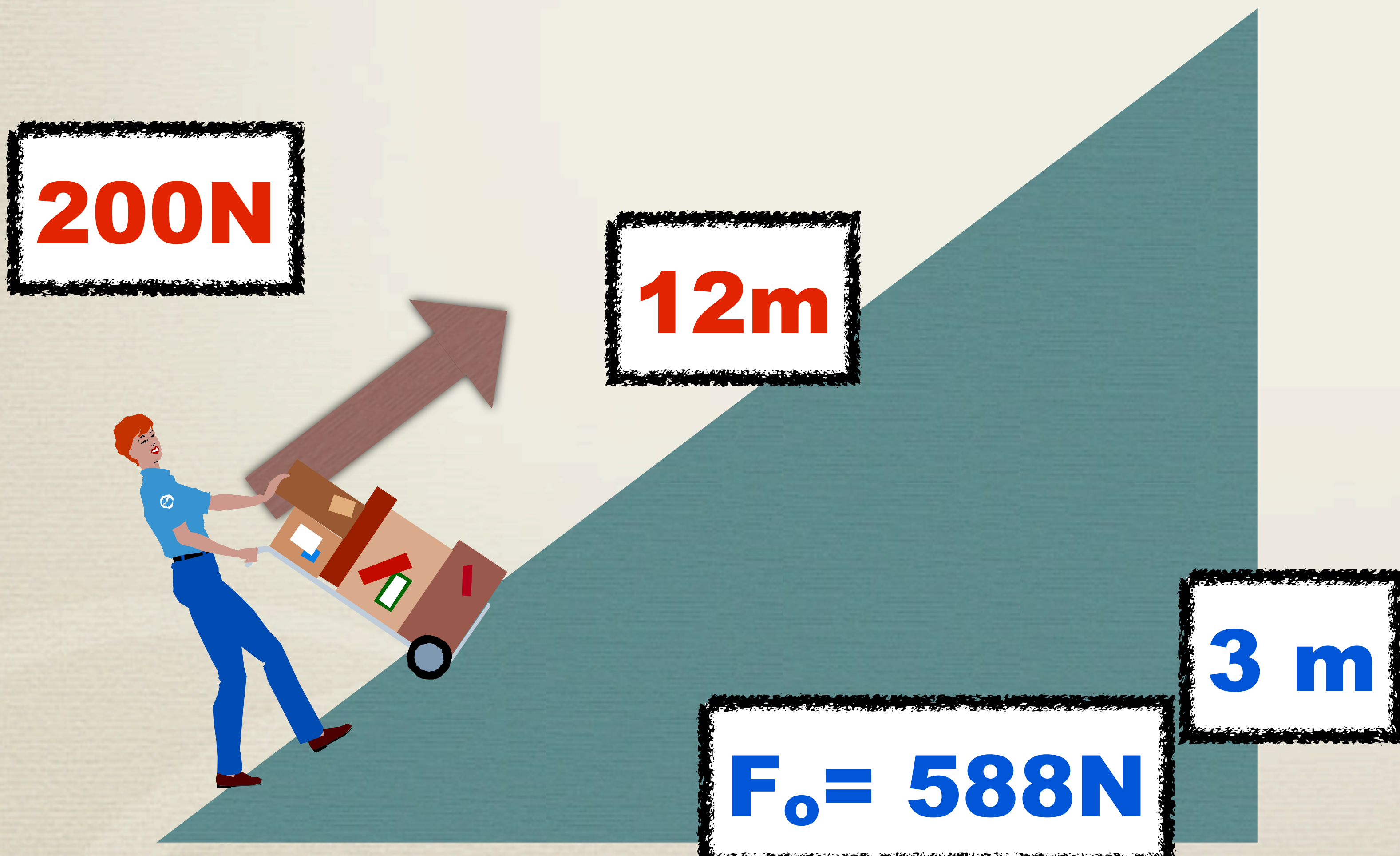
Find; the work input, the work output, the IMA and AMA, the efficiency of the ramp, energy wasted by friction, her power

Efficiency
$= W_o / W_i$
= AMA / IMA
Eff = 73.5%

Lost Energy to Friction
2400J - 1764J
636J



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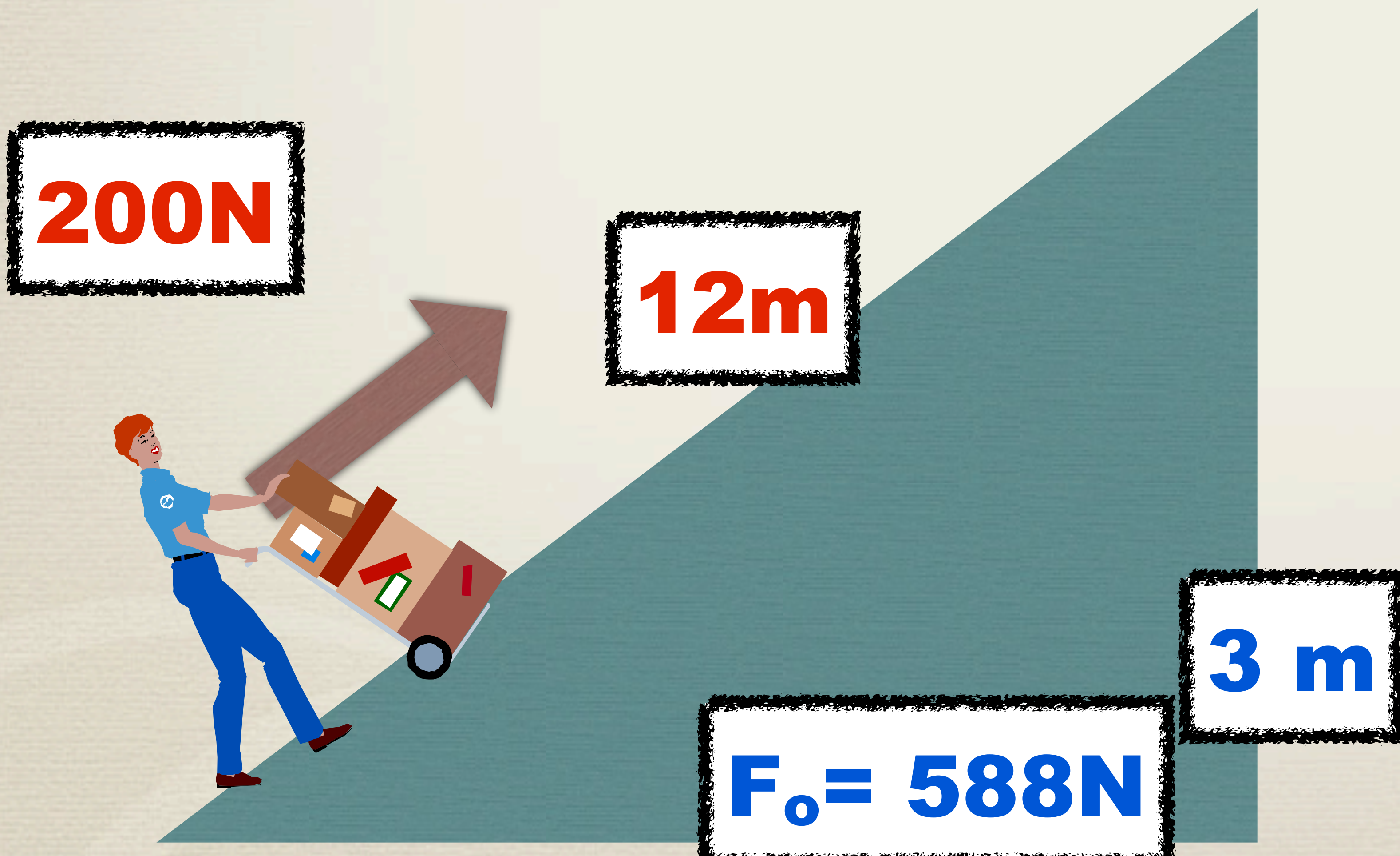


Efficiency

$= W_o / W_i$

= AMA / IMA

Eff = 73.5%

Lost Energy to Friction

2400J - 1764J

636J

Power = W / t

Laura lifts some boxes up 3m by pushing the 60 kg cart up a 12 m ramp. She uses a force of 200 N and takes 30 seconds to travel.

Find; the work input, the work output, the IMA and AMA, the efficiency of the ramp, energy wasted by friction, her power

Efficiency

$= W_o / W_i$

= AMA / IMA

Eff = 73.5%

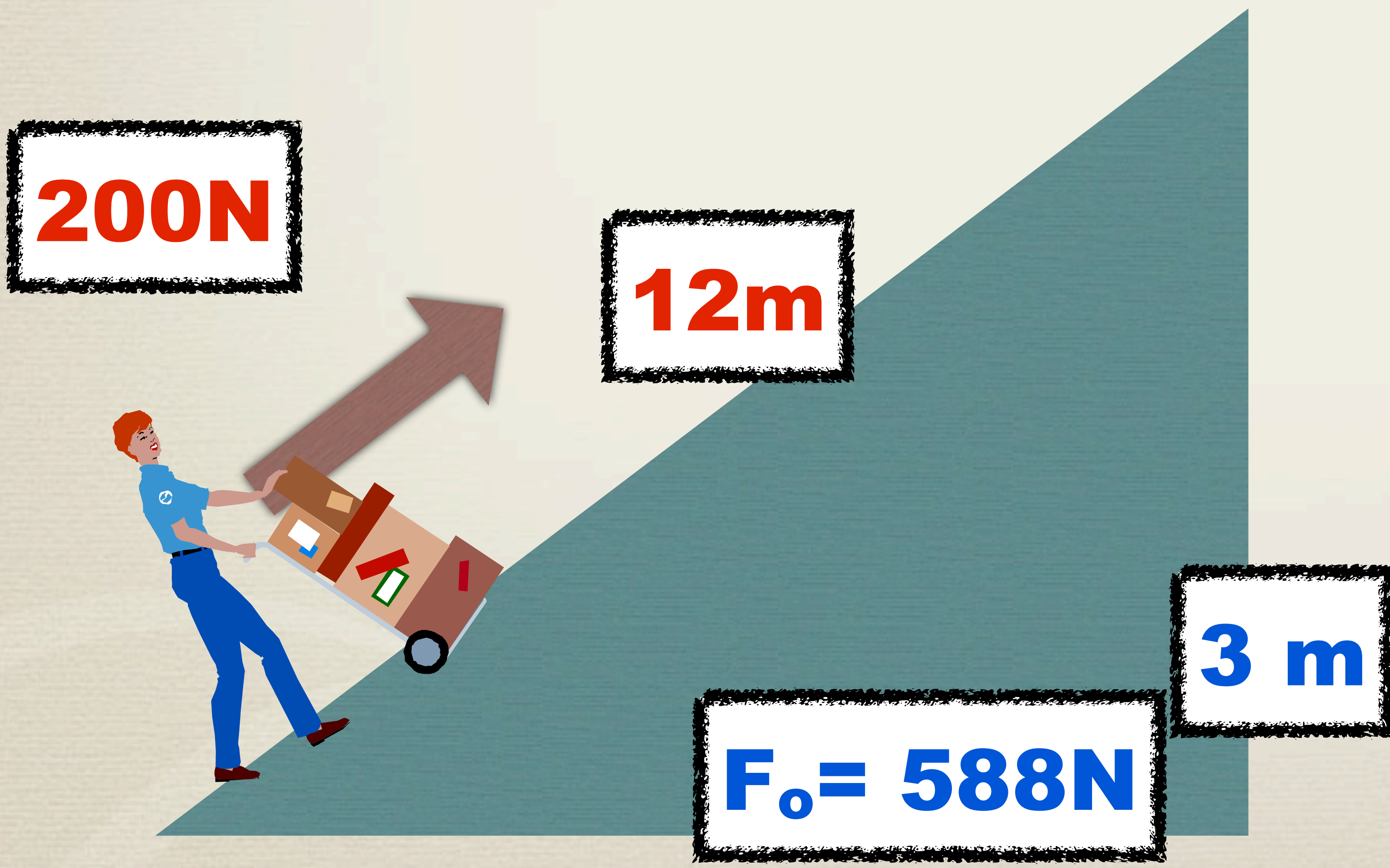
Lost Energy to Friction

2400J - 1764J

636J

Power = W / t

P = 2400J / 30s



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Find; the work input, the work output, the IMA and AMA, the efficiency of the ramp, energy wasted by friction, her power

Efficiency

$= W_o / W_i$

= AMA / IMA

Eff = 73.5%

Lost Energy to Friction

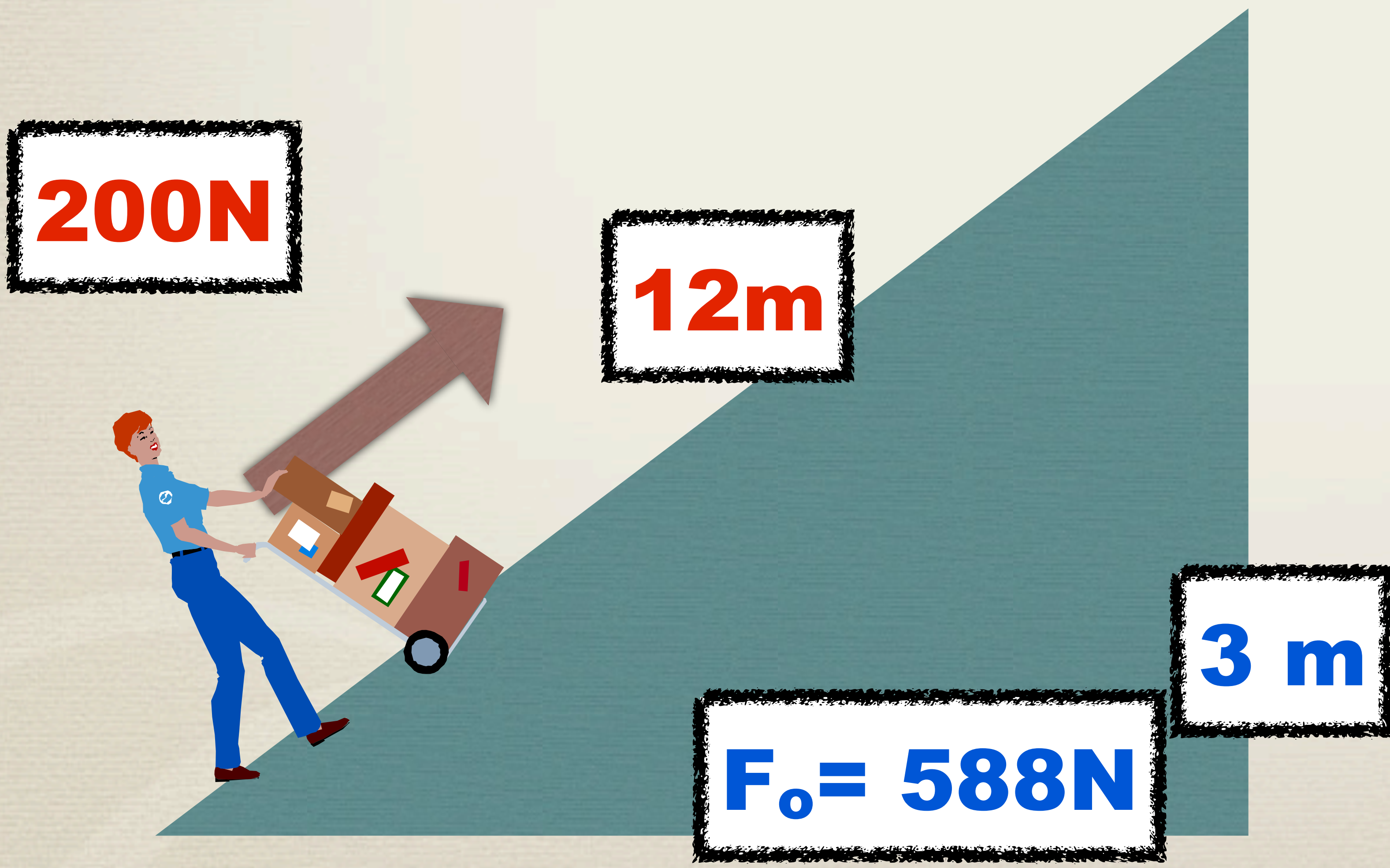
2400J - 1764J

636J

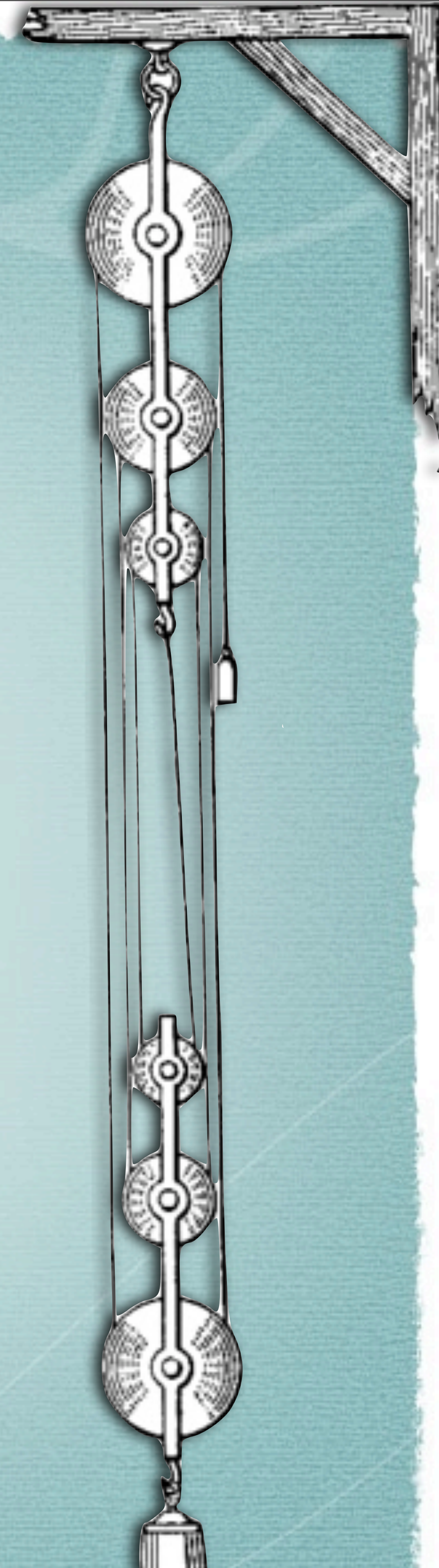
Power = W / t

P = 2400J / 30s

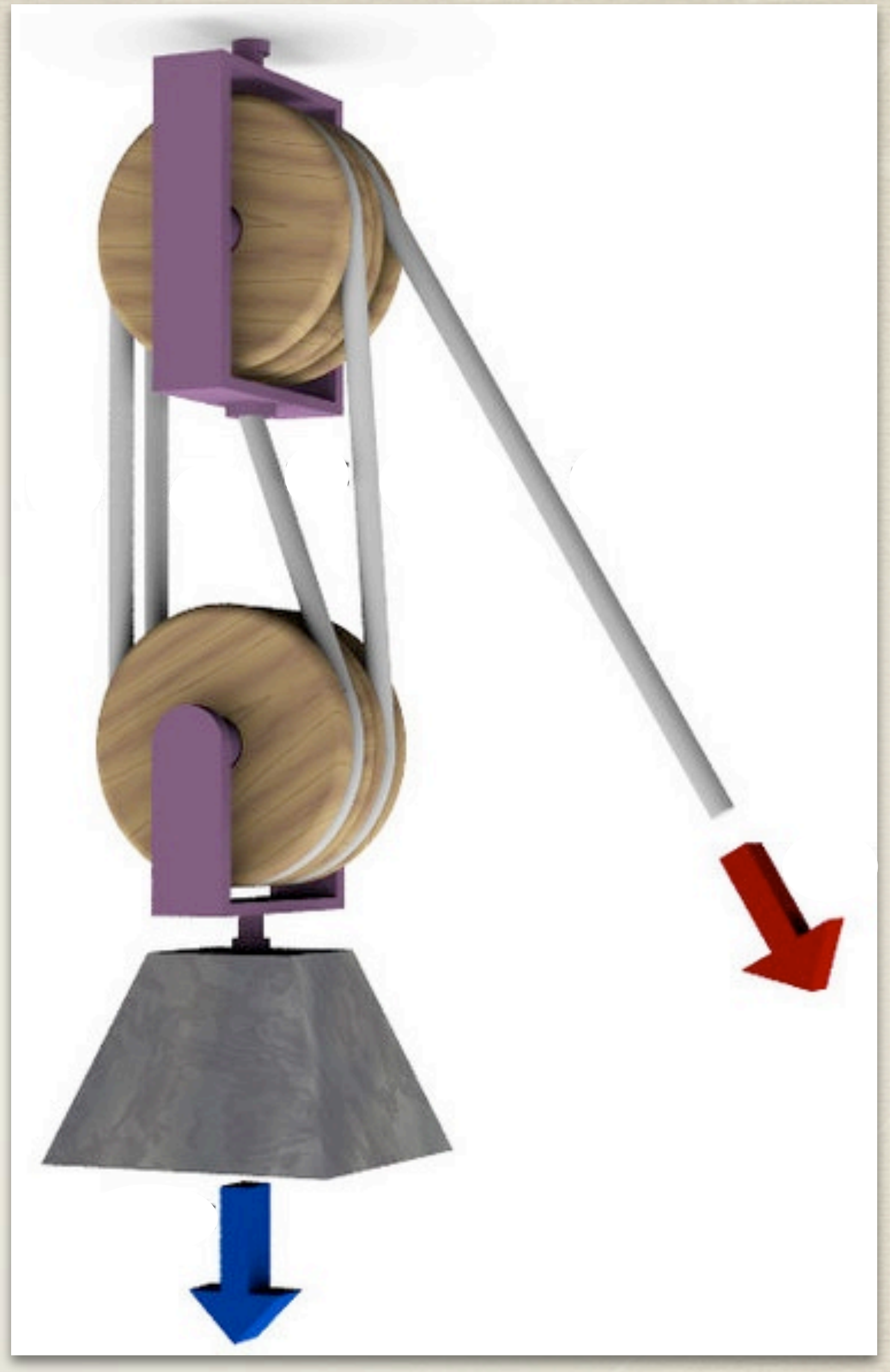
P = 80 W



Pulley Arrangements



- In the Pulley arrangement shown, A force of 2.2 N is used to lift a 450 g Mass. While the mass goes up 20 cm, a student pulls in 80 cm of string. It takes her 5 seconds to lift.



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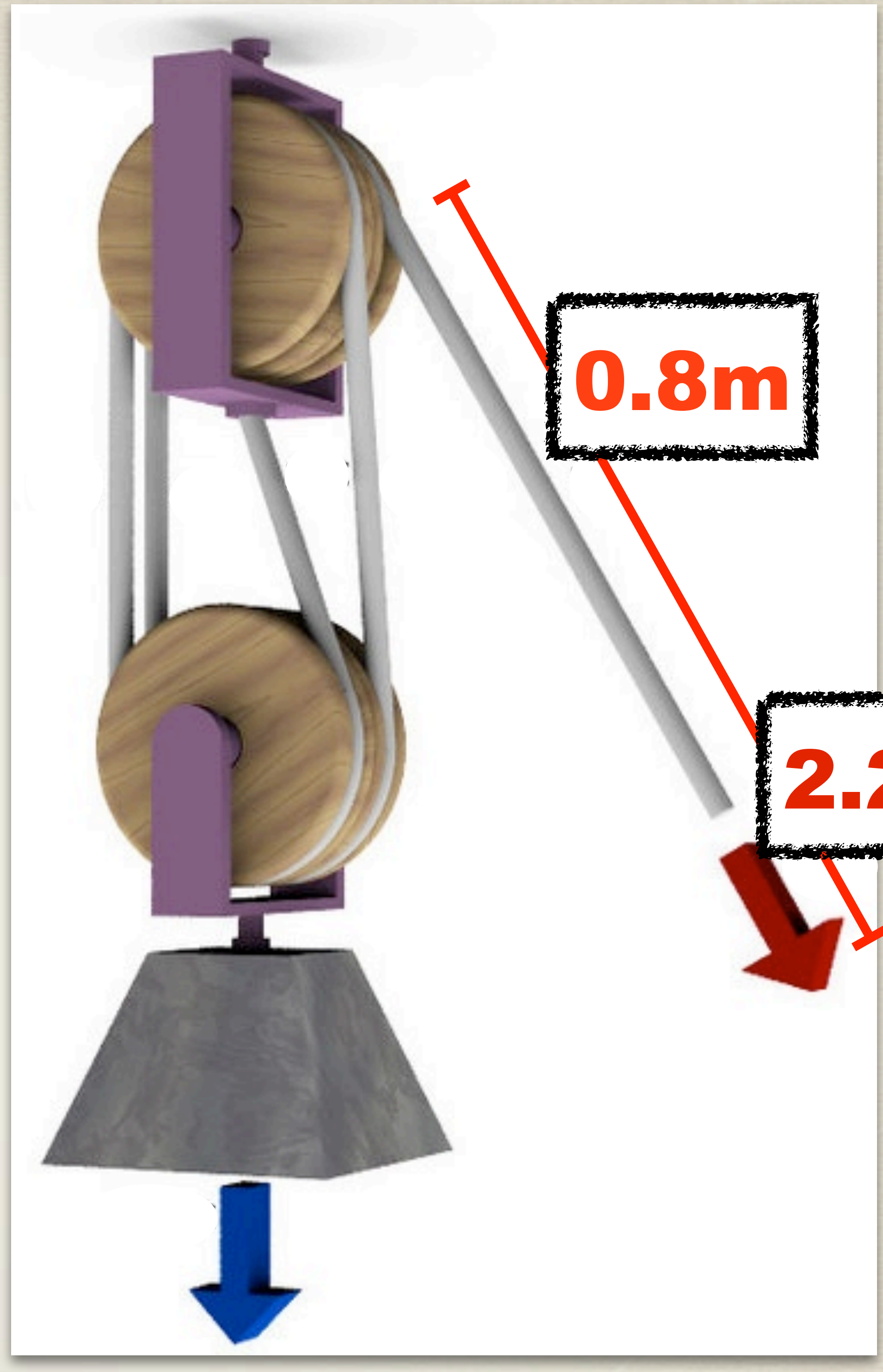

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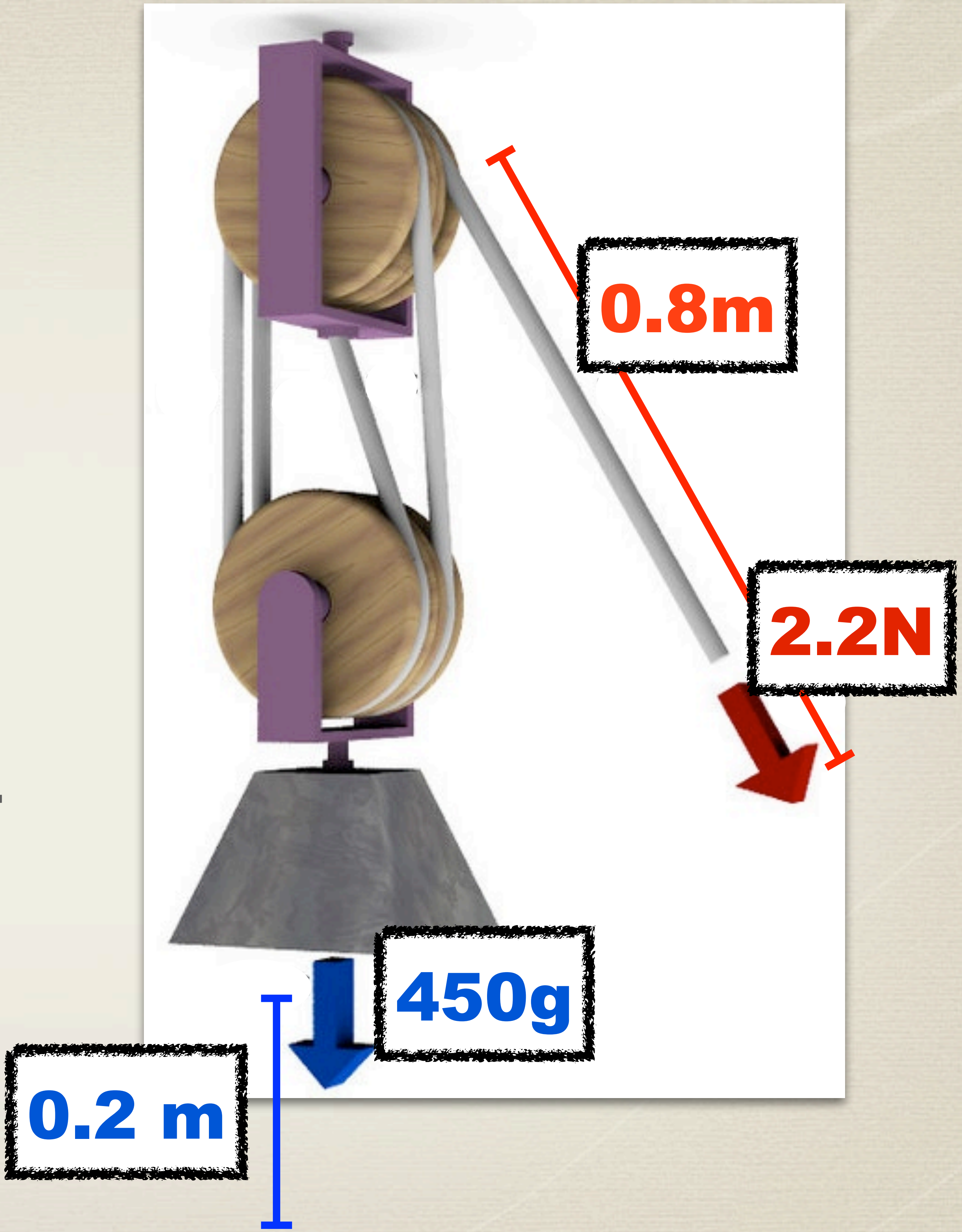

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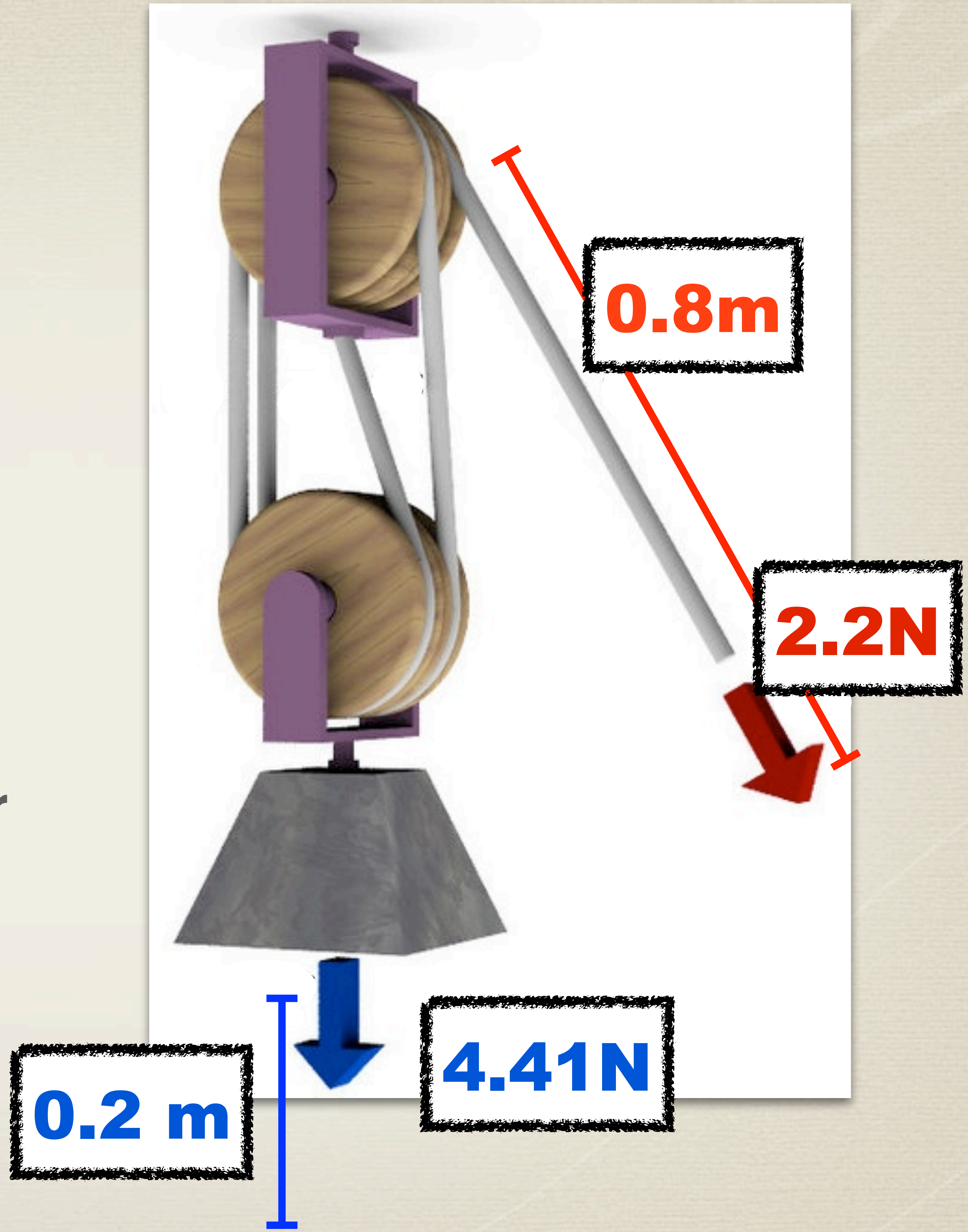
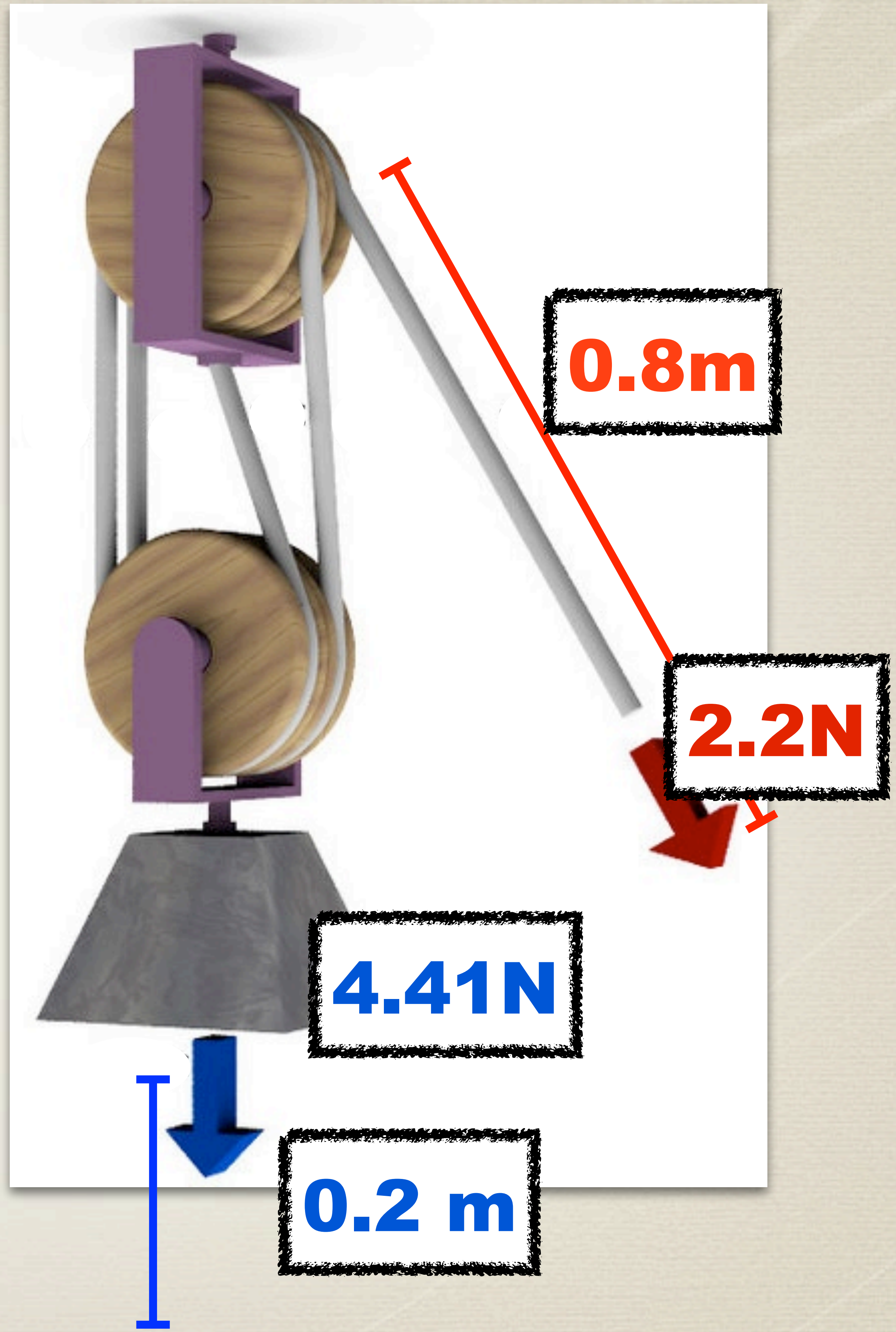


A force of 2.2 N is used to lift a 450 g mass. While the mass goes up 20 cm, a student pulls in 80 cm of string. It takes her 5 seconds to lift

Find the work input,
the work output,
the IMA,
the AMA,
the efficiency of the pulley,
the energy wasted by friction,
her power



A force of 2.2 N is used to lift a 450 g mass. While the mass goes up 20 cm, a student pulls in 80 cm of string. It takes her 5 seconds to lift

Find the work input,
the work output,
the IMA,
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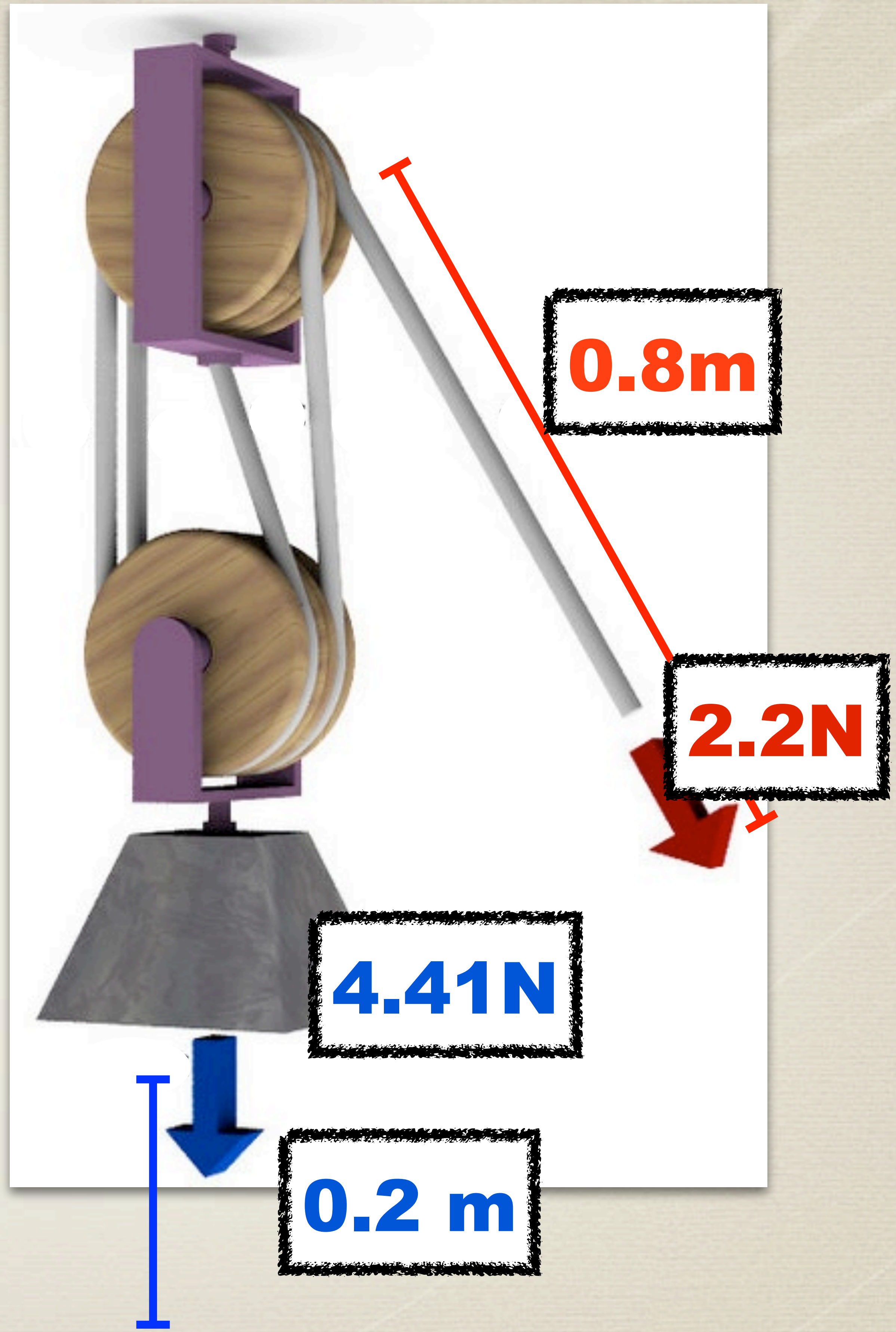
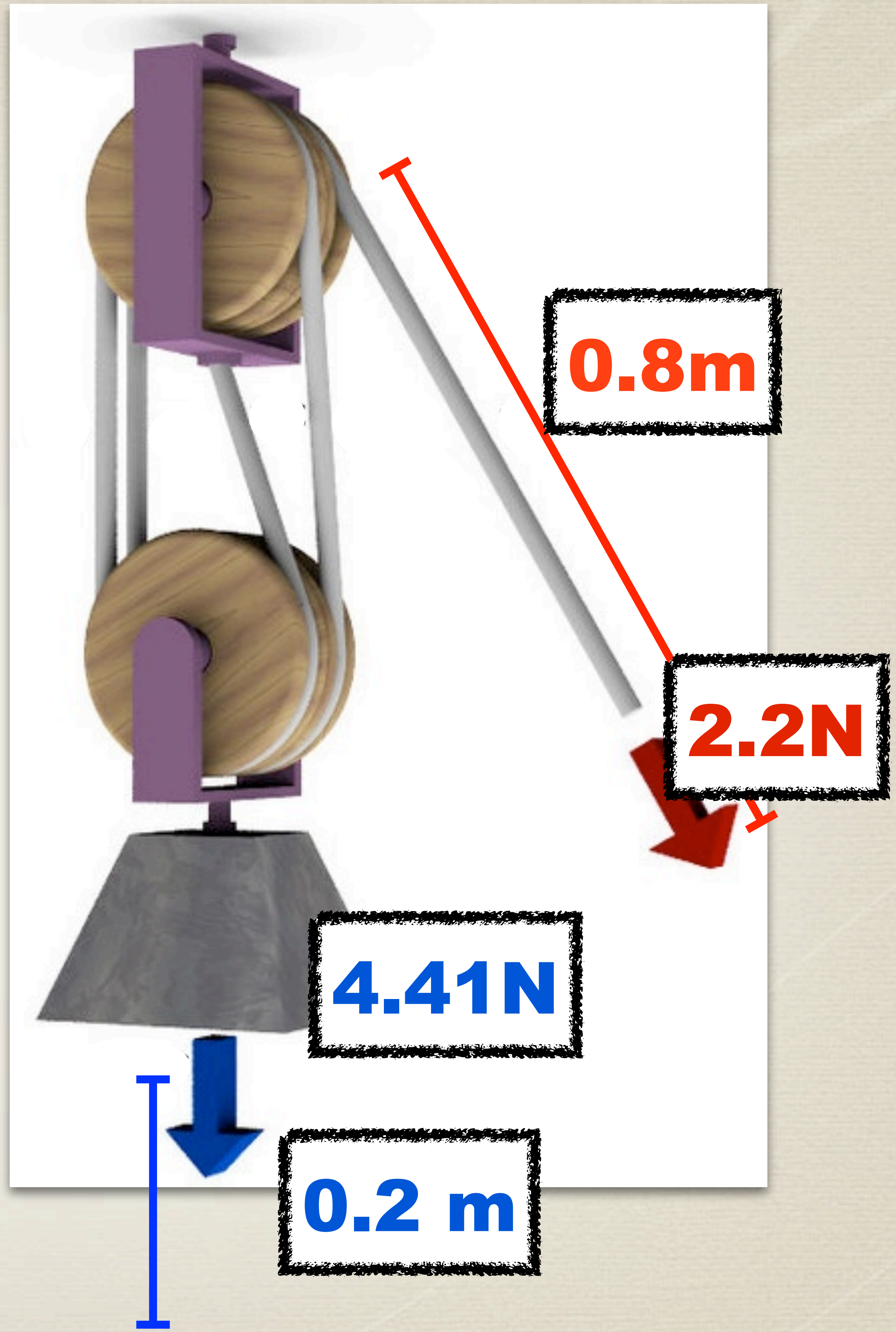
$$W_i = FD$$



A force of 2.2 N is used to lift a 450 g mass. While the mass goes up 20 cm, a student pulls in 80 cm of string. It takes her 5 seconds to lift

Find the work input,
the work output,
the IMA,
the AMA,
the efficiency of the pulley,
the energy wasted by friction,
her power

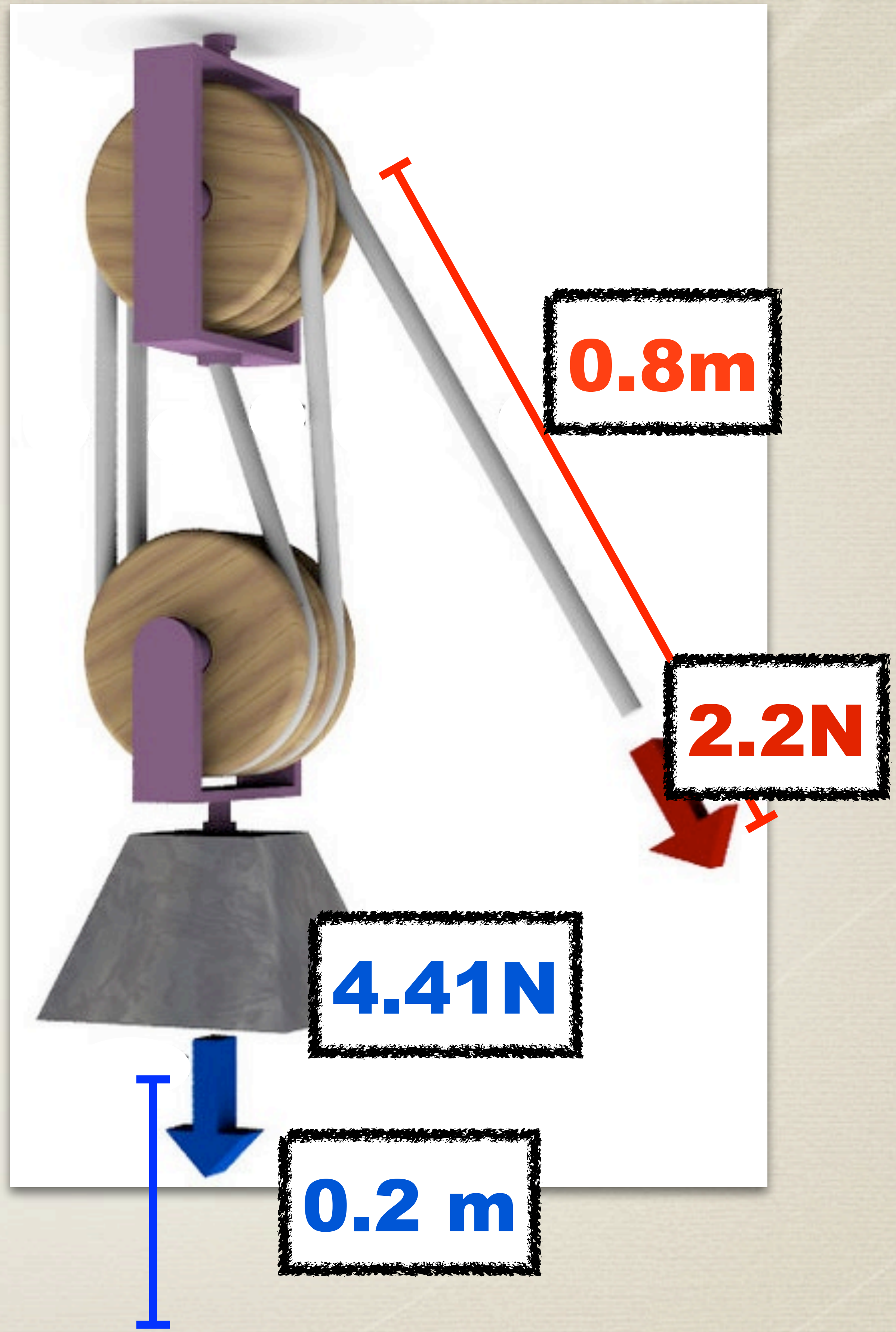
$$W_i = FD$$
$$W_i = (2.2N)(0.8m)$$



A force of 2.2 N is used to lift a 450 g mass. While the mass goes up 20 cm, a student pulls in 80 cm of string. It takes her 5 seconds to lift

Find the work input,
the work output,
the IMA,
the AMA,
the efficiency of the pulley,
the energy wasted by friction,
her power

$$W_i = FD$$
$$W_i = (2.2N)(0.8m)$$
$$W_i = 1.76\ J$$



A force of 2.2 N is used to lift a 450 g mass. While the mass goes up 20 cm, a student pulls in 80 cm of string. It takes her 5 seconds to lift

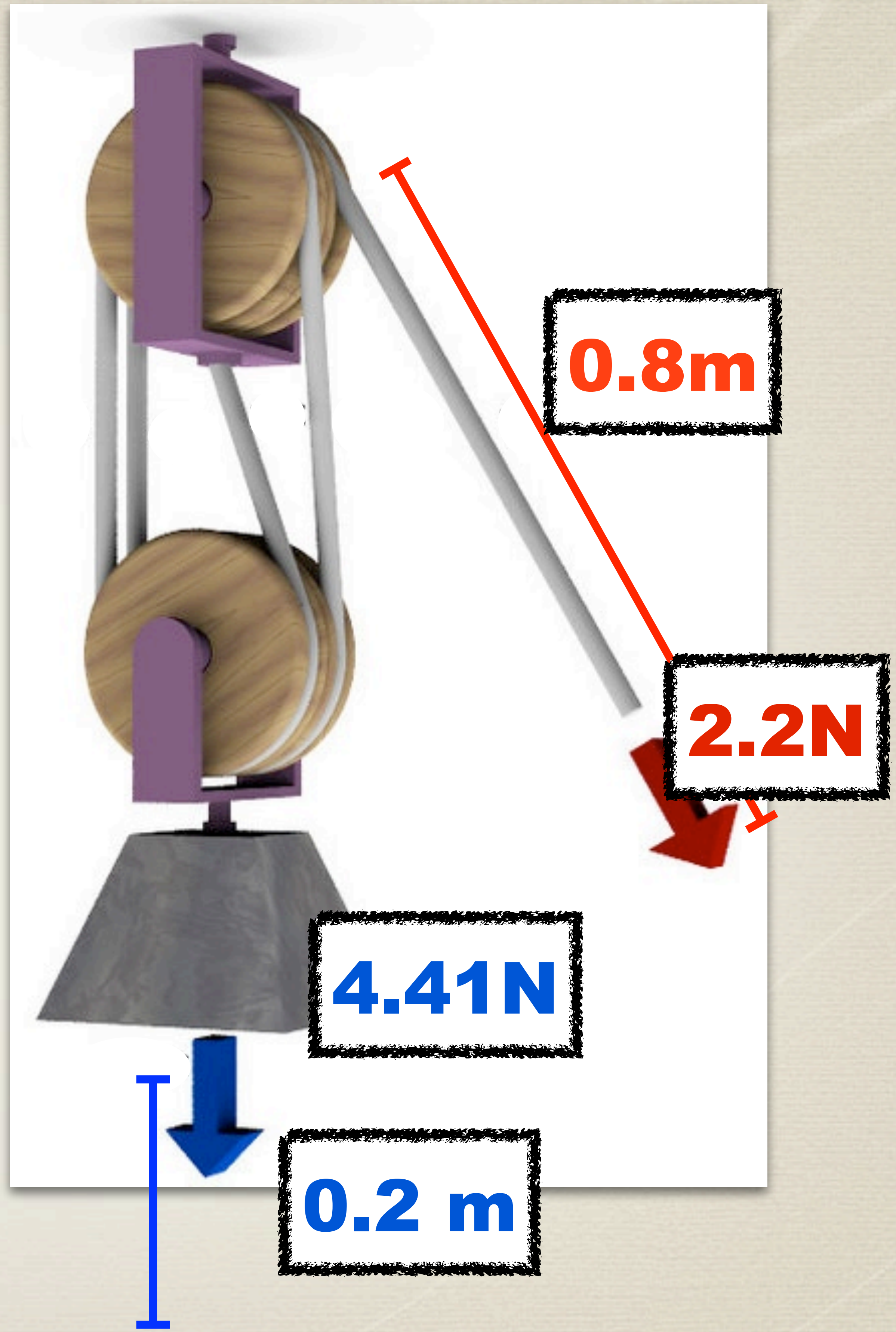
Find the work input,
the work output,
the IMA,
the AMA,
the efficiency of the pulley,
the energy wasted by friction,
her power

$W_i = FD$

$W_i = (2.2N)(0.8m)$

$W_i = 1.76\ J$

$W_o = FD$

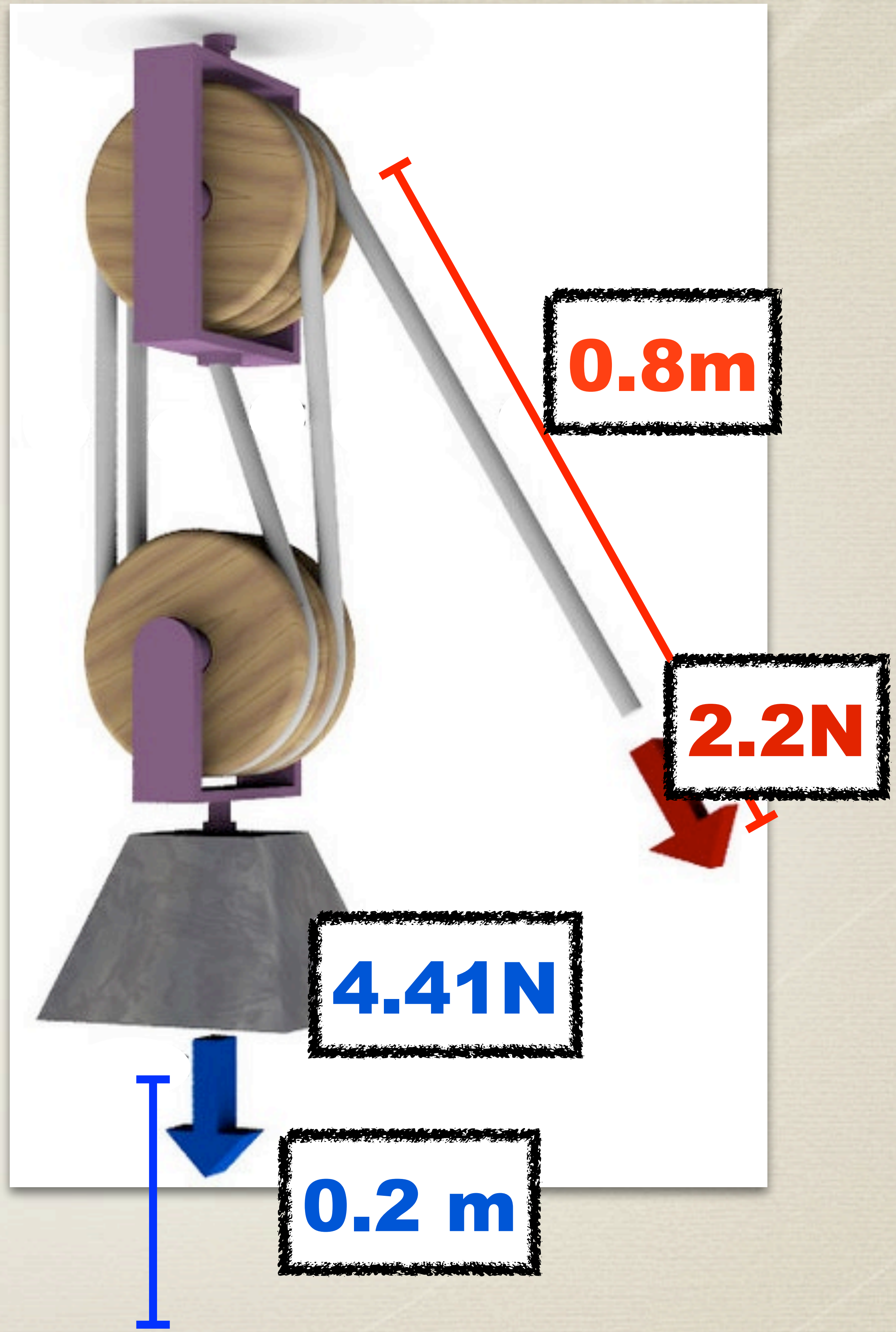


A force of 2.2 N is used to lift a 450 g mass. While the mass goes up 20 cm, a student pulls in 80 cm of string. It takes her 5 seconds to lift

Find the work input,
the work output,
the IMA,
the AMA,
the efficiency of the pulley,
the energy wasted by friction,
her power

$$W_i = FD$$
$$W_i = (2.2N)(0.8m)$$
$$W_i = 1.76\ J$$

$$W_o = FD$$
$$W_o = 4.41N(0.2m)$$

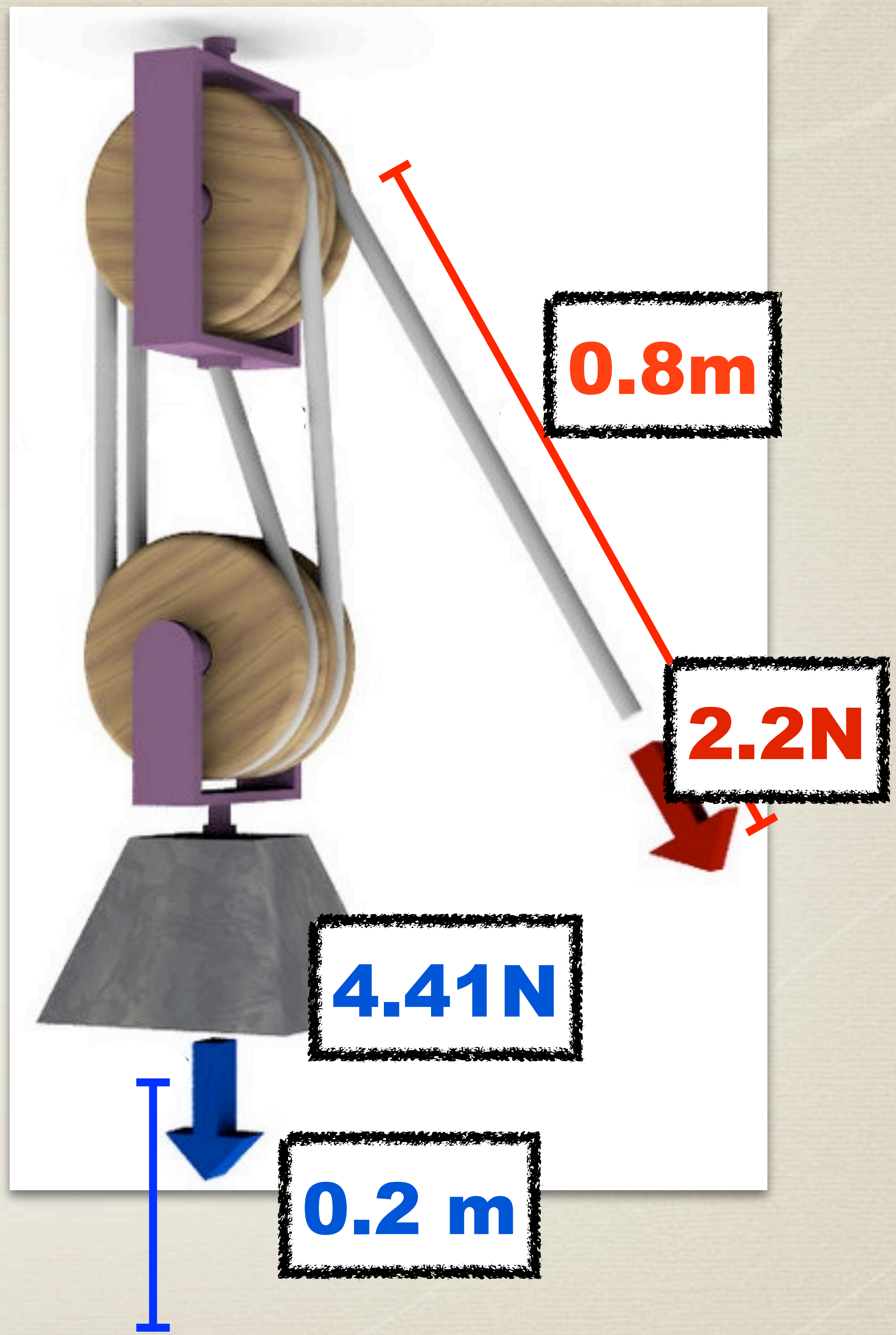


A force of 2.2 N is used to lift a 450 g mass. While the mass goes up 20 cm, a student pulls in 80 cm of string. It takes her 5 seconds to lift

Find the work input,
the work output,
the IMA,
the AMA,
the efficiency of the pulley,
the energy wasted by friction,
her power

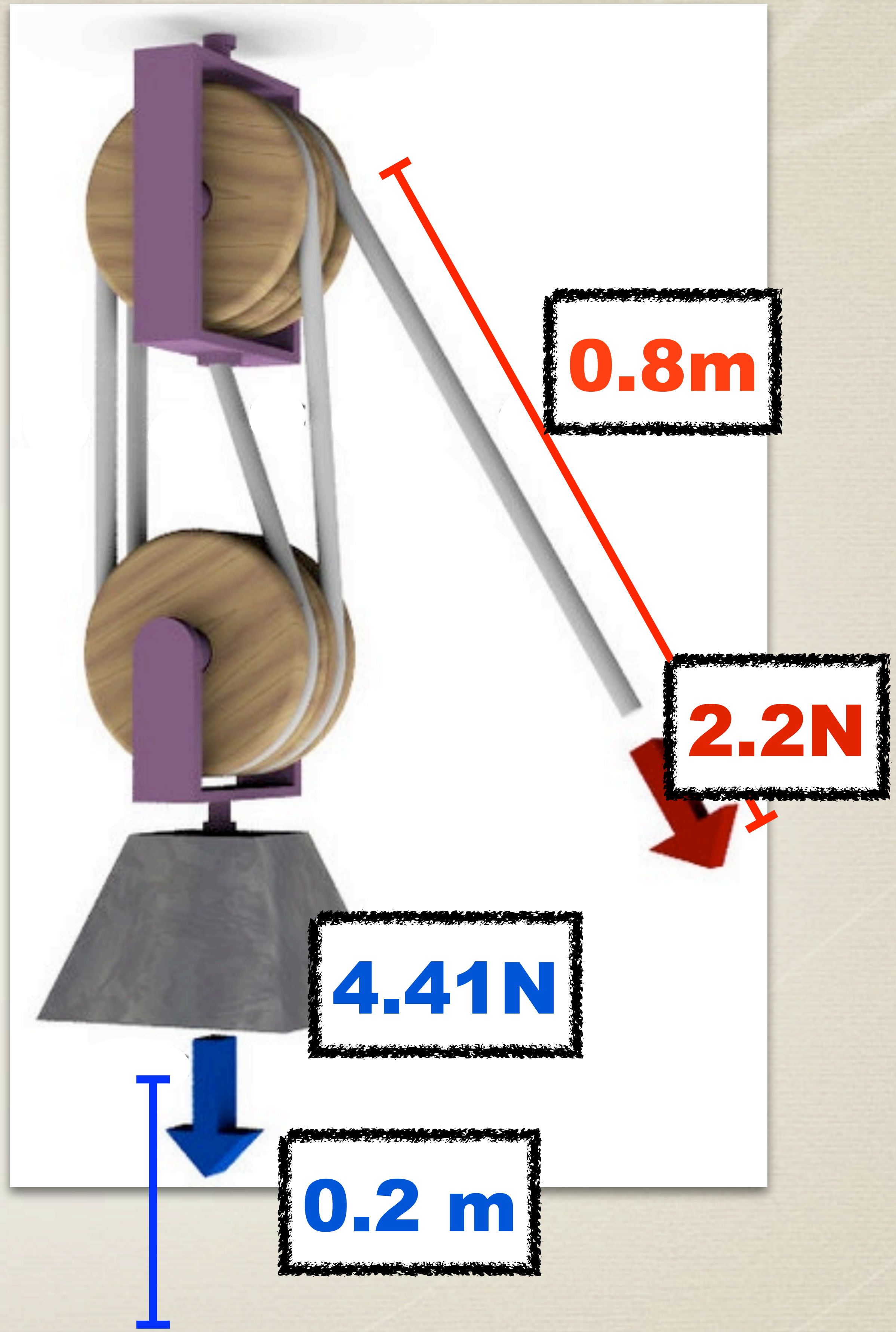
$$W_i = FD$$
$$W_i = (2.2N)(0.8m)$$
$$W_i = 1.76\ J$$

$$W_o = FD$$
$$W_o = 4.41N(0.2m)$$
$$W_o = 0.882\ J$$



A force of 2.2 N is used to lift a 450 g mass. While the mass goes up 20 cm, a student pulls in 80 cm of string. It takes her 5 seconds to lift

Find the work input Wi = 1.76 J
the work output, Wo = 0.882 J
the IMA,
the AMA,
the efficiency of the pulley,
the energy wasted by friction,
her power



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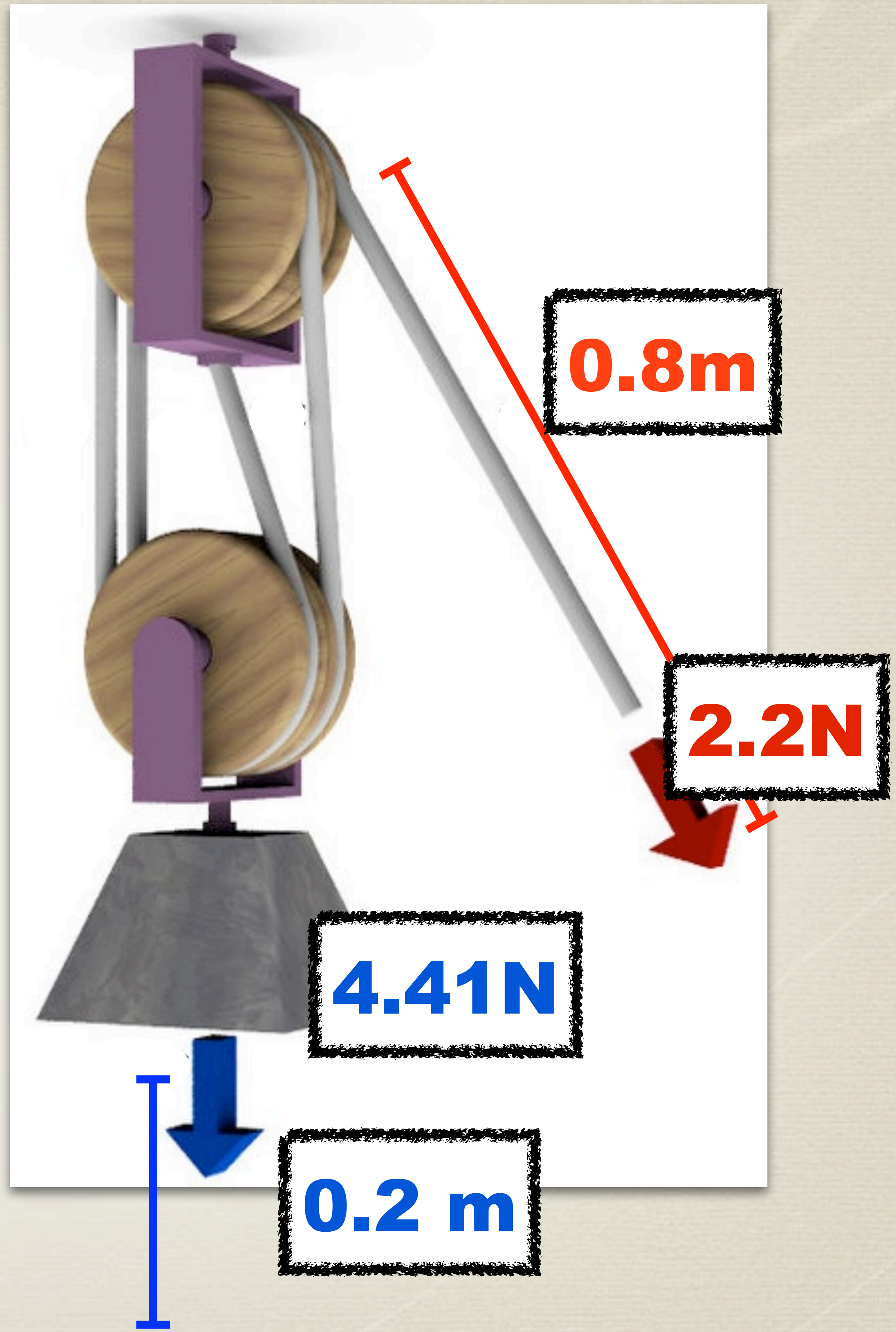
Find the work input Wi = 1.76 J
the work output, Wo = 0.882 J
the IMA,
the AMA,
the efficiency of the pulley,
the energy wasted by friction,
her power

$$IMA = D_i / D_o$$



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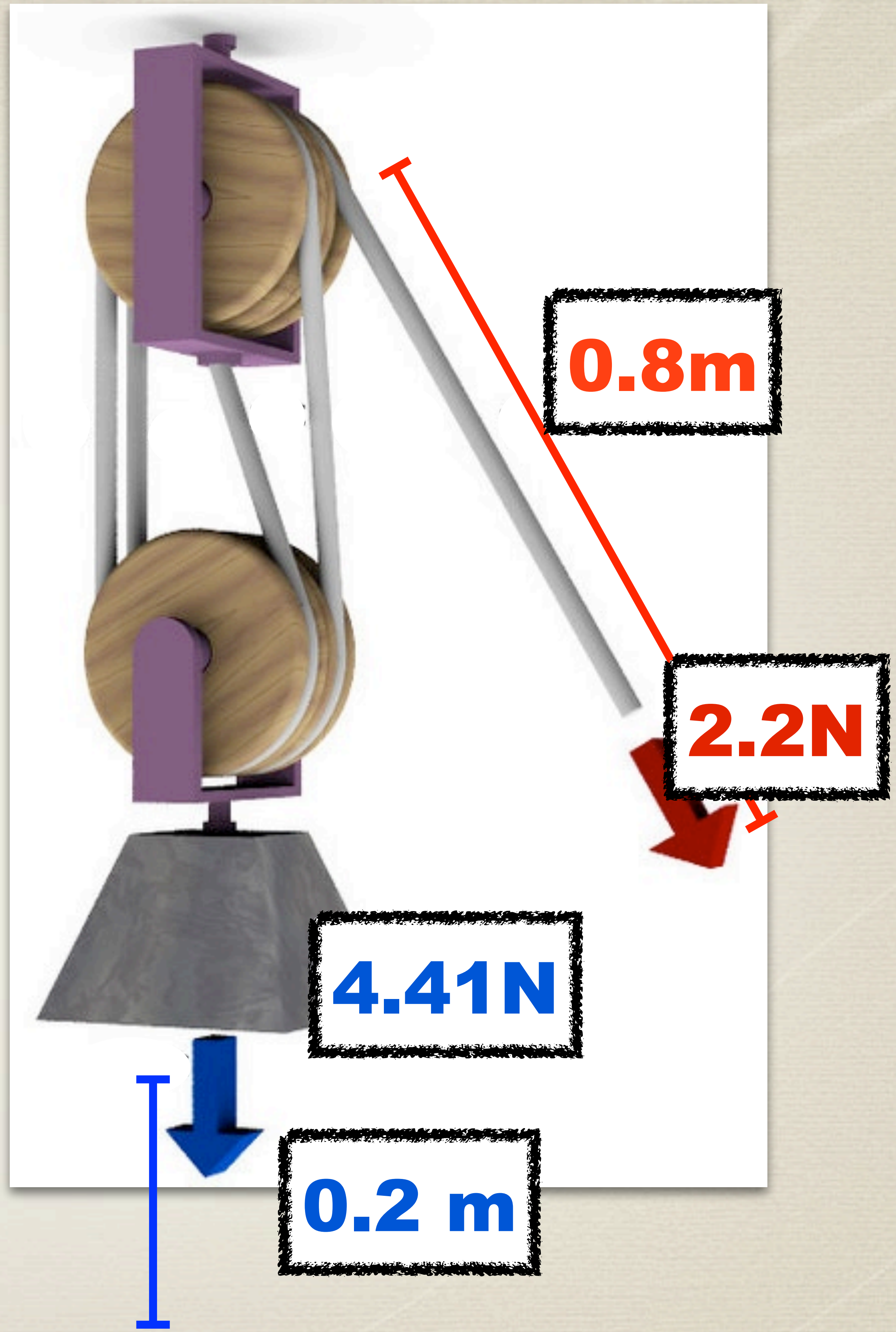
the work output, Wo = 0.882 J
the IMA,
the AMA,
the efficiency of the pulley,
the energy wasted by friction,
her power

$$IMA = D_i / D_o$$
$$IMA = (0.8m) / (0.2m)$$



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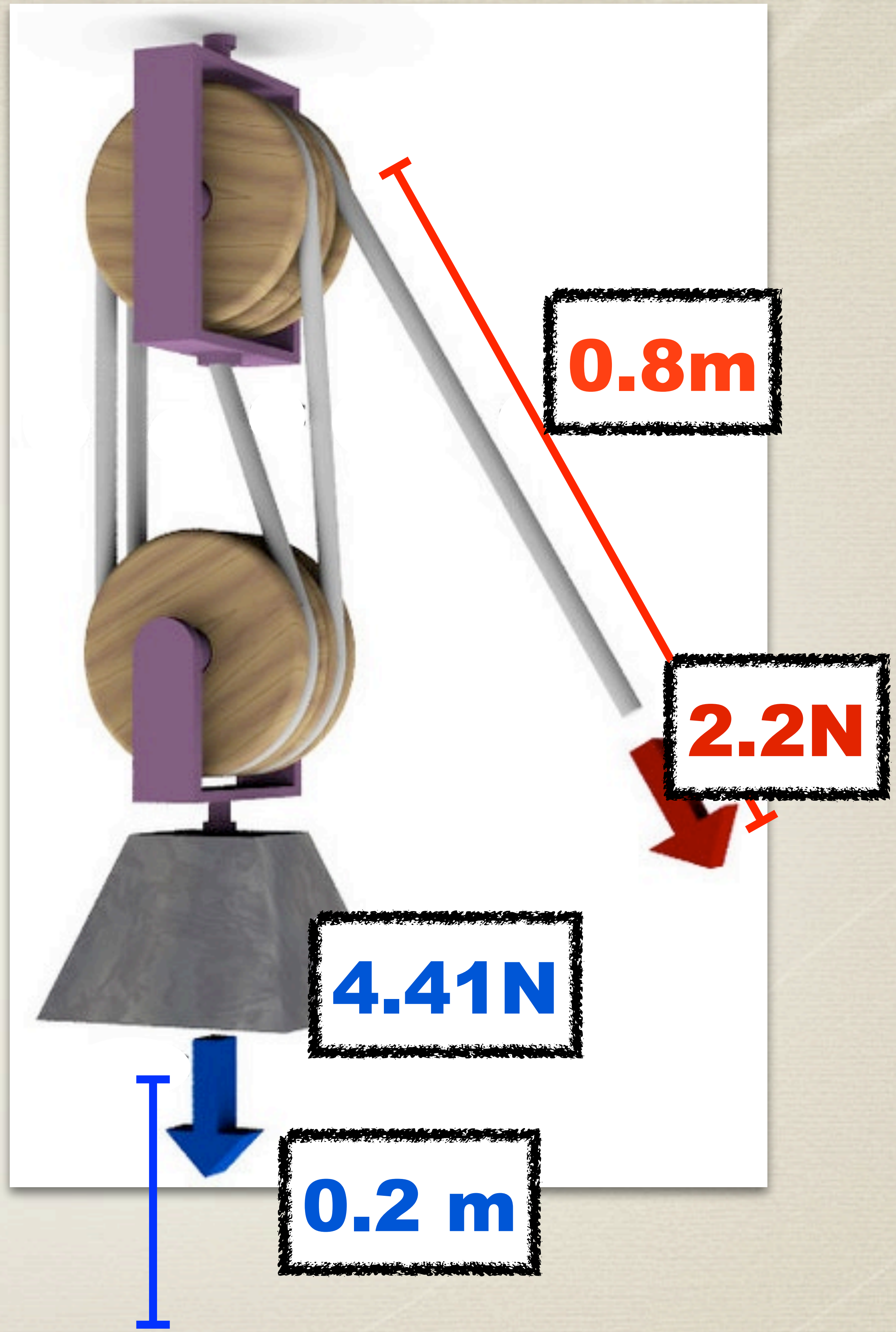
Find the work input Wi = 1.76 J
the work output, Wo = 0.882 J
the IMA,
the AMA,
the efficiency of the pulley,
the energy wasted by friction,
her power

$$IMA = D_i / D_o$$
$$IMA = (0.8m) / (0.2m)$$
$$IMA = 4$$

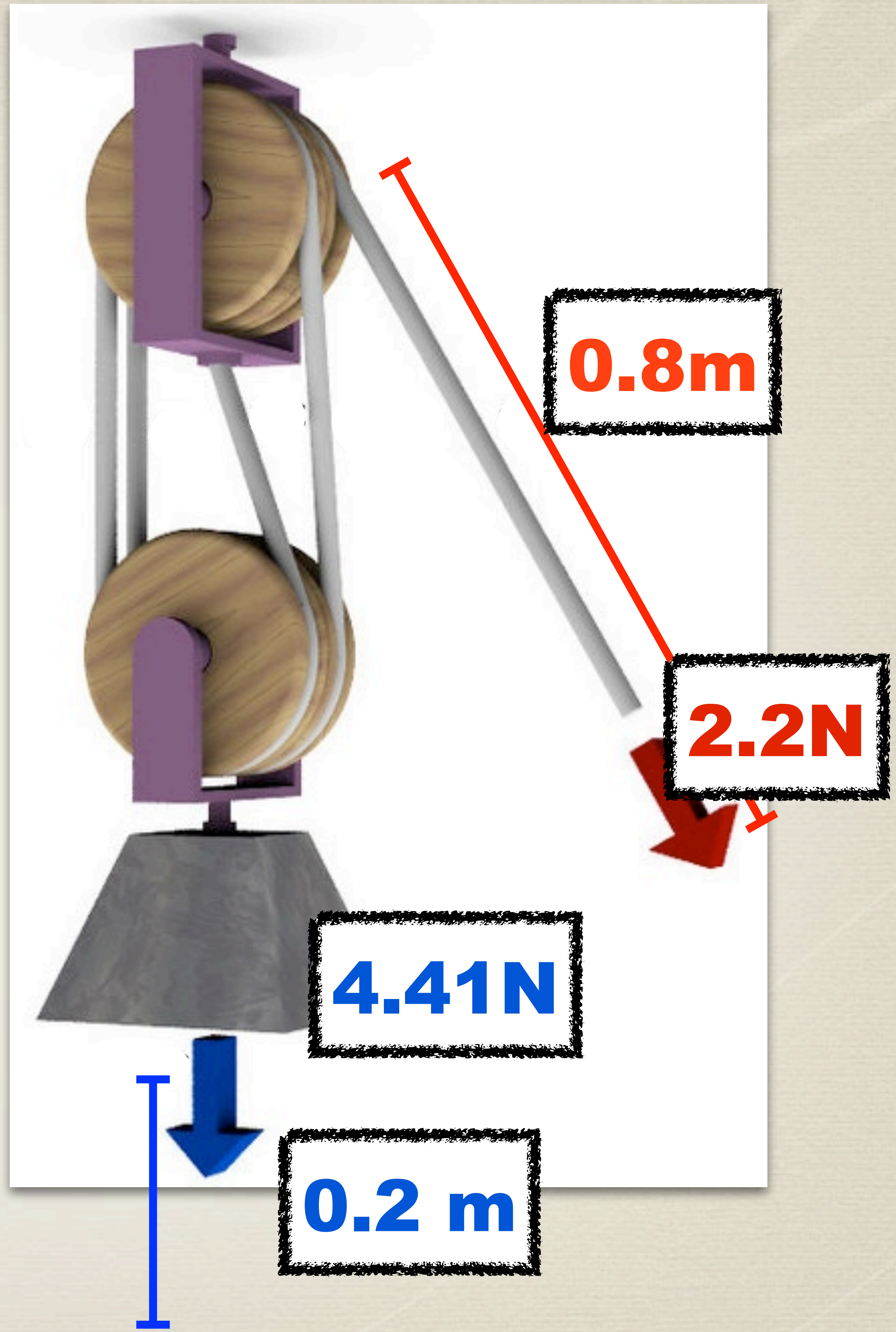


A force of 2.2 N is used to lift a 450 g mass. While the mass goes up 20 cm, a student pulls in 80 cm of string. It takes her 5 seconds to lift

Find the work input $W_i = 1.76$ J
the work output, $W_o = 0.882$ J
the IMA,
the AMA,
the efficiency of the pulley,
the energy wasted by friction,
her power

$$IMA = D_i / D_o$$
$$IMA = (0.8m) / (0.2m)$$
$$IMA = 4$$

$$AMA = F_o / F_i$$



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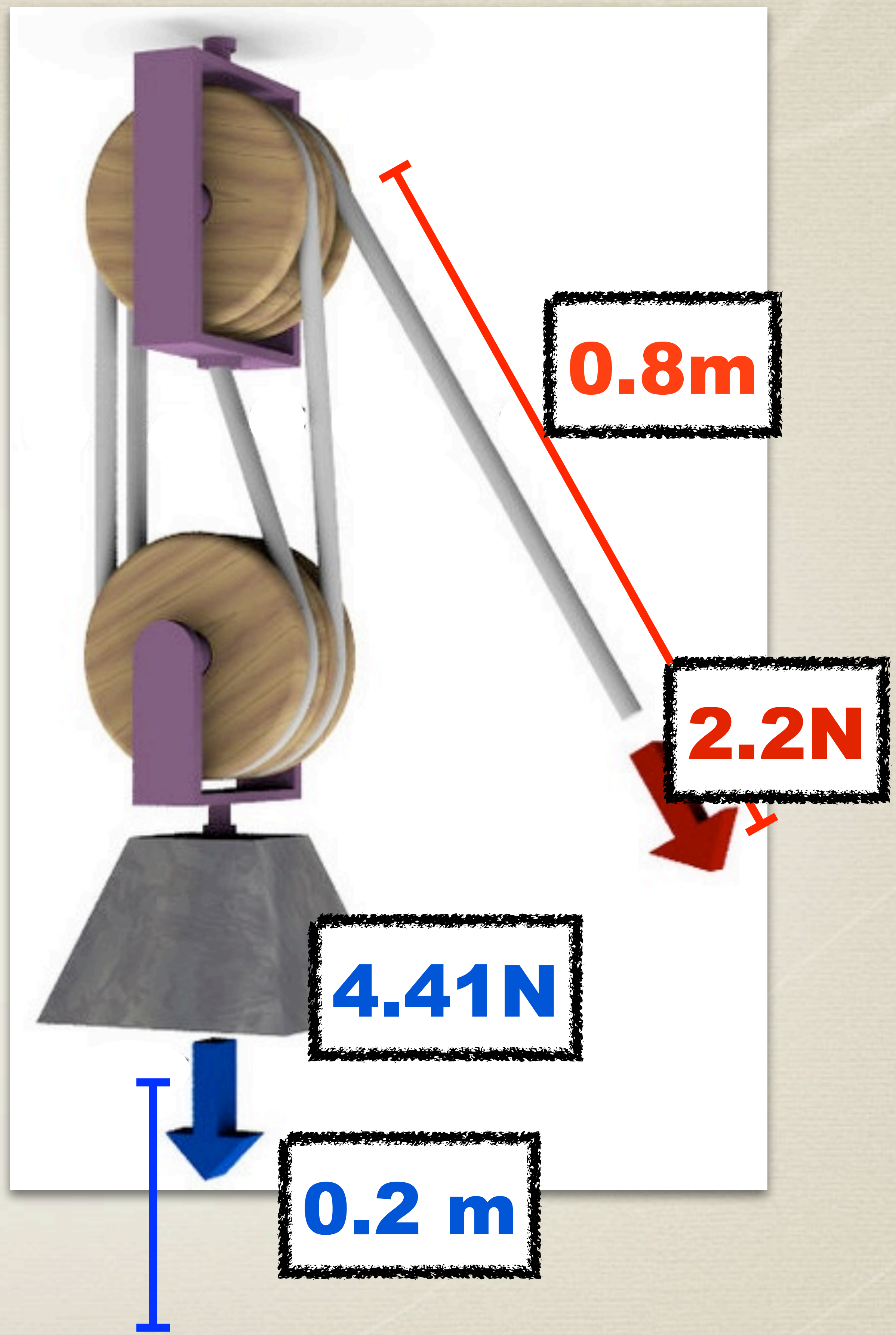
the work output, Wo = 0.882 J
the IMA,
the AMA,
the efficiency of the pulley,
the energy wasted by friction,
her power

$$IMA = D_i / D_o$$
$$IMA = (0.8m) / (0.2m)$$
$$IMA = 4$$

$$AMA = F_o / F_i$$
$$AMA = 4.41N / (2.2N)$$



A force of 2.2 N is used to lift a 450 g mass. While the mass goes up 20 cm, a student pulls in 80 cm of string. It takes her 5 seconds to lift

Find the work input $W_i = 1.76$ J
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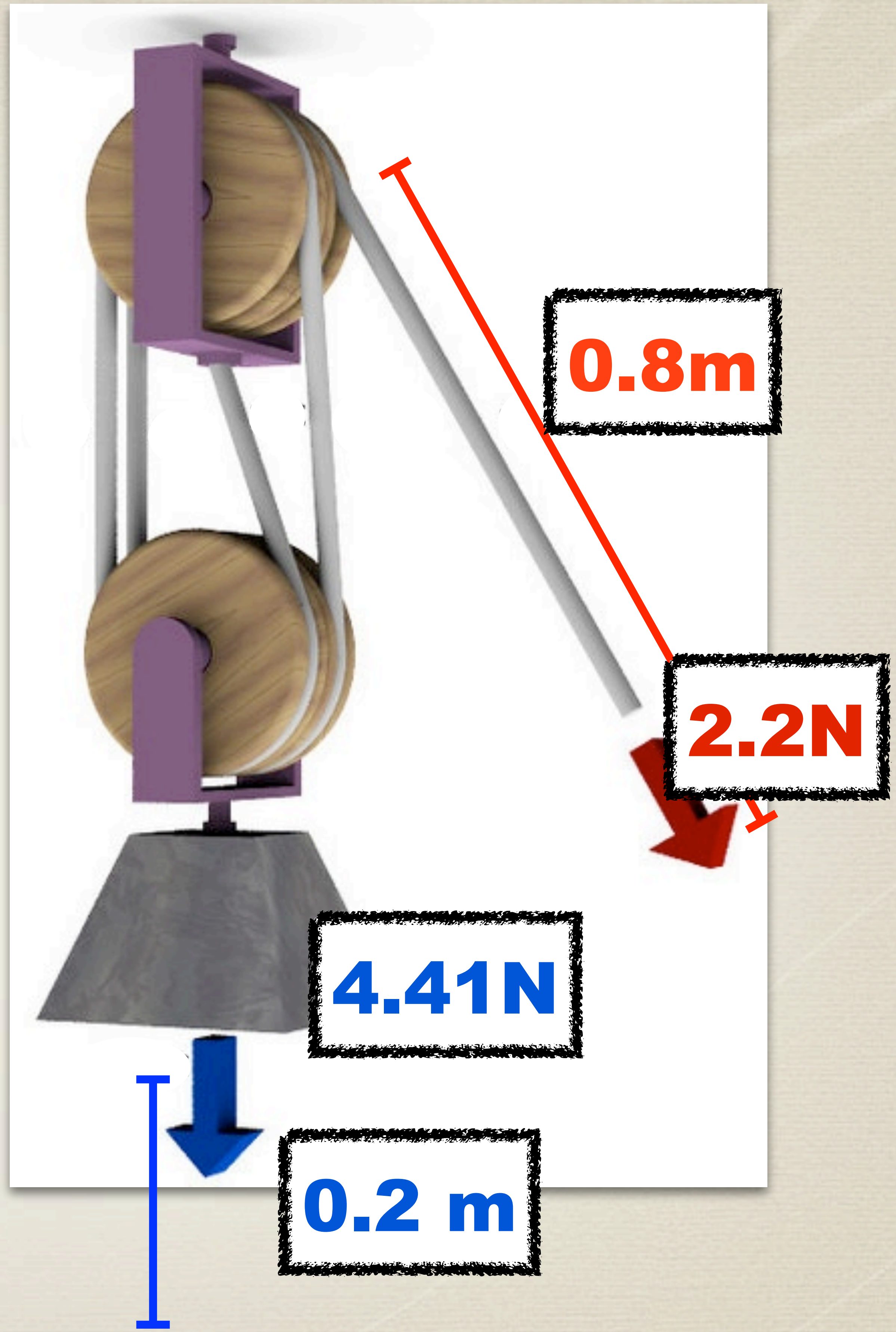
the IMA,
the AMA,
the efficiency of the pulley,
the energy wasted by friction,
her power

$$IMA = D_i / D_o$$
$$IMA = (0.8m) / (0.2m)$$
$$IMA = 4$$

$$AMA = F_o / F_i$$
$$AMA = 4.41N / (2.2N)$$
$$AMA = 2$$



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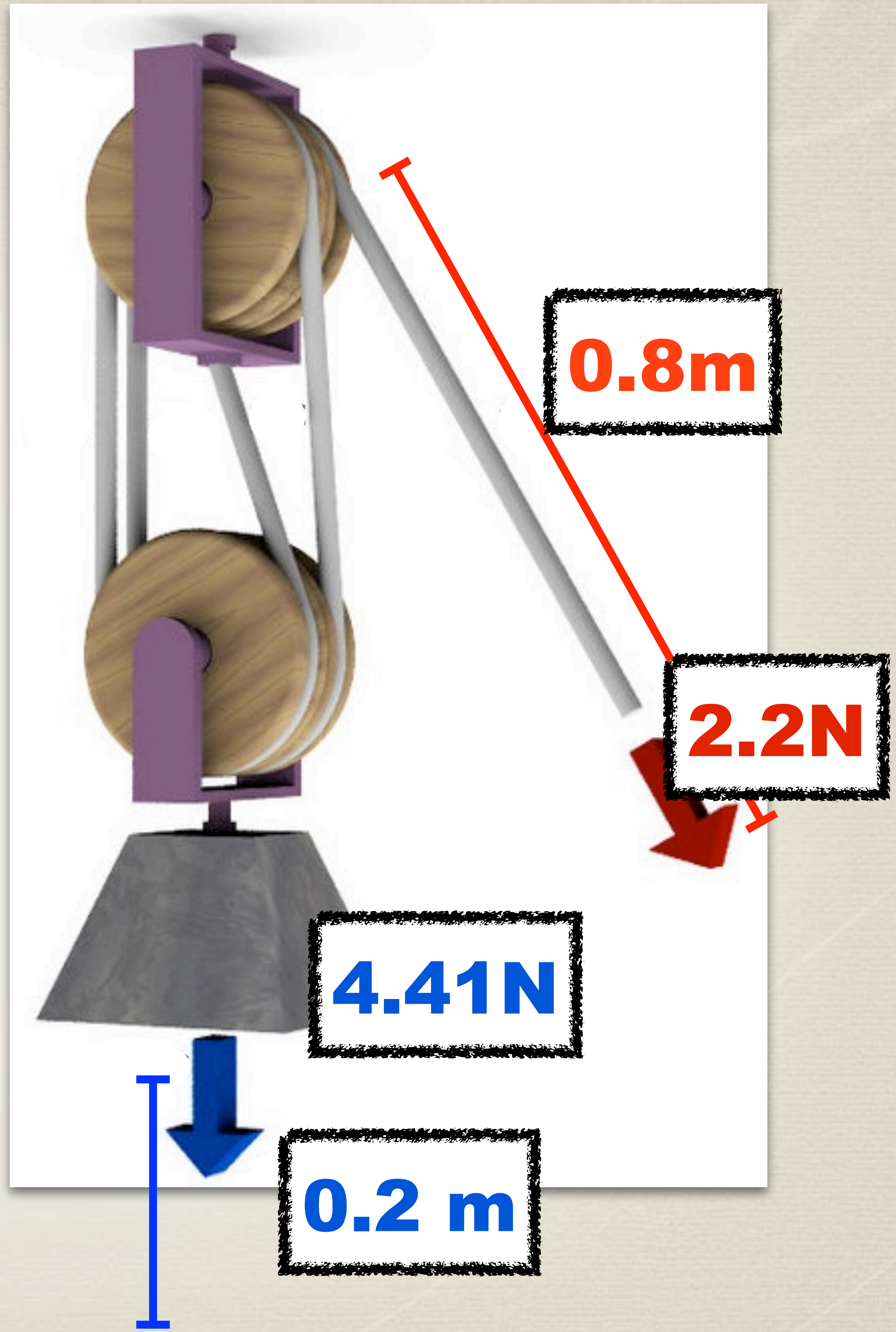
the work output, Wo = 0.882 J
the IMA, IMA = 4
the AMA, AMA = 2
the efficiency of the pulley,
the energy wasted by friction,
her power



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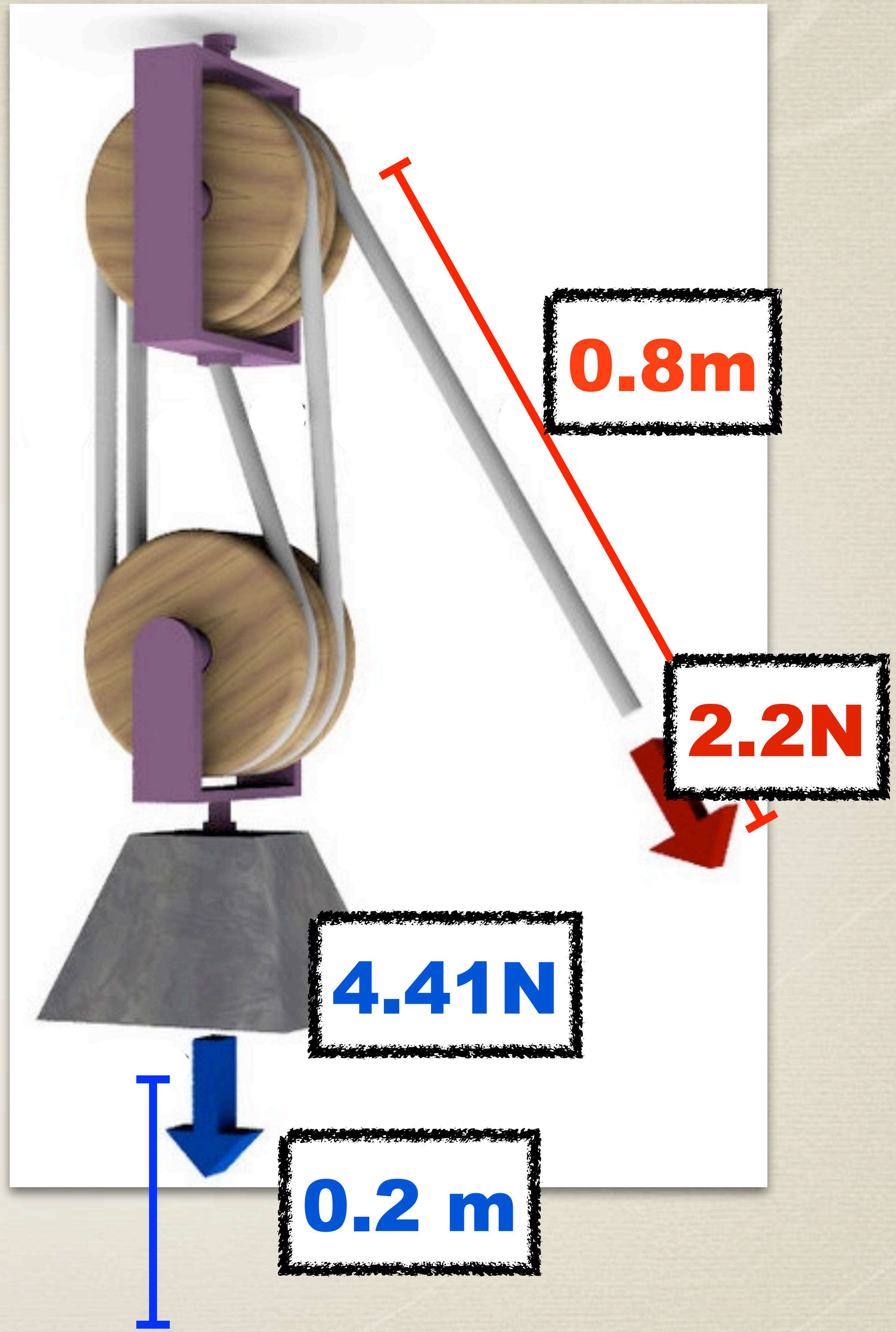
$$\text{Efficiency} = W_o / W_i$$



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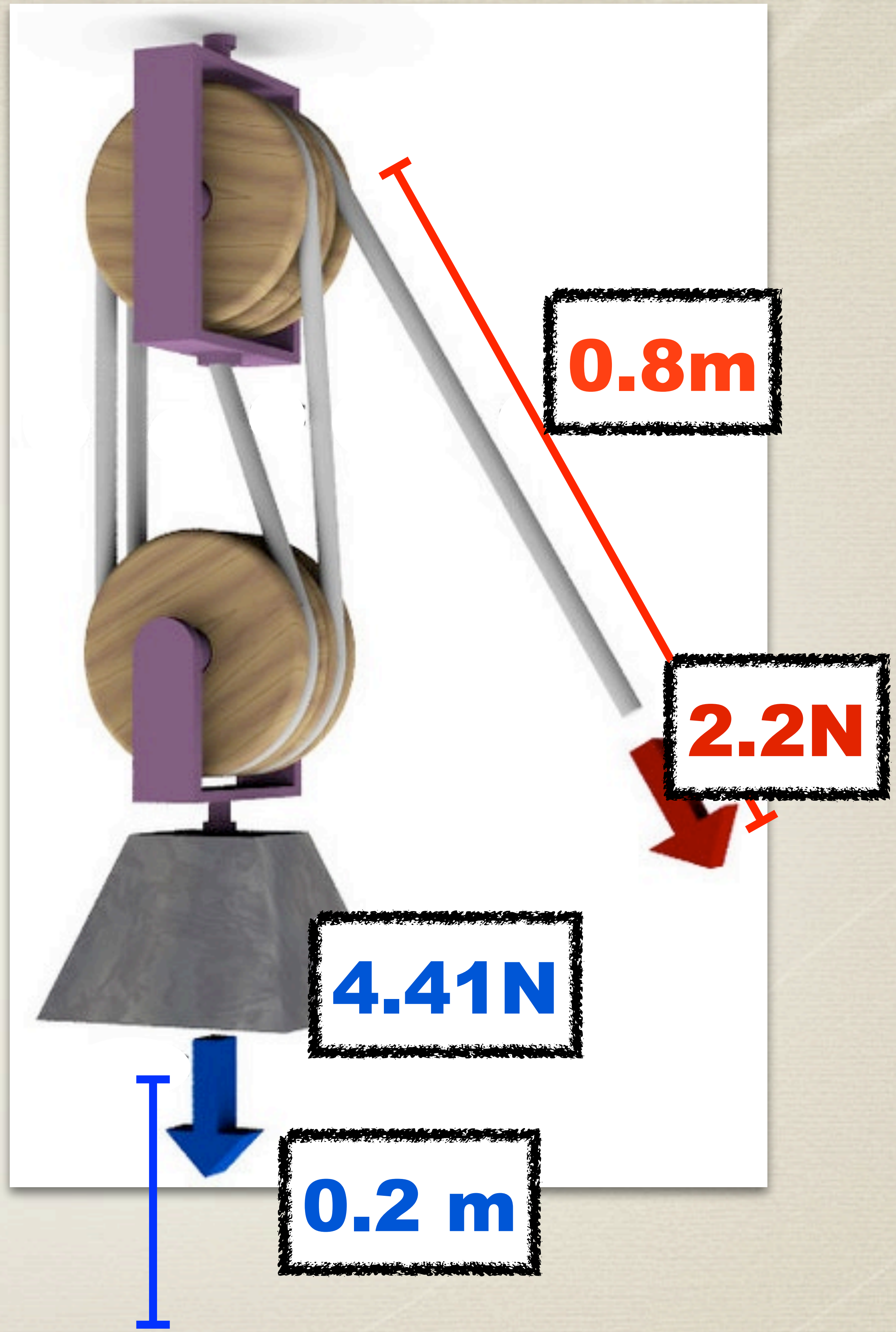
the efficiency of the pulley,
the energy wasted by friction,
her power

$$\text{Efficiency} = W_o / W_i$$
$$\text{Efficiency} = (0.882J)/(1.76J)$$



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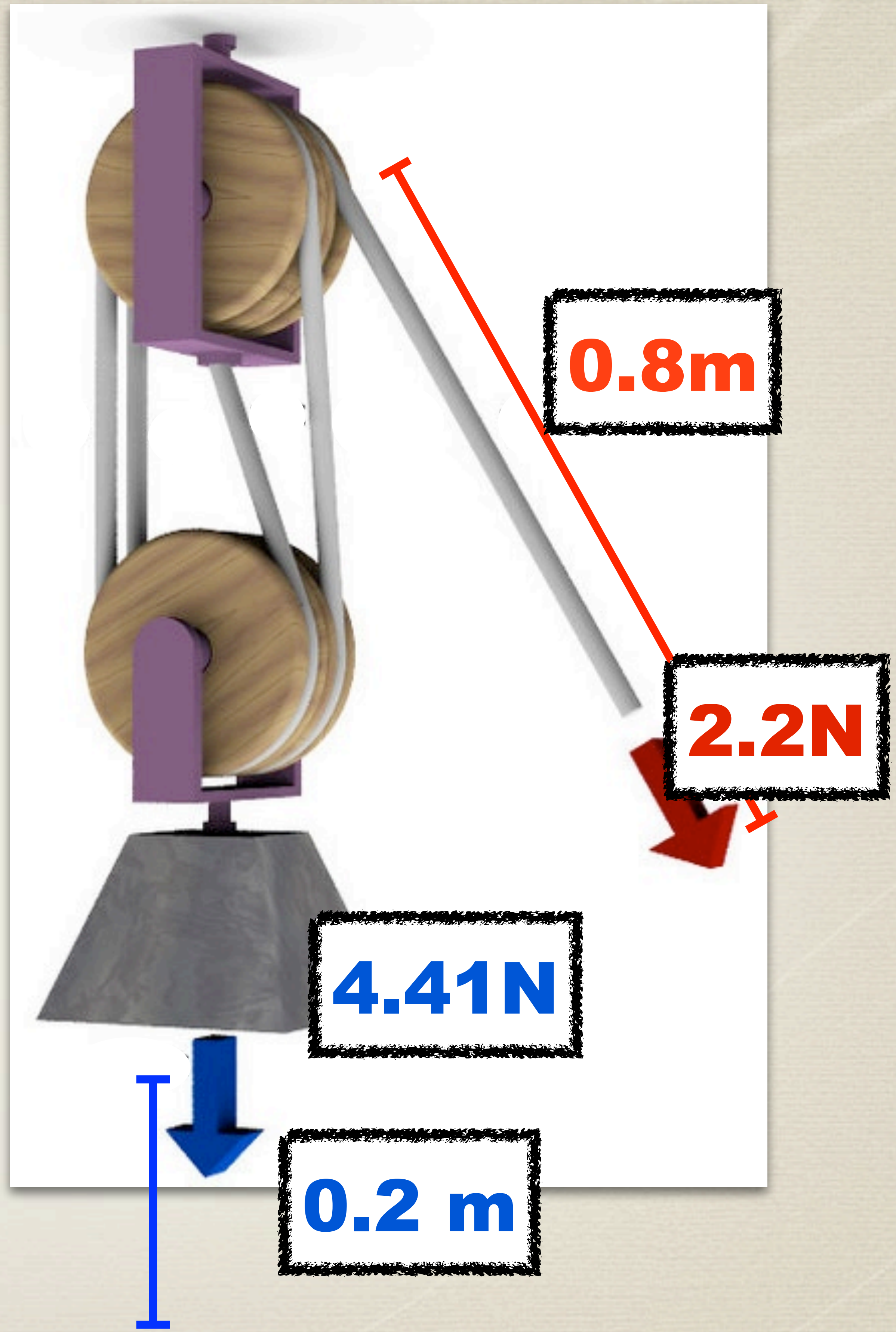
$$\text{Efficiency} = W_o / W_i$$
$$\text{Efficiency} = (0.882\text{J})/(1.76\text{J})$$
$$\text{Efficiency} = 0.5 = 50\%$$



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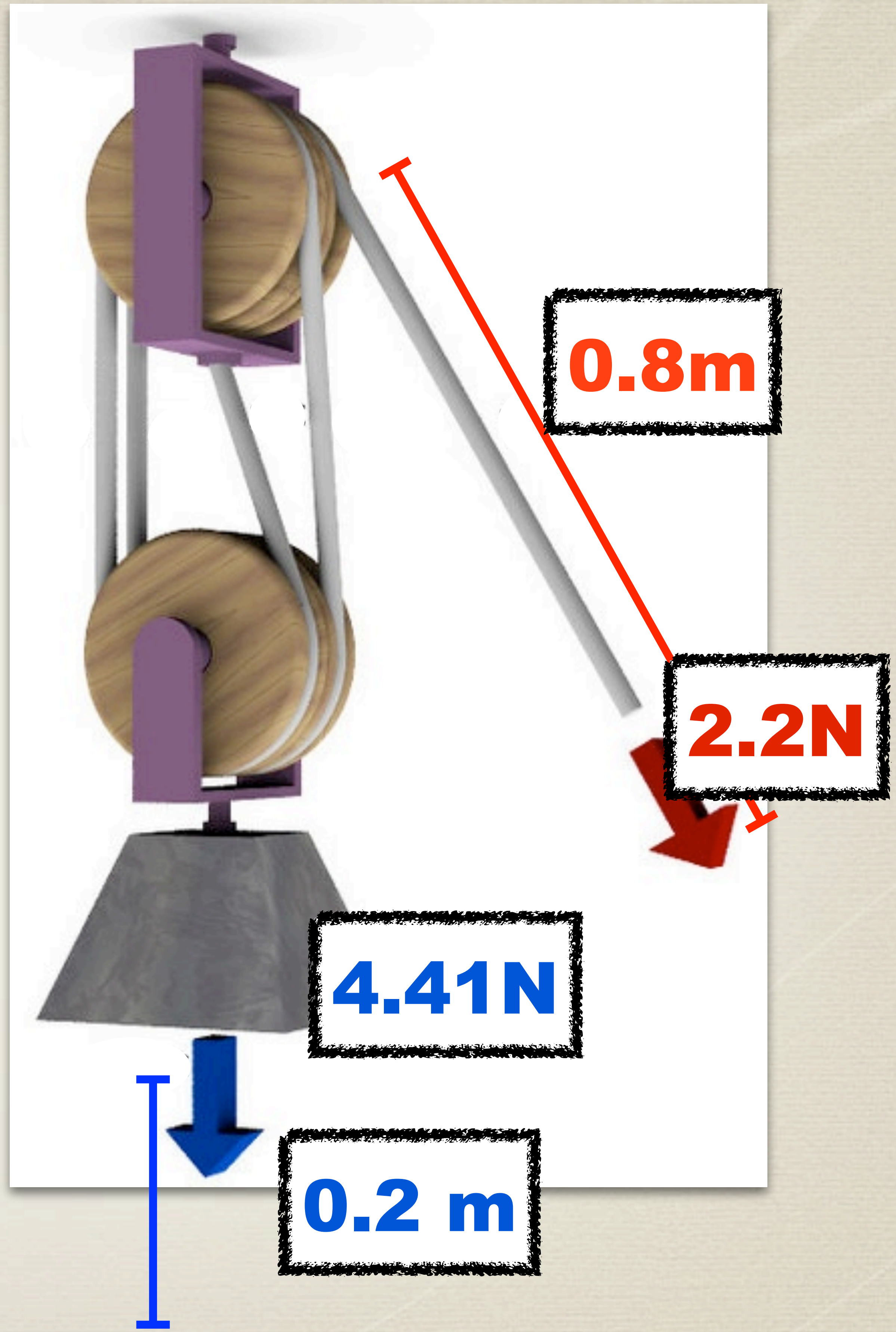
$$\text{Efficiency} = W_o / W_i$$

$$\text{Efficiency} = (0.882\text{J})/(1.76\text{J})$$

$$\text{Efficiency} = 0.5 = 50\%$$

Energy Lost



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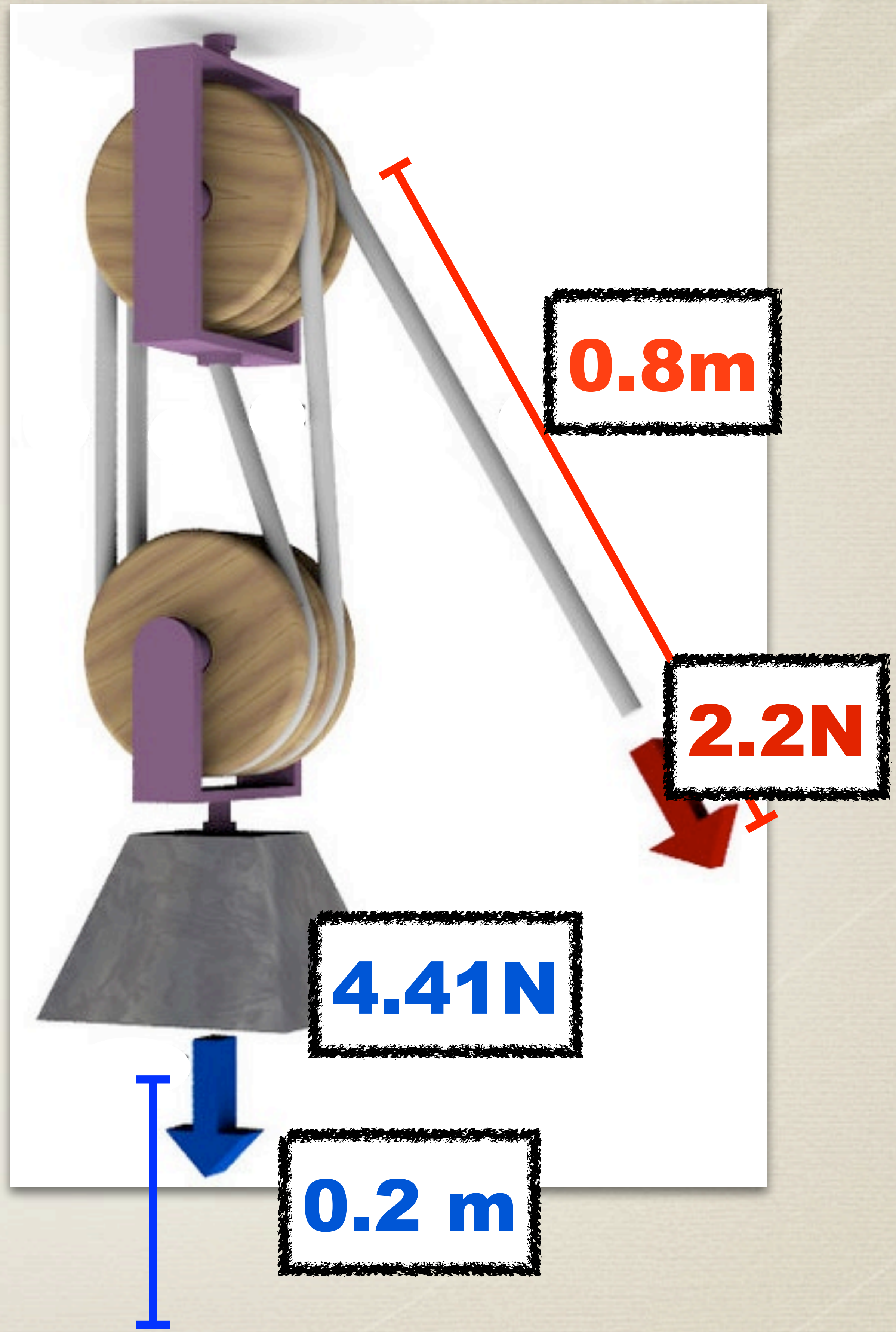
$$\text{Efficiency} = W_o / W_i$$
$$\text{Efficiency} = (0.882J)/(1.76J)$$
$$\text{Efficiency} = 0.5 = 50\%$$

Energy Lost
1.76 - 0.882 = 0.878J



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Find the work input Wi = 1.76 J
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the IMA, IMA = 4
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the efficiency of the pulley,
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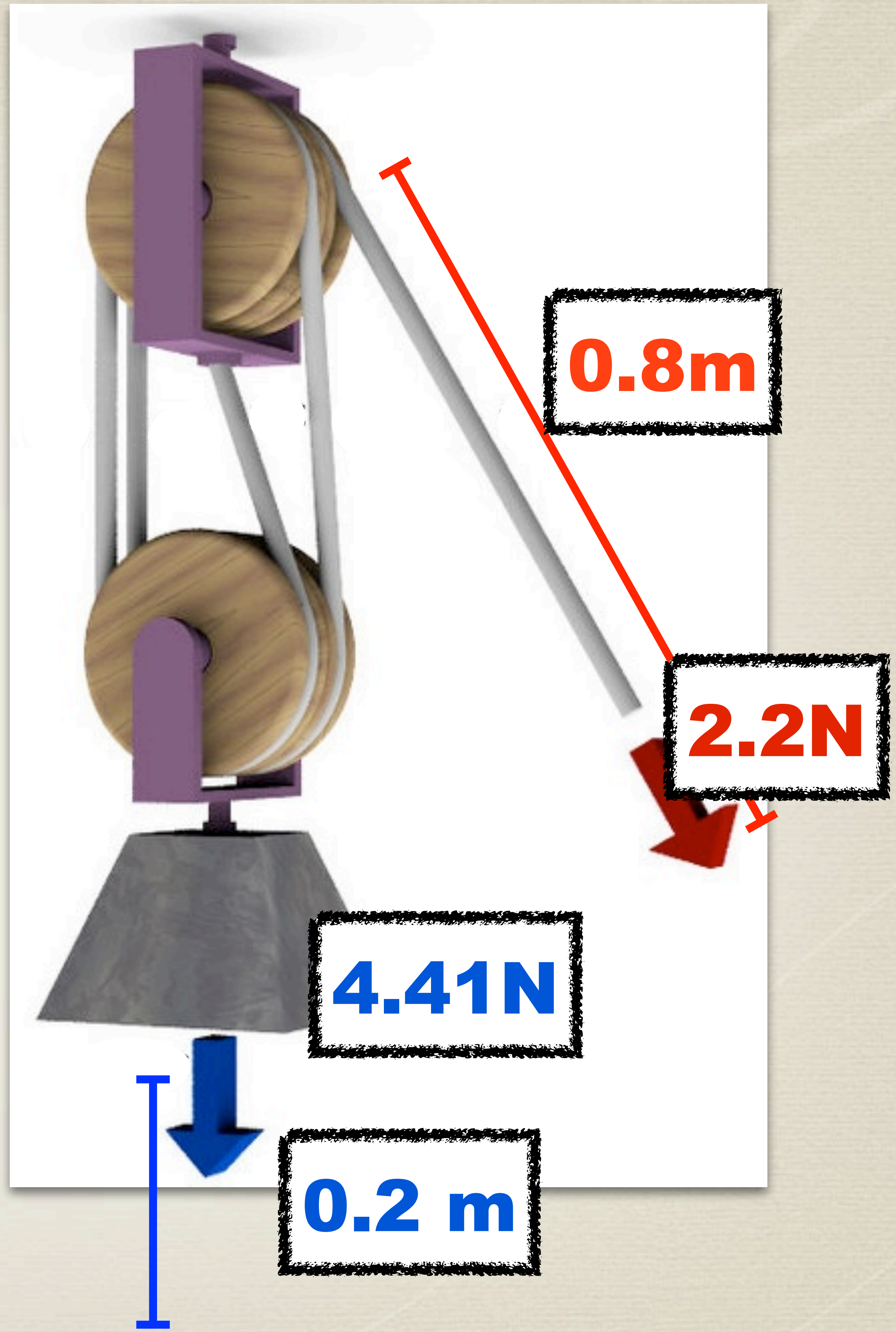
$$Efficiency = W_o / W_i$$
$$Efficiency = (0.882J)/(1.76J)$$
$$Efficiency = 0.5 = 50\%$$

Energy Lost
1.76 - 0.882 = 0.878J

Power = W / t



A force of 2.2 N is used to lift a 450 g mass. While the mass goes up 20 cm, a student pulls in 80 cm of string. It takes her 5 seconds to lift

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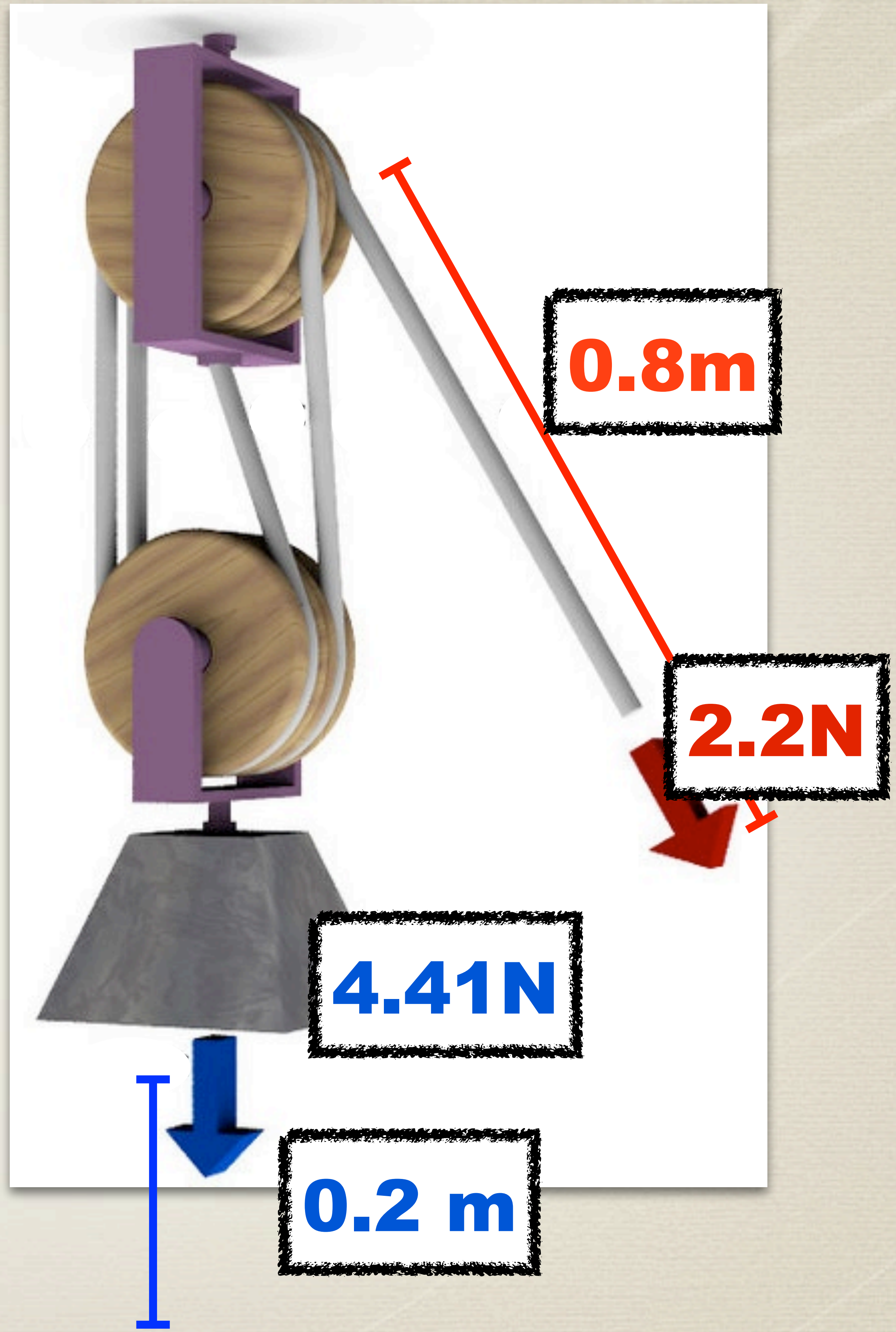
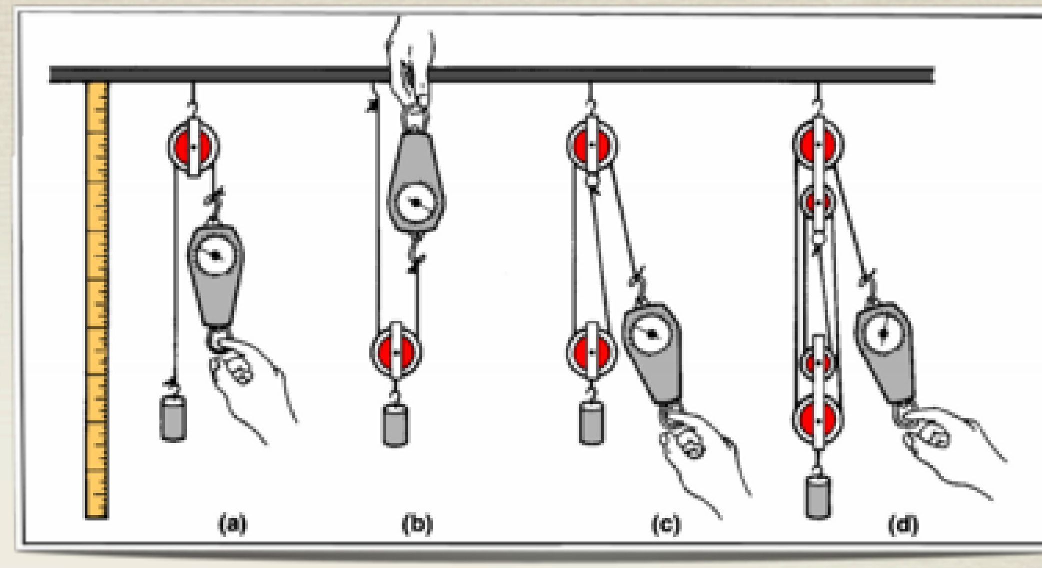


Efficiency = W_o / W_i
Efficiency = (0.882J)/(1.76J)
Efficiency = 0.5 = 50%

Energy Lost
1.76 - 0.882 = 0.878J

Power = W / t
Power = 1.76 / 5s = 0.352W

Pulley Lab



Data:		Draw the pulley arrangement	Calculations:	
mass lifted			Number of lifting strings	
Weight Lifted			Work input **F x D**	
Height lifted			Work output **W x H**	
mass needed			Efficiency Wo / Wi	
Force applied				
Distance				

Academic Assignment

Academic Physics

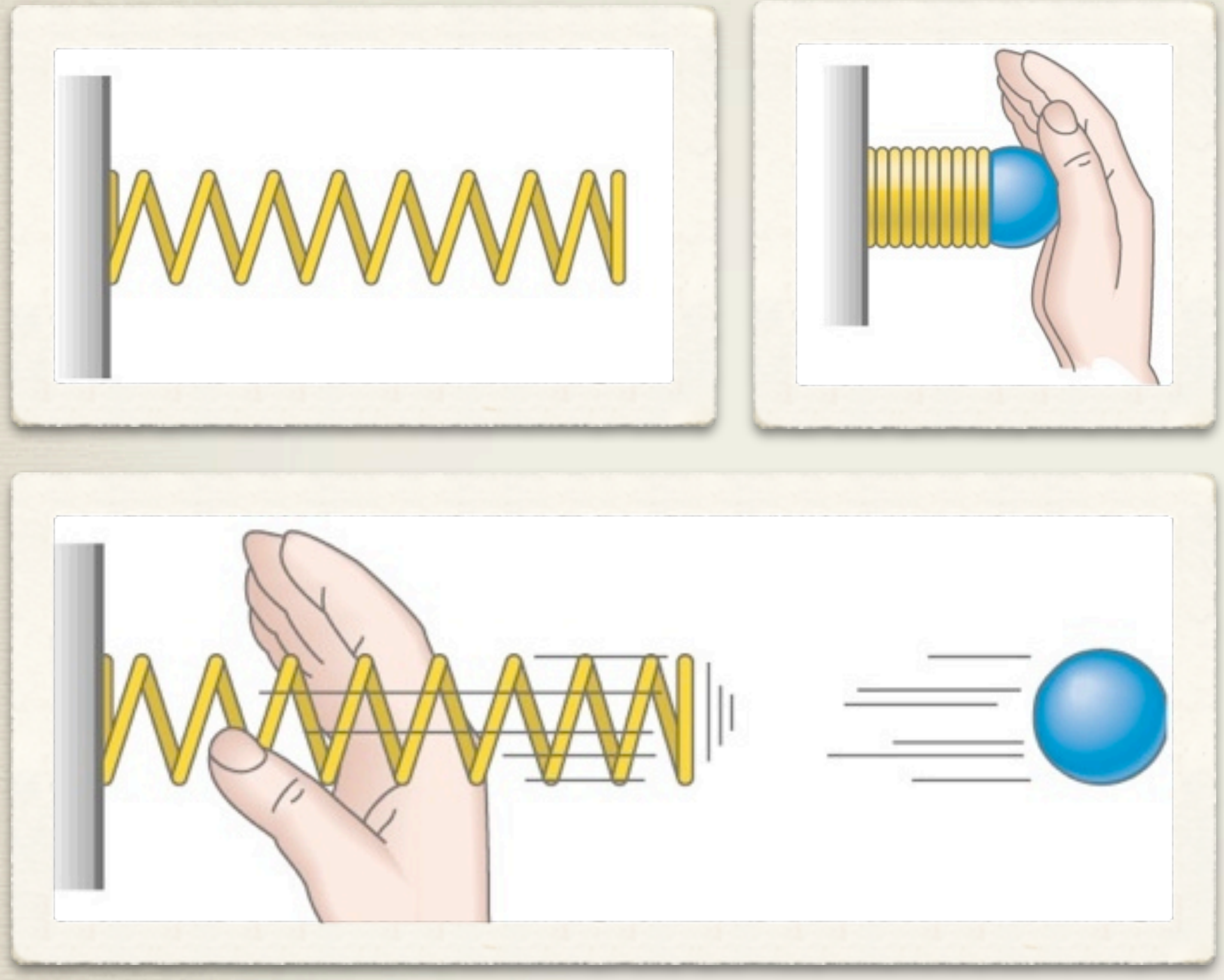
Set 1 - Chapter 10

1, 2, 3, 5, 6, 7, 25, 26, 27, 28, 52, 53, 56, 57

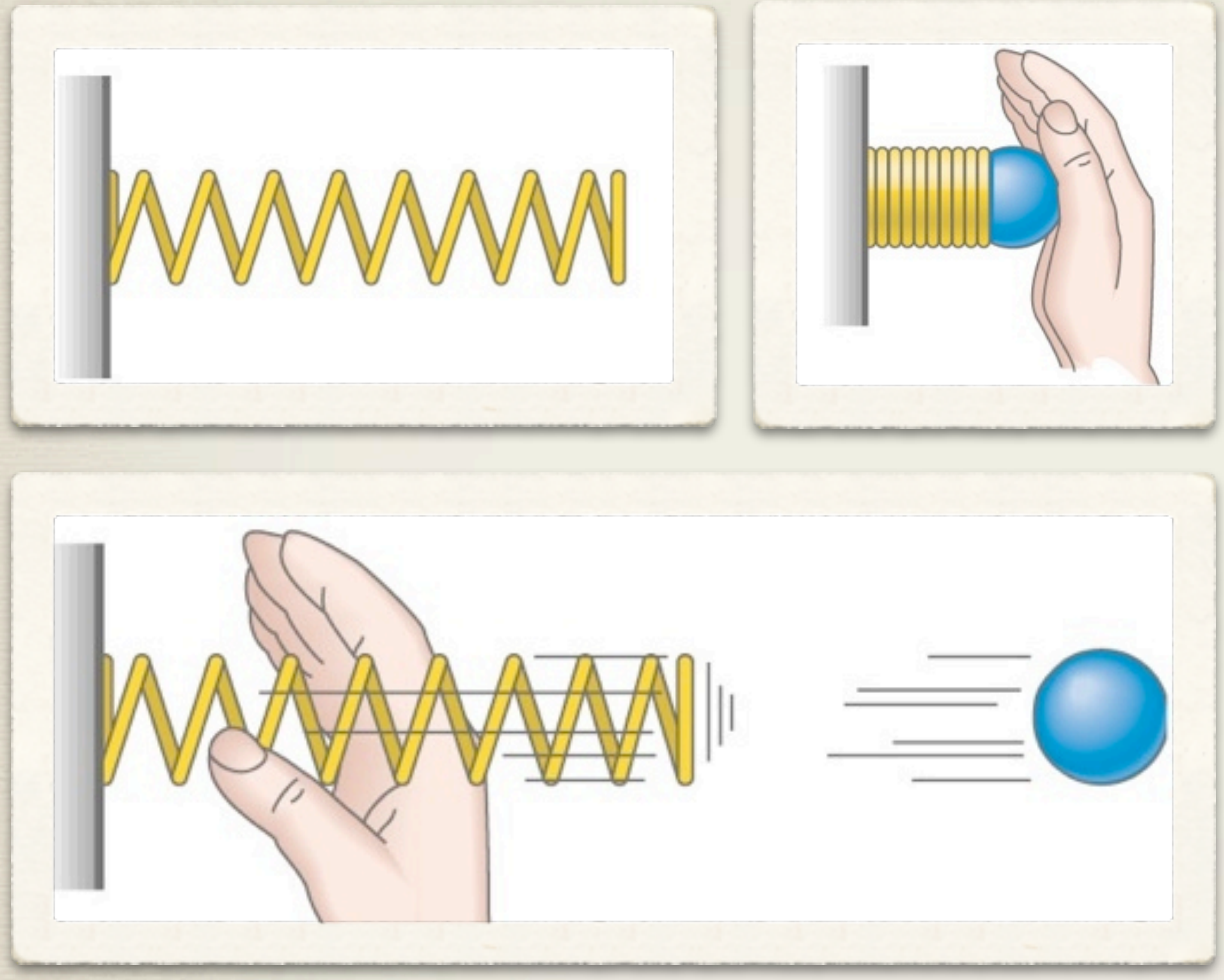
Solving Problems with Energy

instead of old equations

Elastic Potential Energy



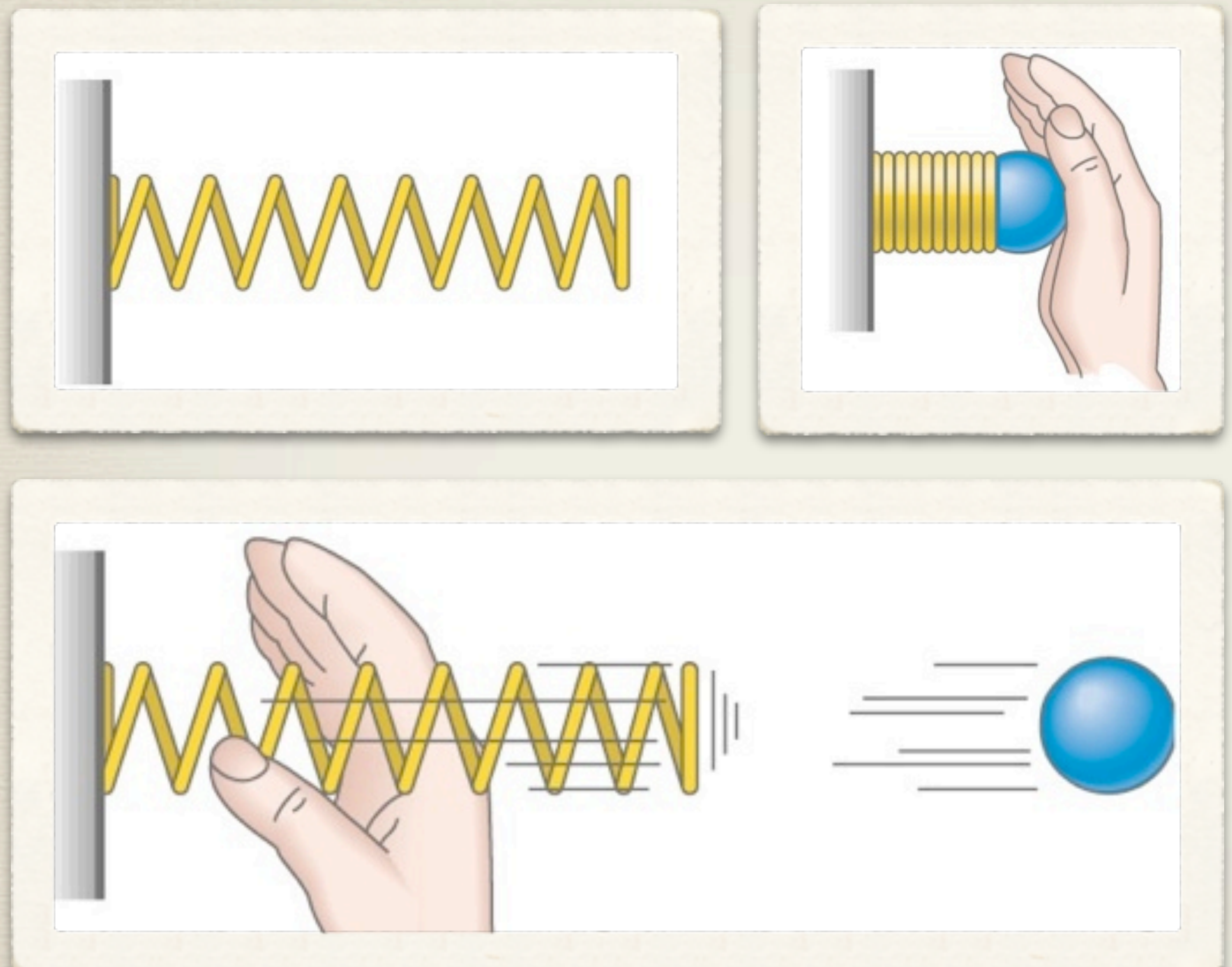
Elastic Potential Energy



- W = F D

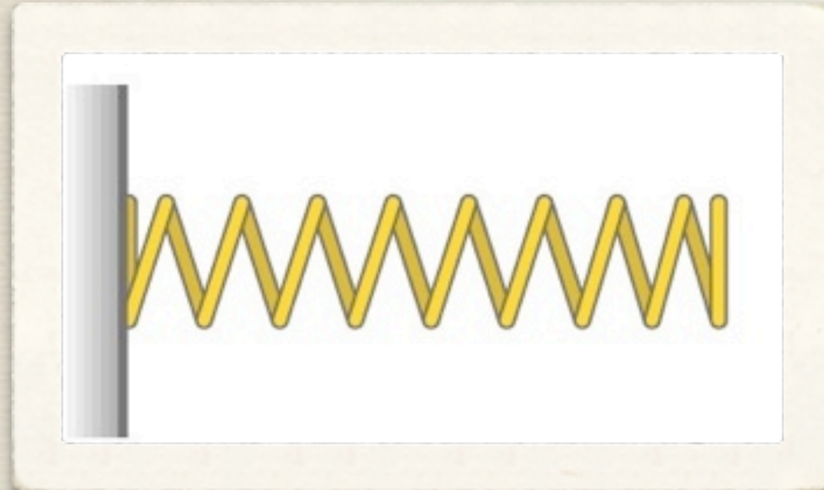
Wednesday, December 14, 11

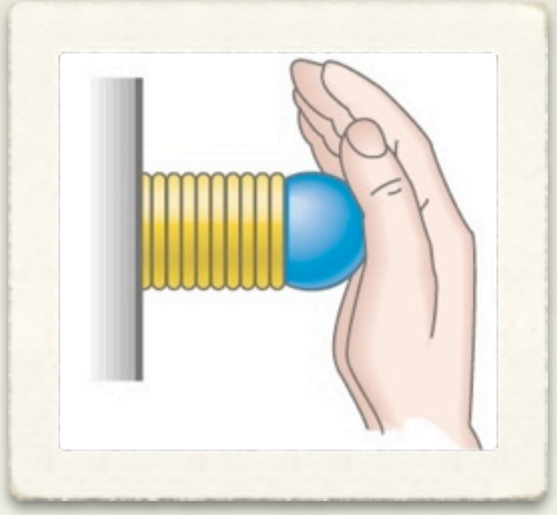
Elastic Potential Energy

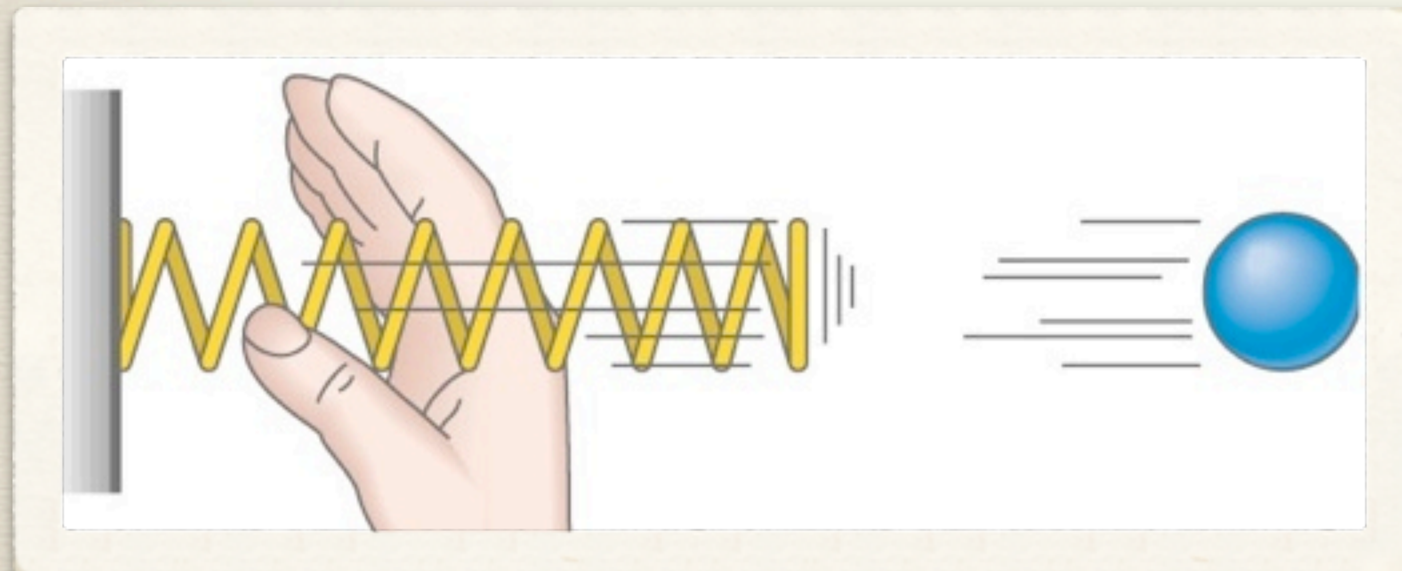


- $W = F D$
- $F = k x$

Elastic Potential Energy

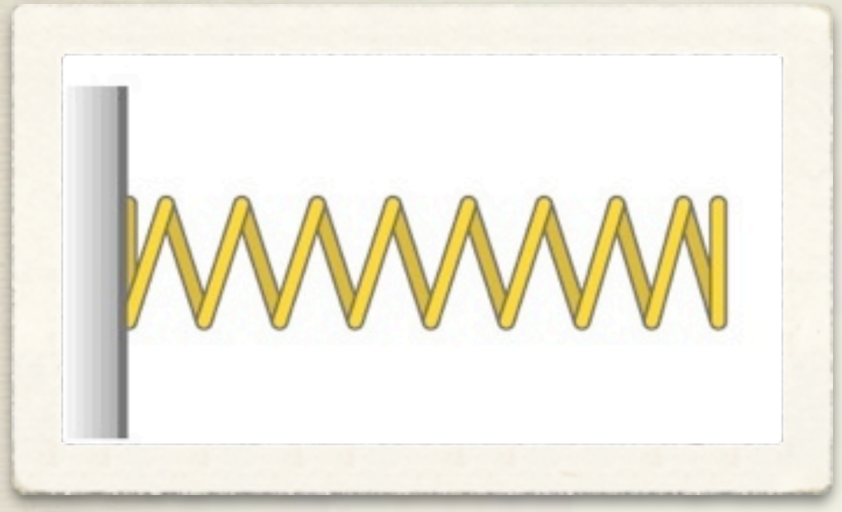


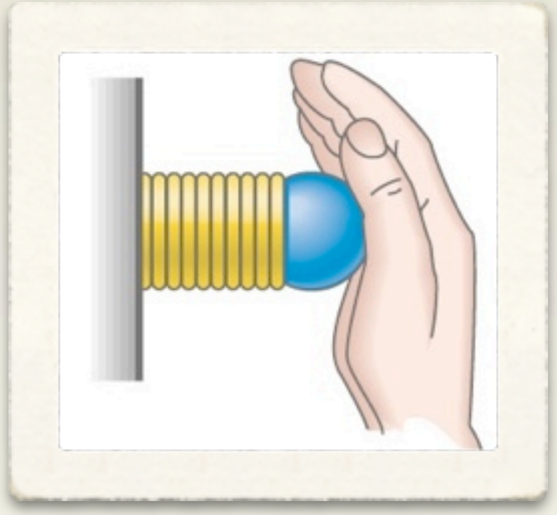


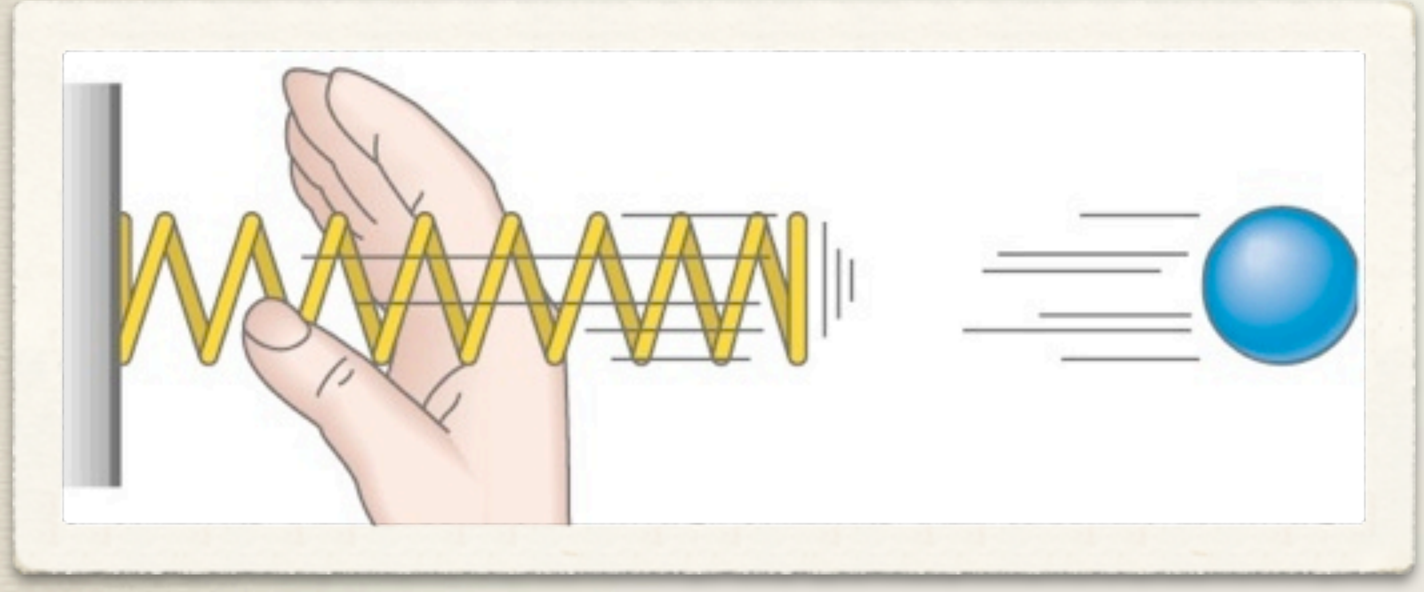


- $W = F\,D$
- $F = k\,x$
- $F_{avg} = \frac{1}{2}\,k\,x$

Elastic Potential Energy

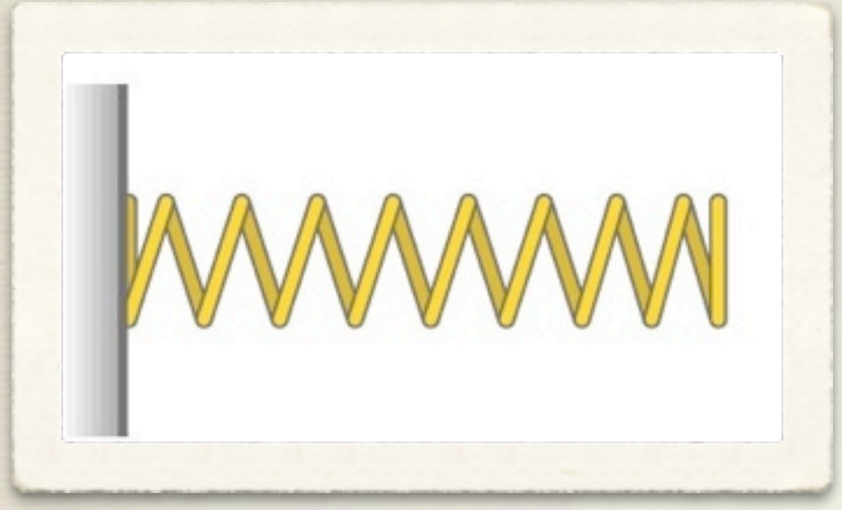


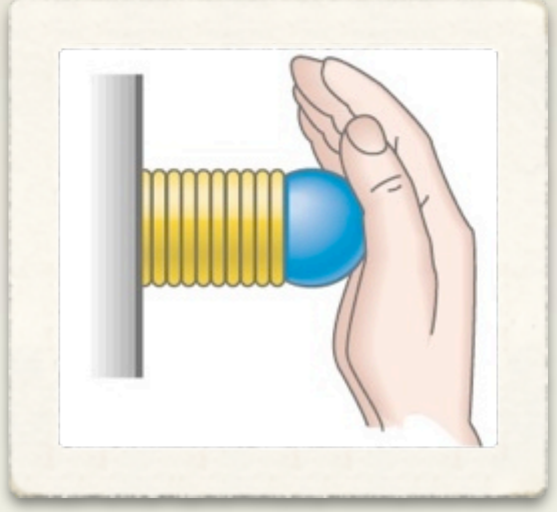


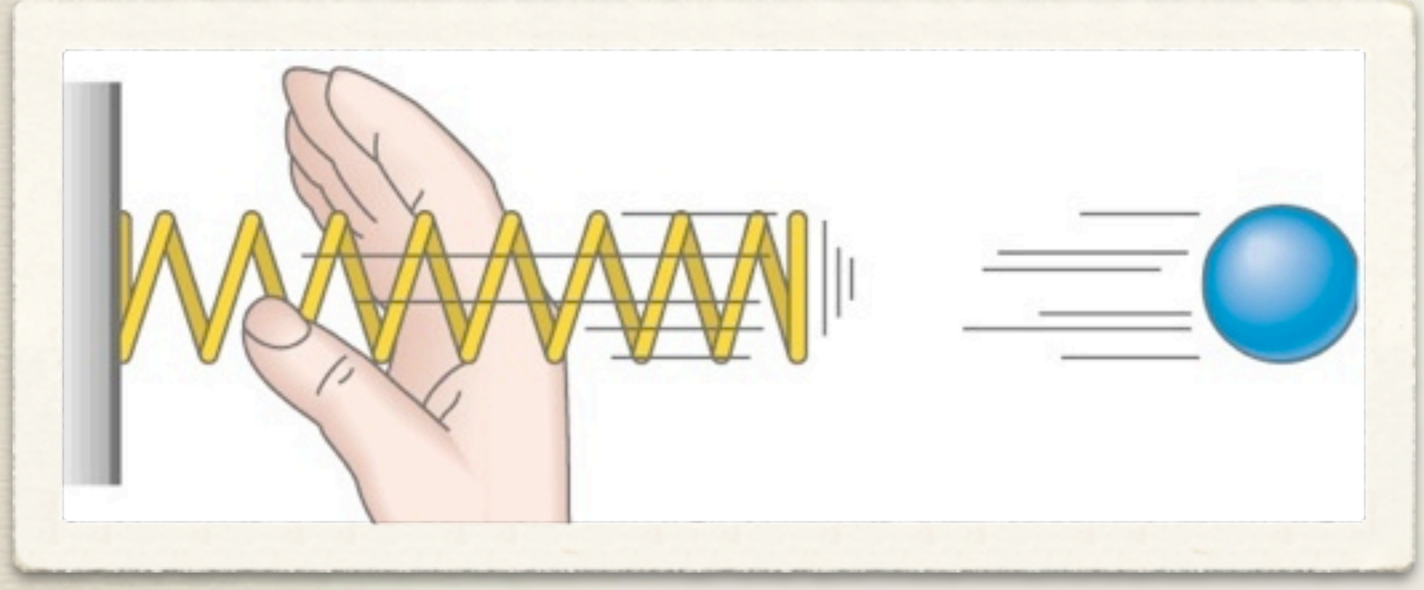


- $W = F D$
- $F = k x$
- $F_{avg} = ½ k x$
- $W = (½ k x) (x)$

Elastic Potential Energy

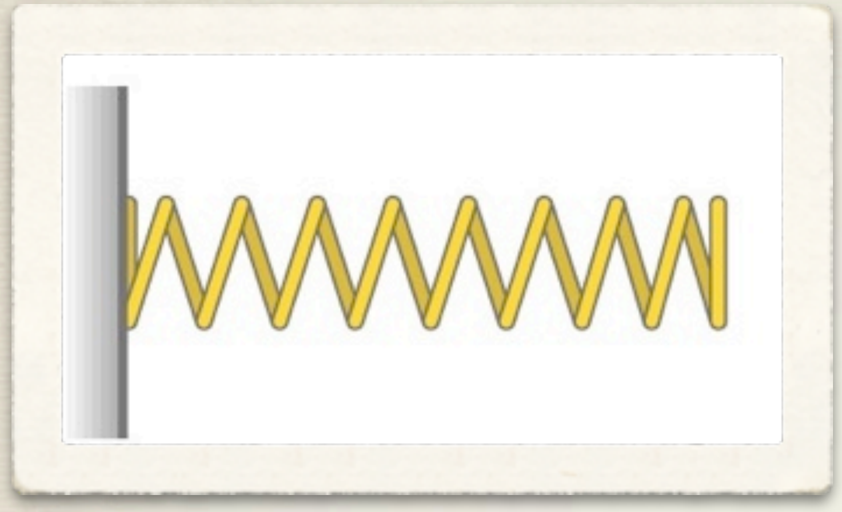


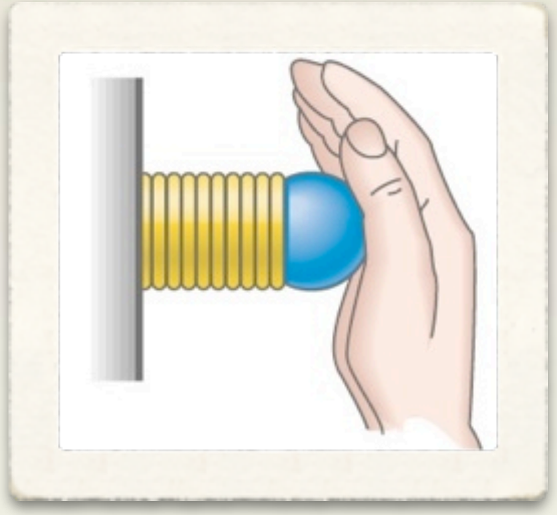


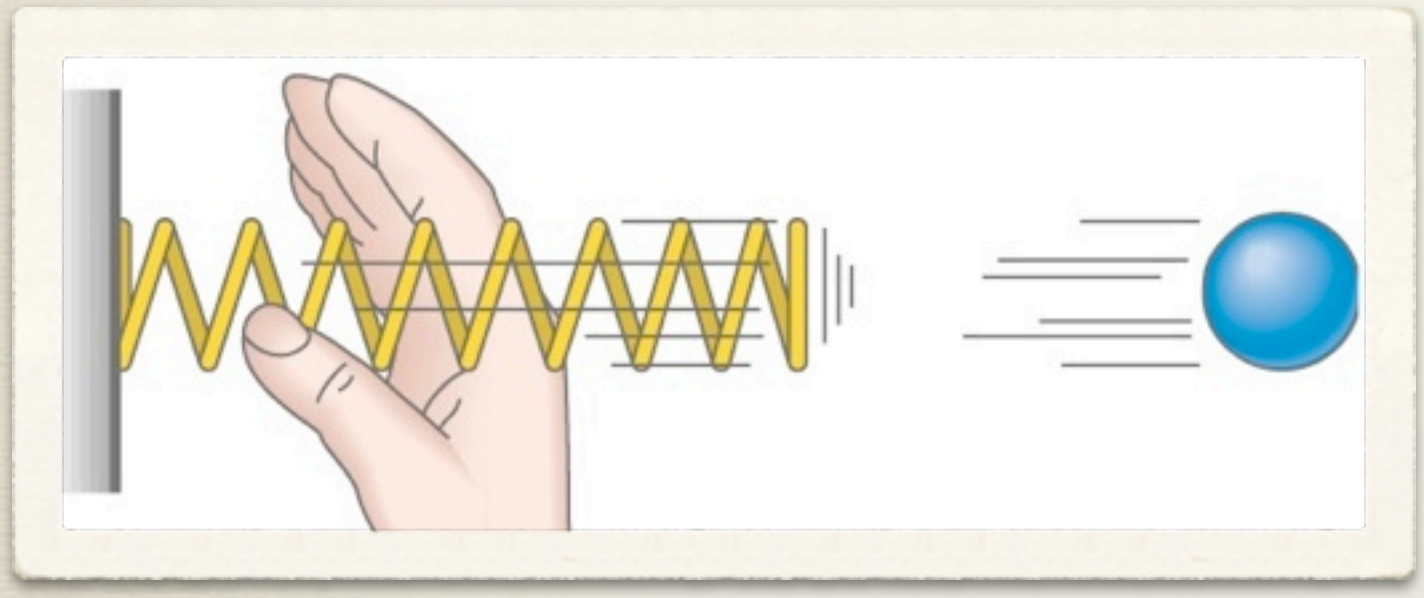


- $W = F D$
- $F = k x$
- $F_{avg} = \frac{1}{2} k x$
- $W = (\frac{1}{2} k x)(x)$
- $W = \frac{1}{2} k x^2$

Elastic Potential Energy







- $W = F D$
- $F = k x$
- $F_{avg} = \frac{1}{2} k x$
- $W = (\frac{1}{2} k x)(x)$
- $W = \frac{1}{2} k x^2$
- $PE = \frac{1}{2} k x^2$

Elastic Potential

- In an earlier lab, you compressed a spring to “two clicks” or a distance of 6cm. The 10g ball went up 1.08m when launched at 90^o.
- Find the PE at the top
- Find the Spring Constant k
- Find the KE at the top of the cannon, and the maximum velocity of the ball
- Find the maximum force used to push the spring

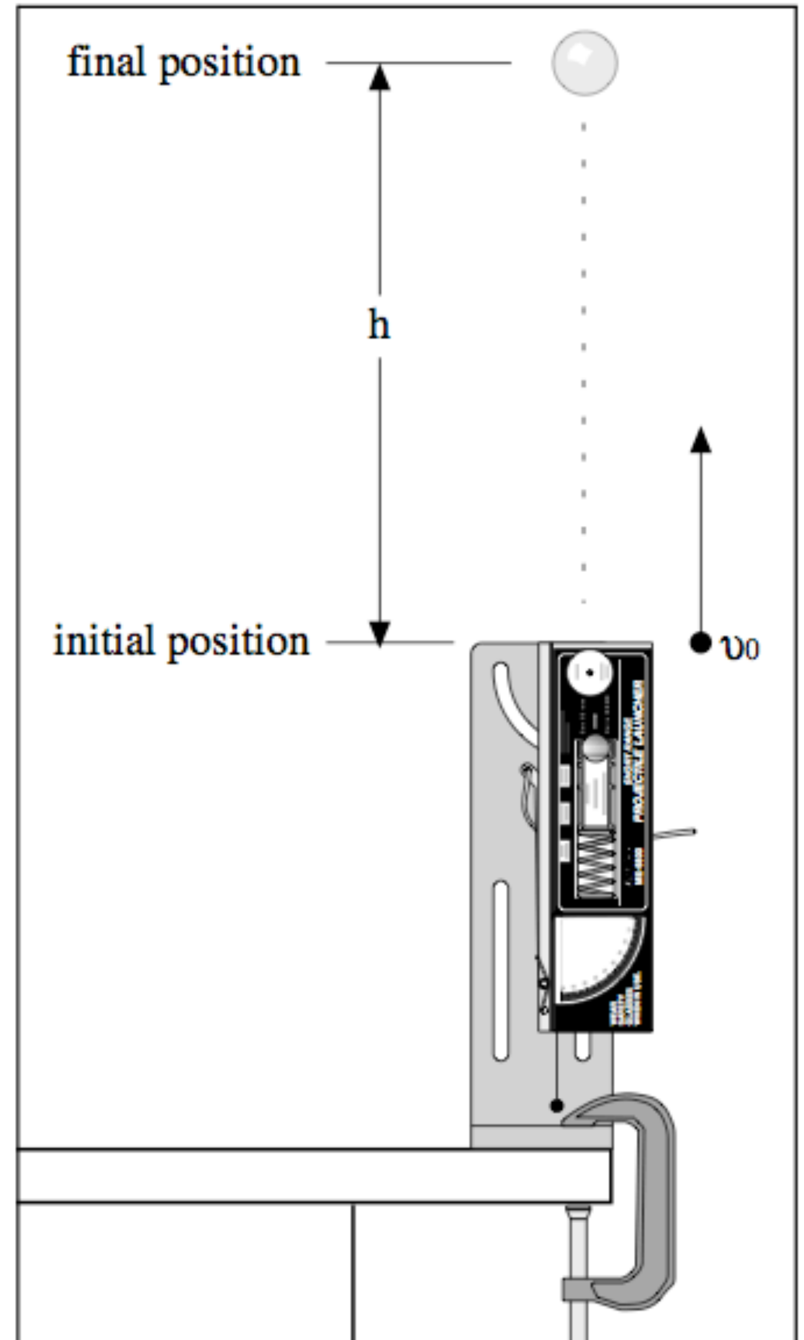
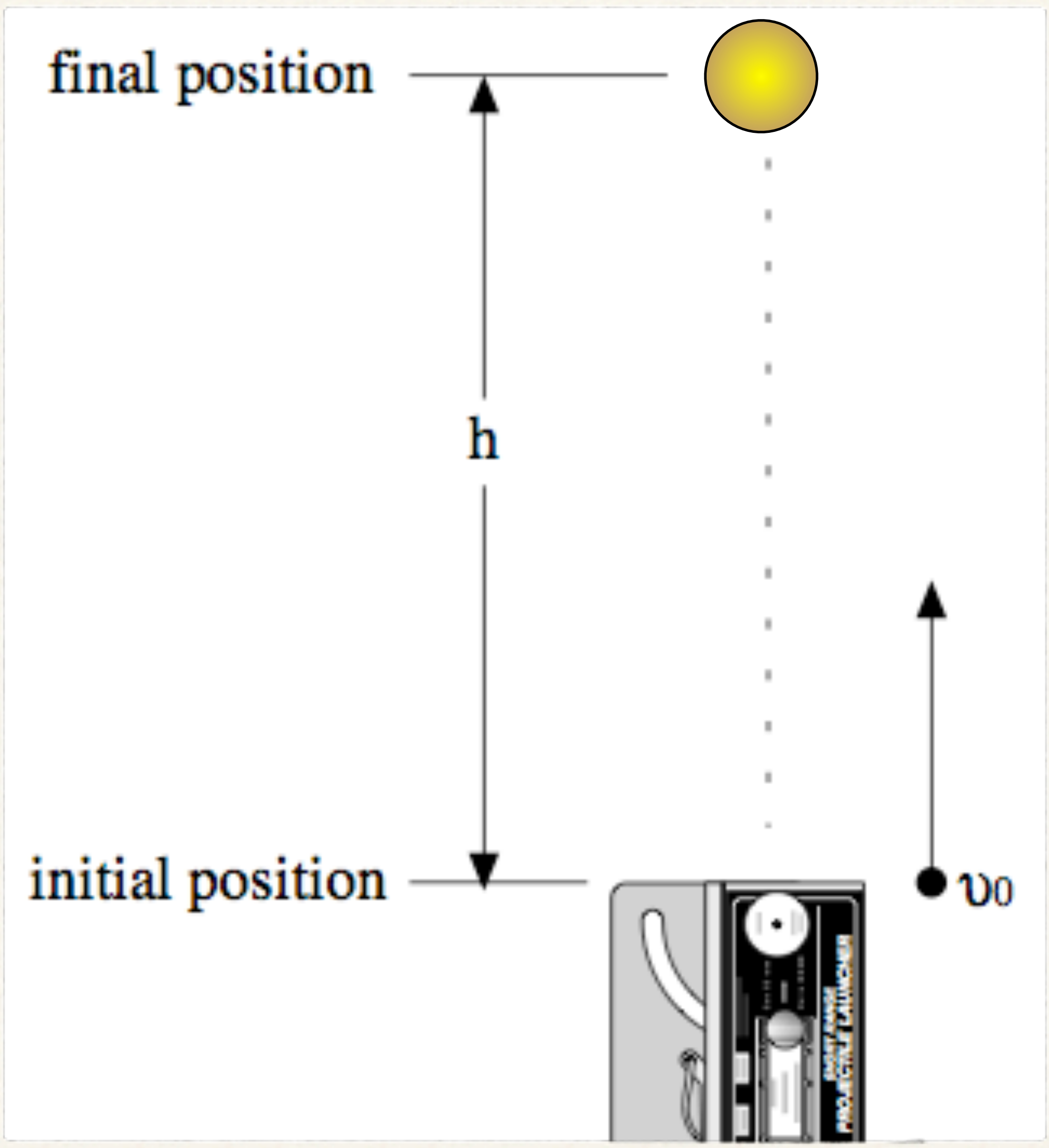


Figure 5.1: Conservation of Energy

Elastic Potential

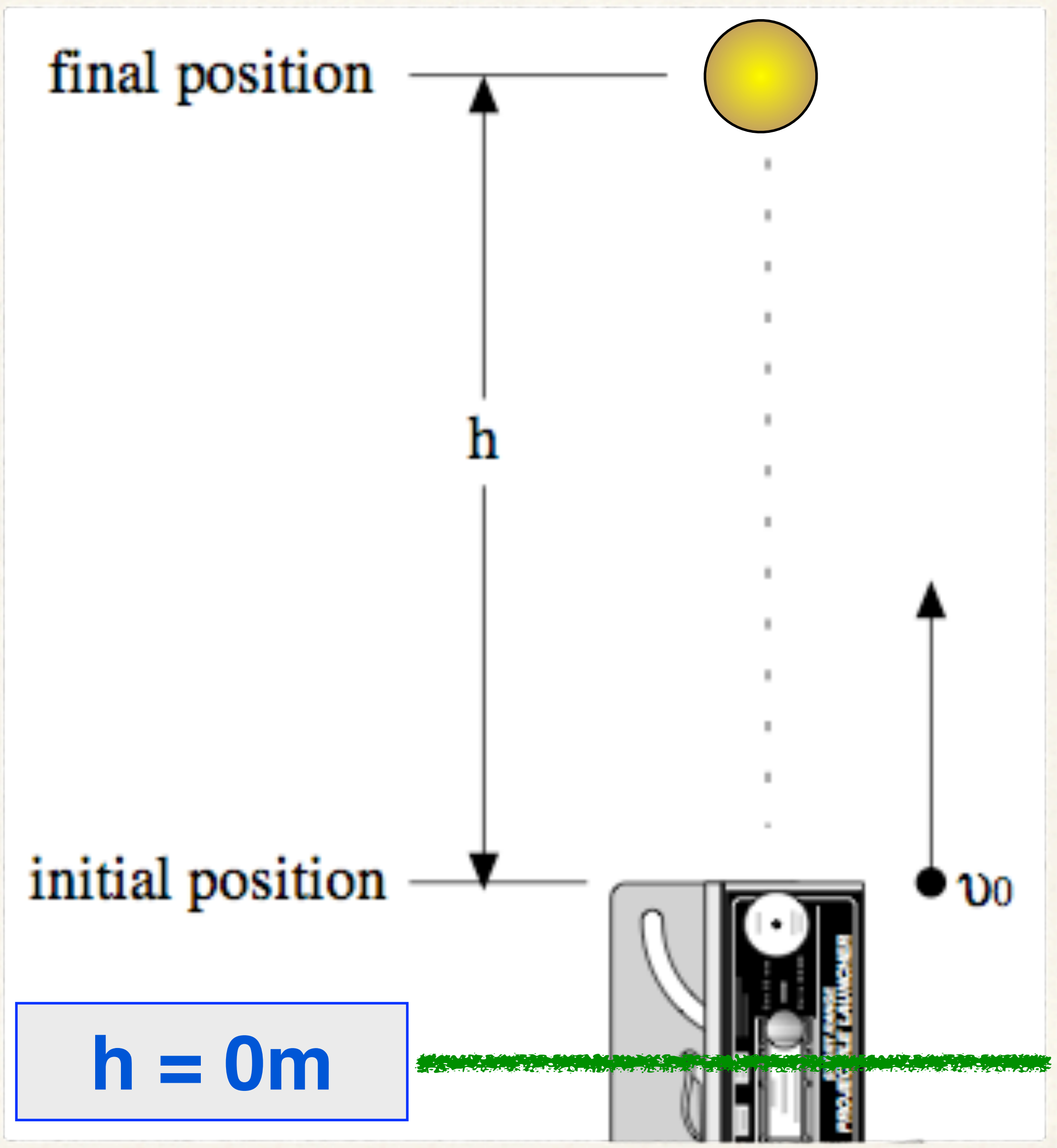
- In lab, you compressed a spring a distance of 6cm. The 10g ball went up 1.08m.



- Find the PE at the top
- Find the Spring Constant k
- Find the KE at the top of the cannon, and the maximum velocity of the ball
- Find the maximum force used to push the spring

Elastic Potential

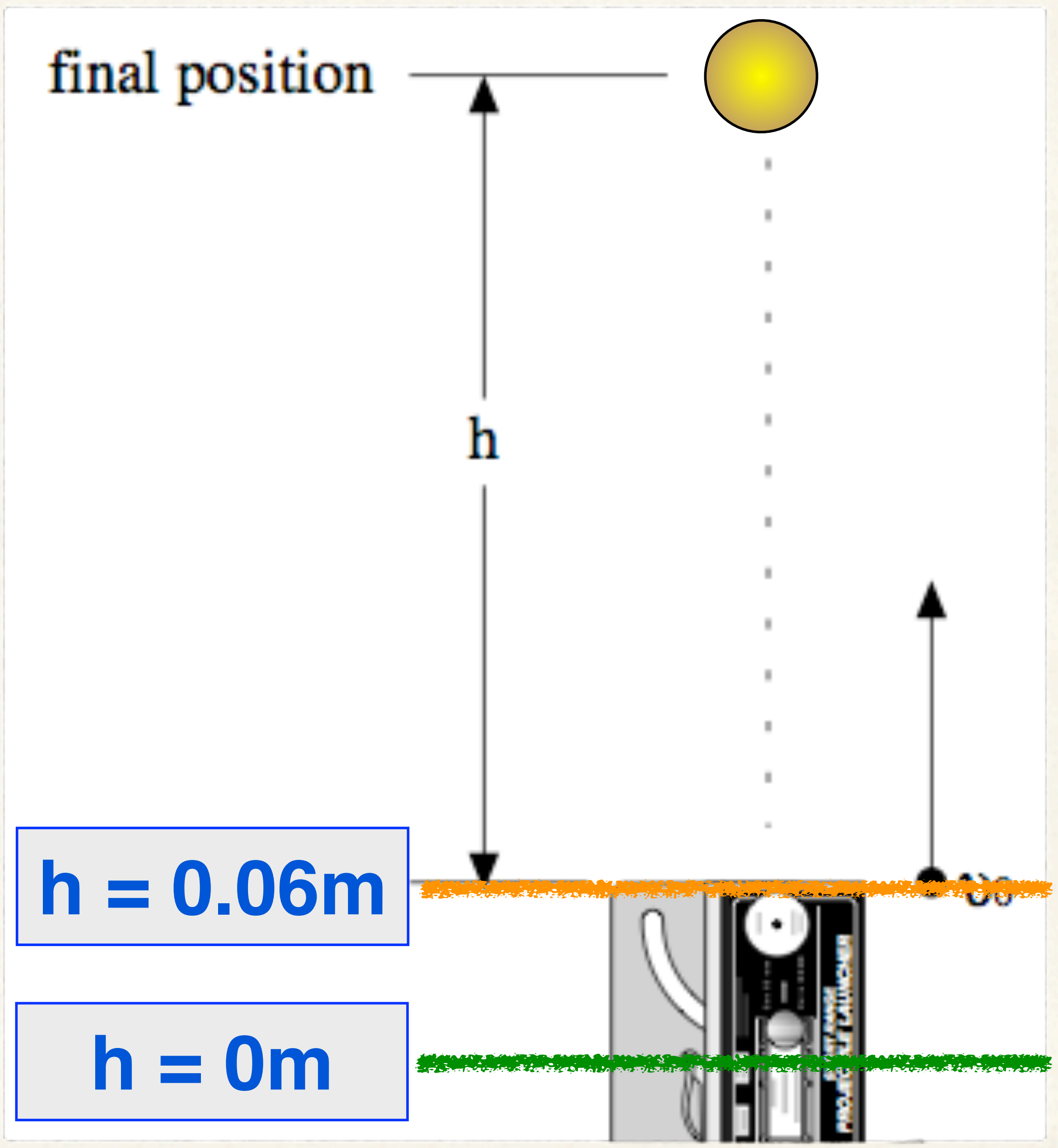
- In lab, you compressed a spring a distance of 6cm. The 10g ball went up 1.08m.



- Find the PE at the top
- Find the Spring Constant k
- Find the KE at the top of the cannon, and the maximum velocity of the ball
- Find the maximum force used to push the spring

Elastic Potential

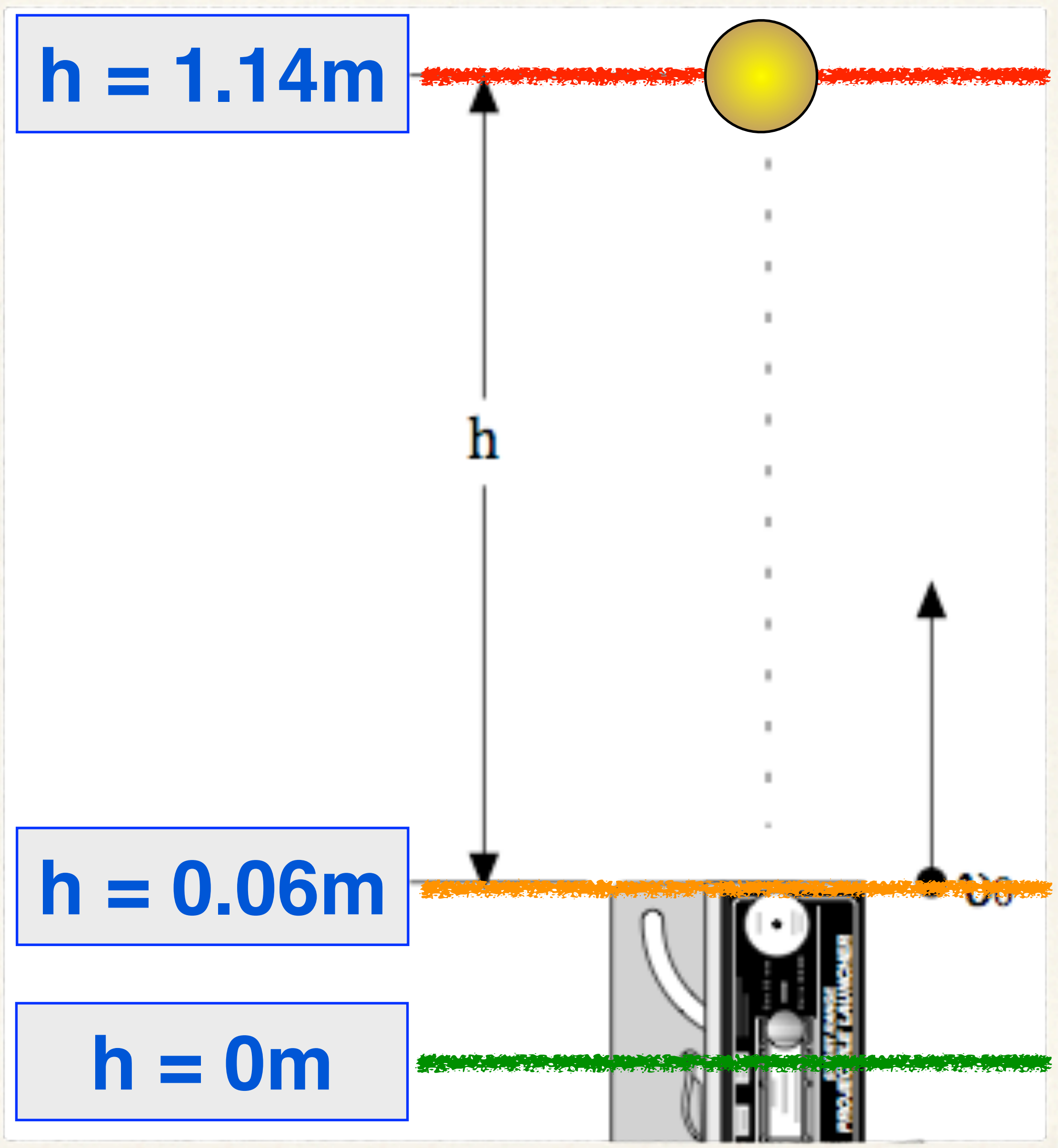
- In lab, you compressed a spring a distance of 6cm. The 10g ball went up 1.08m.



- Find the PE at the top
- Find the Spring Constant k
- Find the KE at the top of the cannon, and the maximum velocity of the ball
- Find the maximum force used to push the spring

Elastic Potential

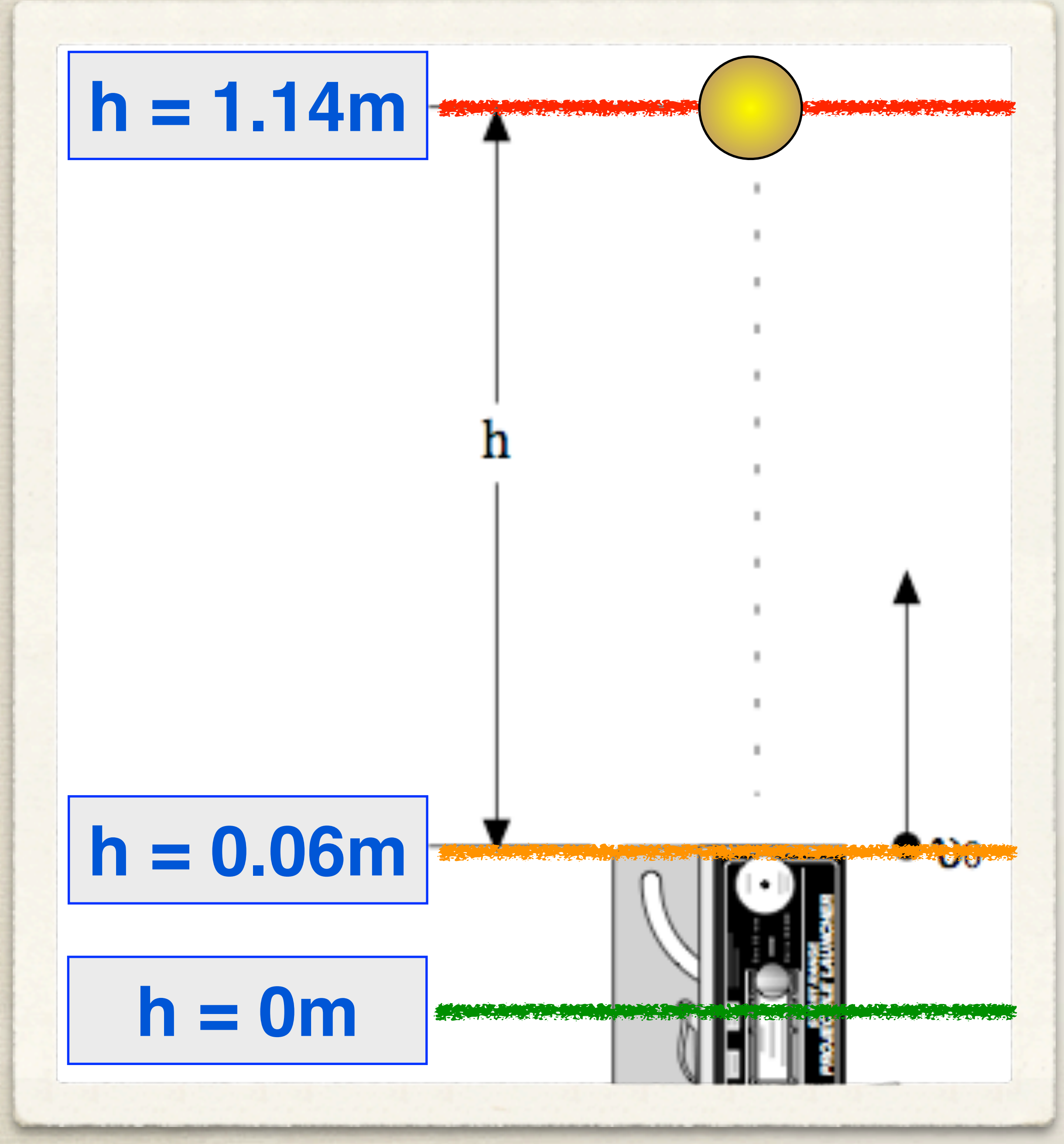
- In lab, you compressed a spring a distance of 6cm. The 10g ball went up 1.08m.



- Find the PE at the top
- Find the Spring Constant k
- Find the KE at the top of the cannon, and the maximum velocity of the ball
- Find the maximum force used to push the spring

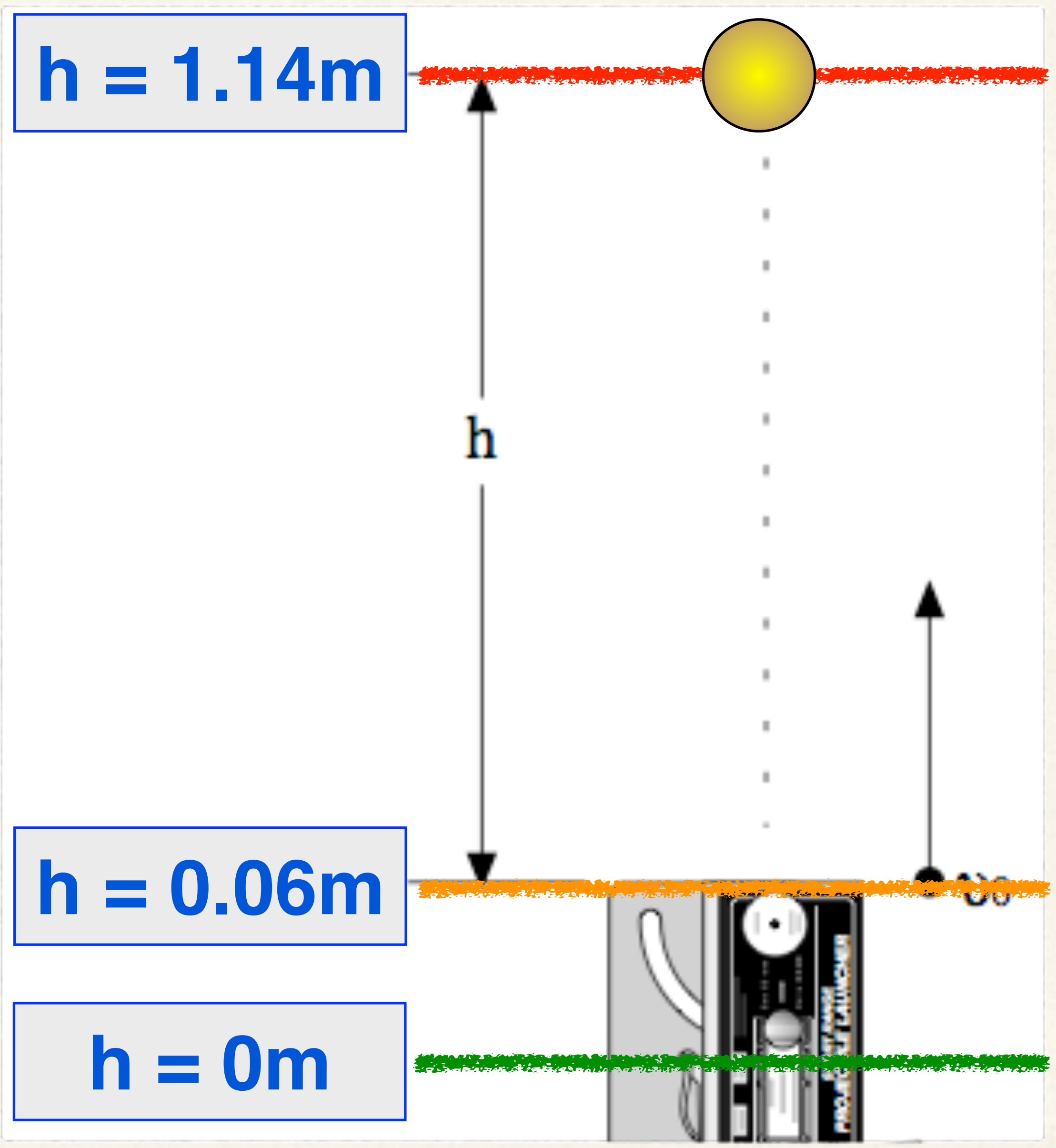
Elastic Potential

- In lab, you compressed a spring a distance of 6cm. The 10g ball went up 1.08m.



Elastic Potential

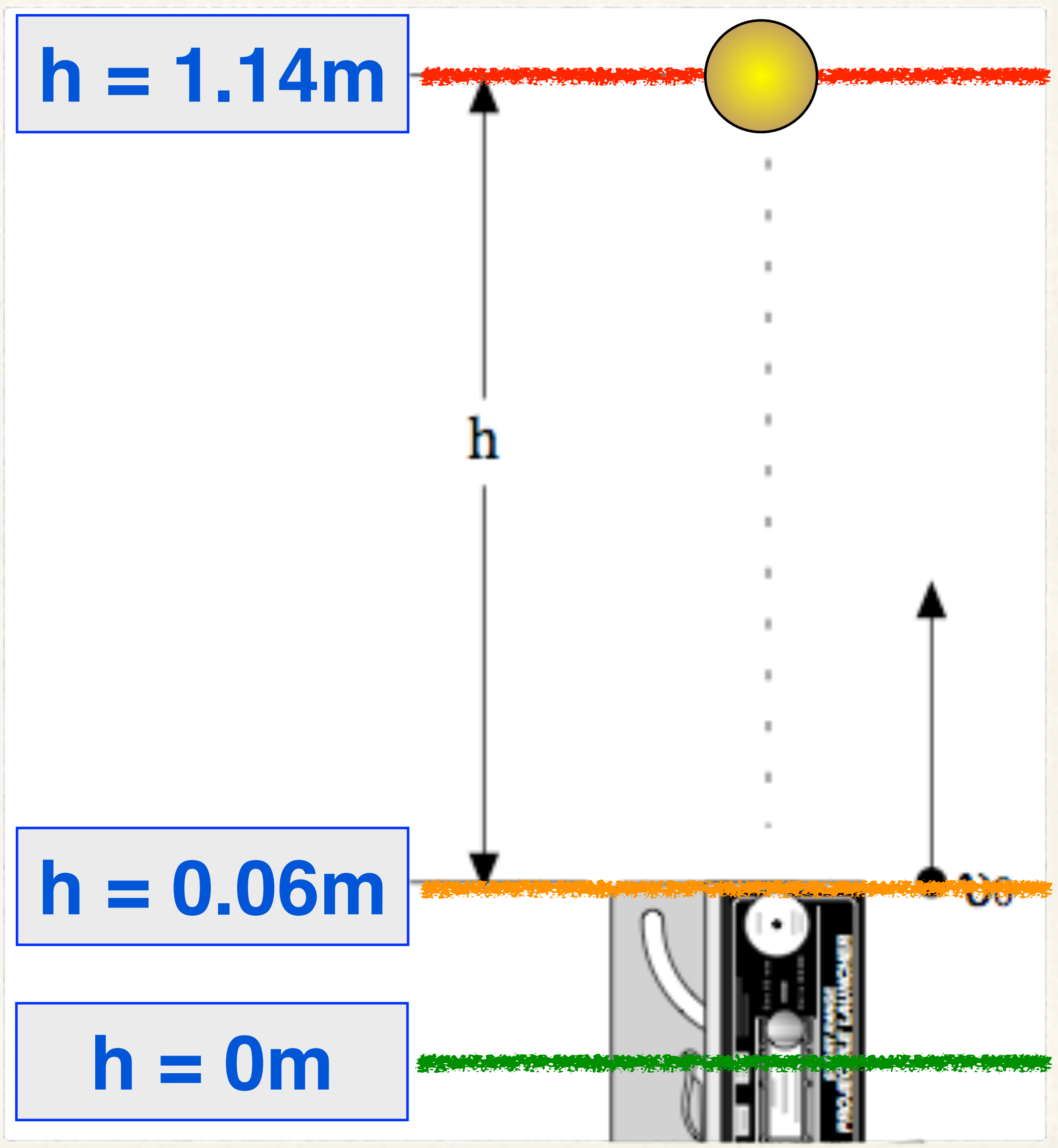
- In lab, you compressed a spring a distance of 6cm. The 10g ball went up 1.08m.



- Find the PE at the top

Elastic Potential

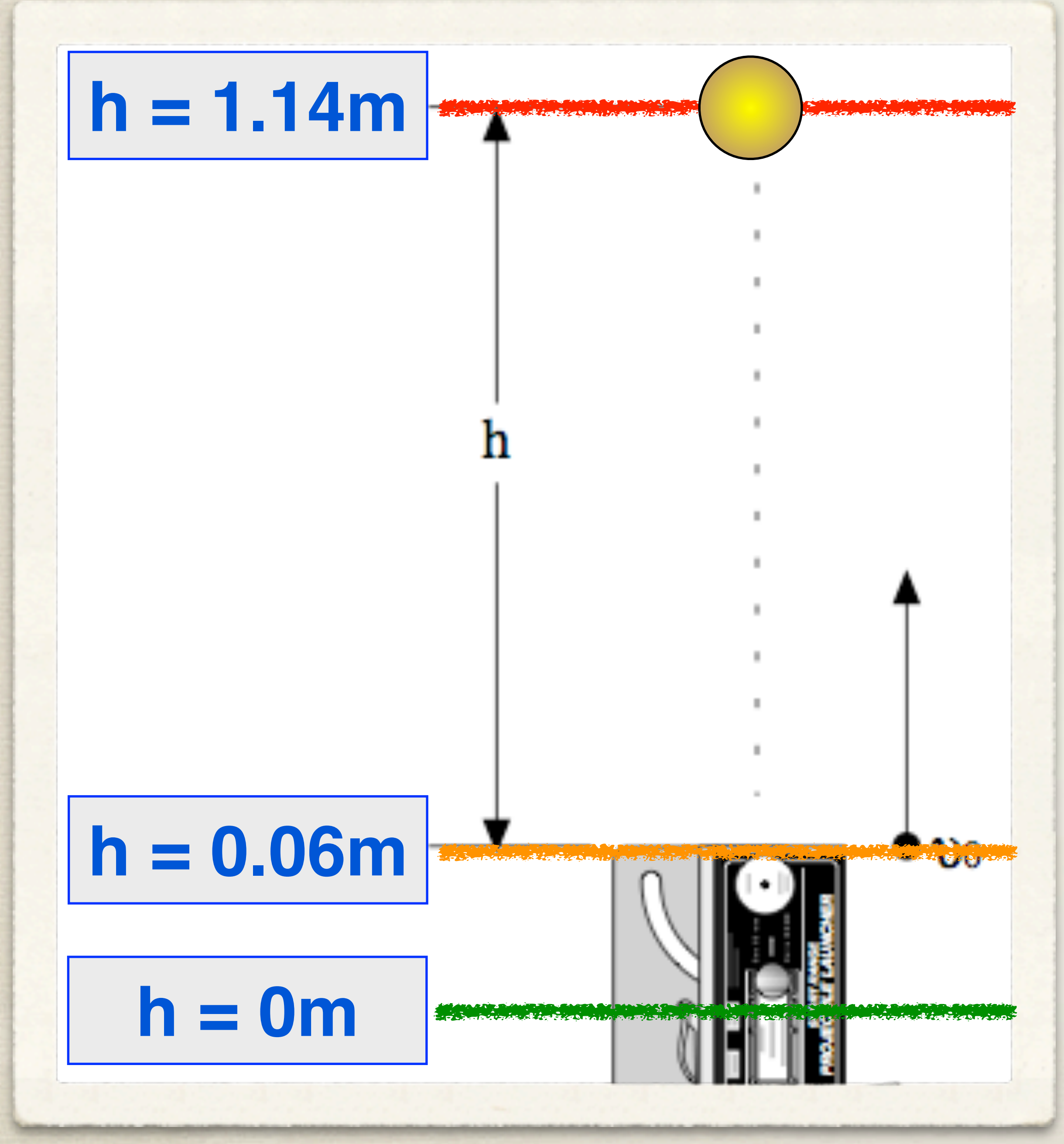
- In lab, you compressed a spring a distance of 6cm. The 10g ball went up 1.08m.



- Find the PE at the top
- PE = mgh

Elastic Potential

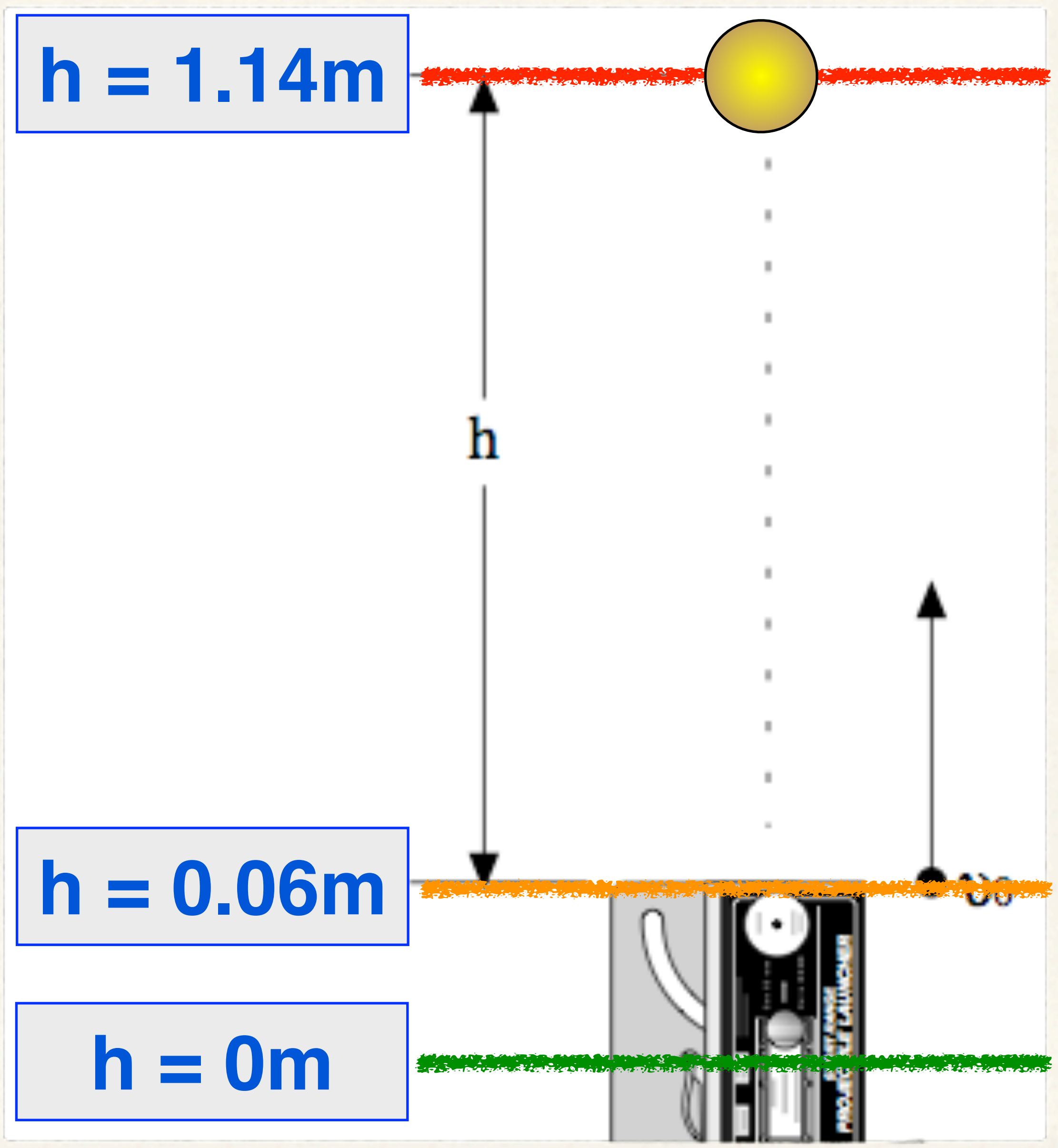
- In lab, you compressed a spring a distance of 6cm. The 10g ball went up 1.08m.



- Find the PE at the top
- PE = mgh
- PE = (0.010kg)(9.8)(1.14)

Elastic Potential

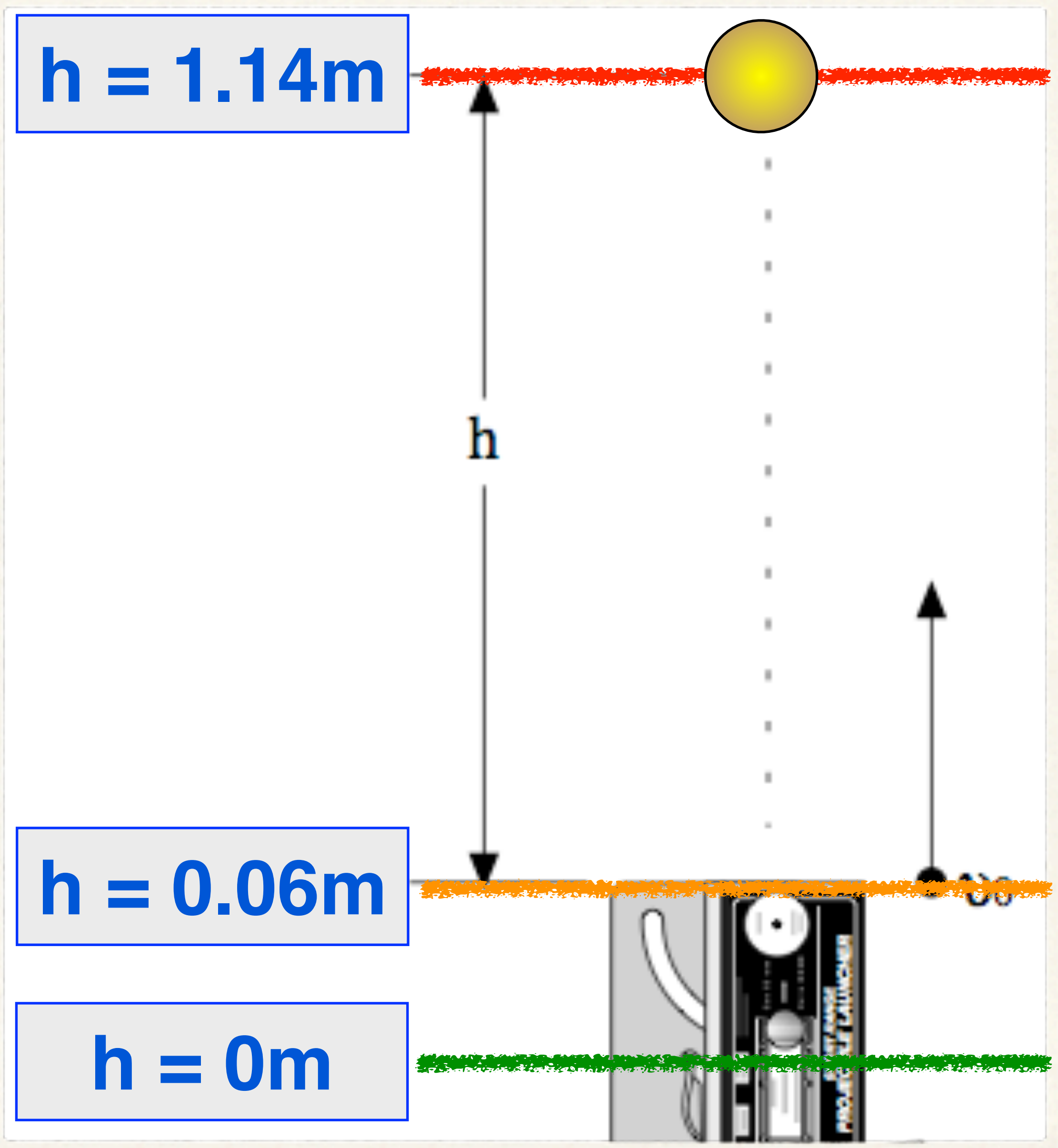
- In lab, you compressed a spring a distance of 6cm. The 10g ball went up 1.08m.



- Find the PE at the top
- PE = mgh
- PE = (0.010kg)(9.8)(1.14)
- PE = 0.1117J

Elastic Potential

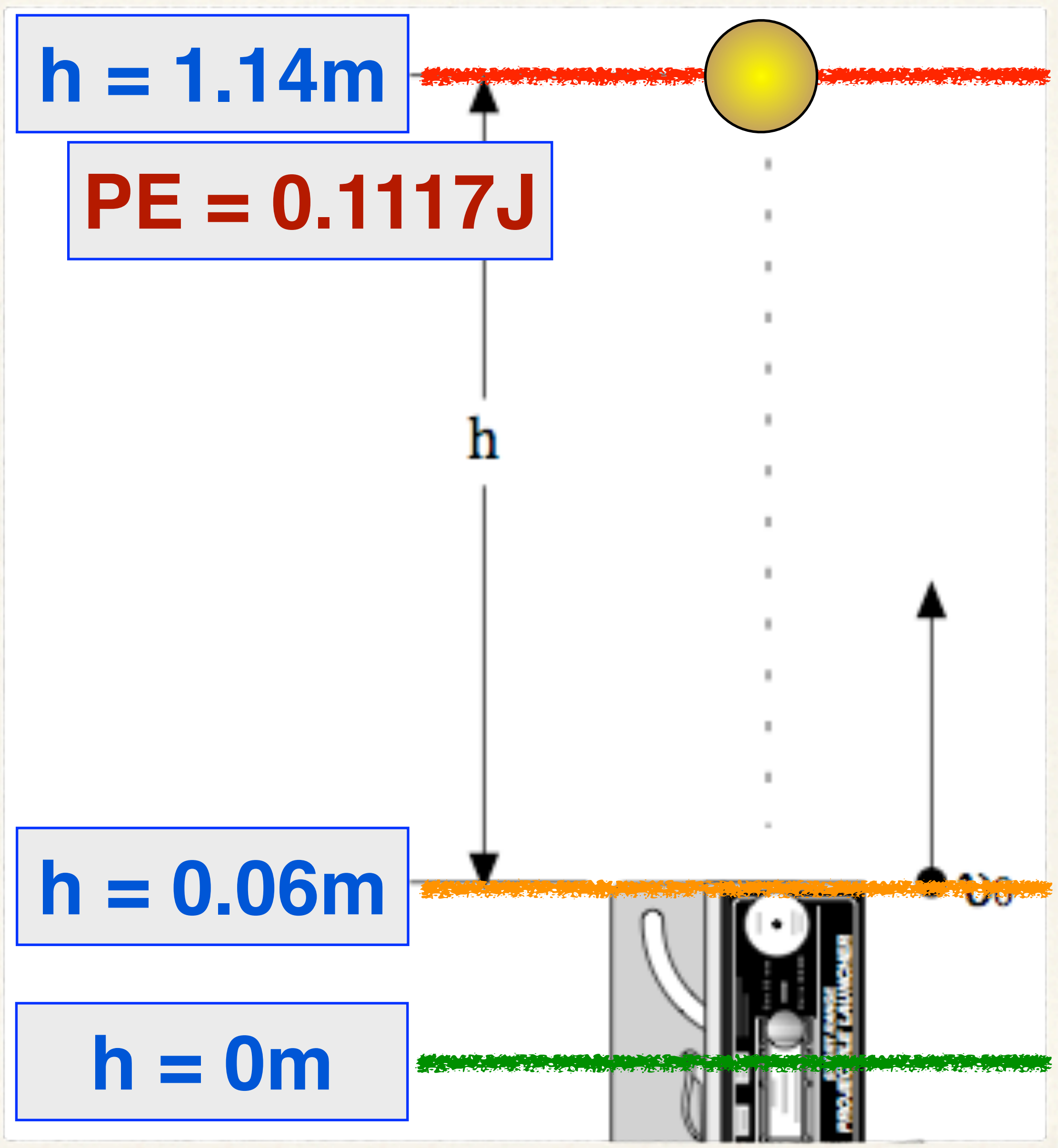
- In lab, you compressed a spring a distance of 6cm. The 10g ball went up 1.08m.



- Find the PE at the top
- PE = mgh
- PE = (0.010kg)(9.8)(1.14)
- PE = 0.1117J
- TE = 0.1117J

Elastic Potential

- In lab, you compressed a spring a distance of 6cm. The 10g ball went up 1.08m.



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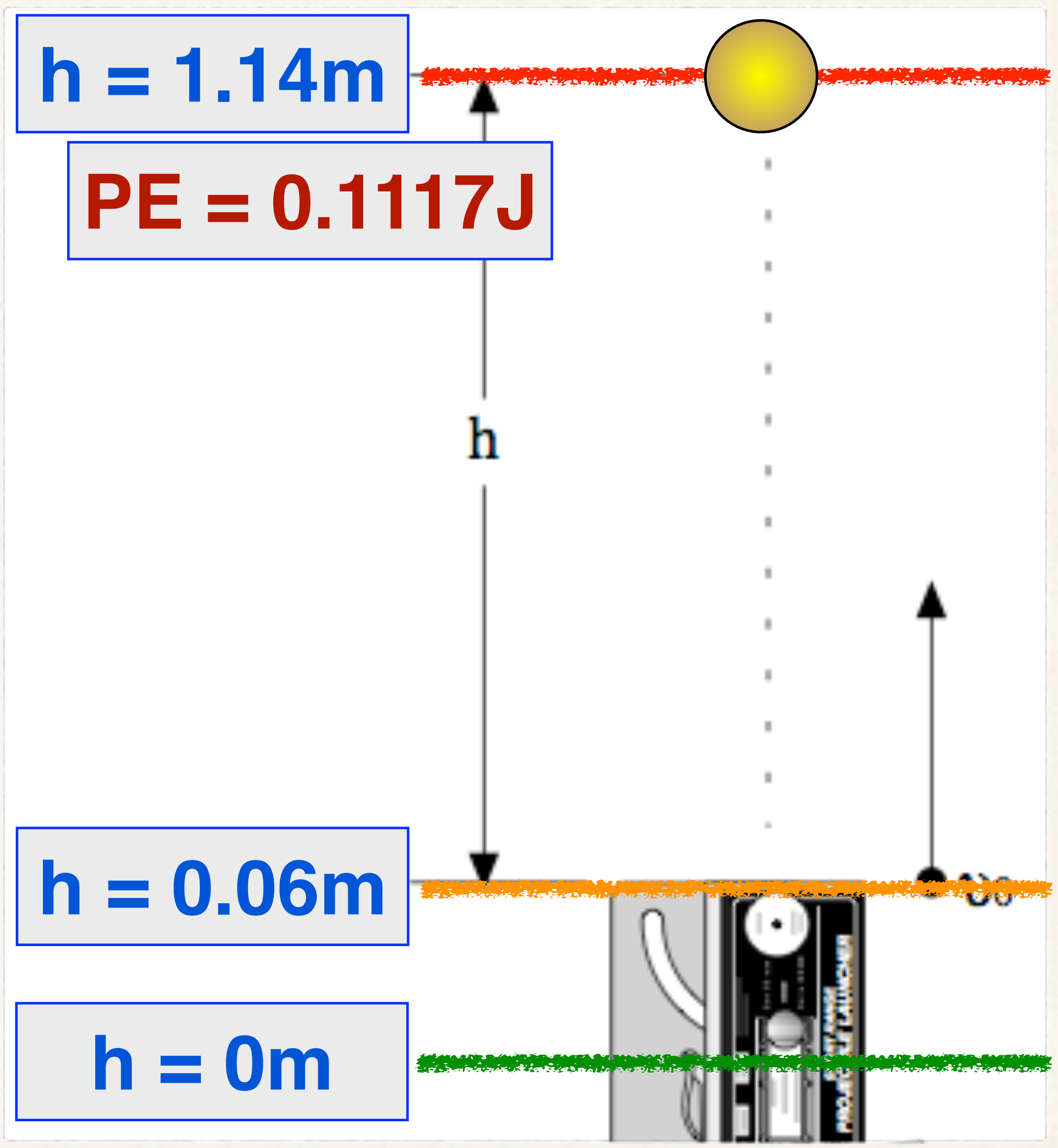

- Find the Spring Constant k

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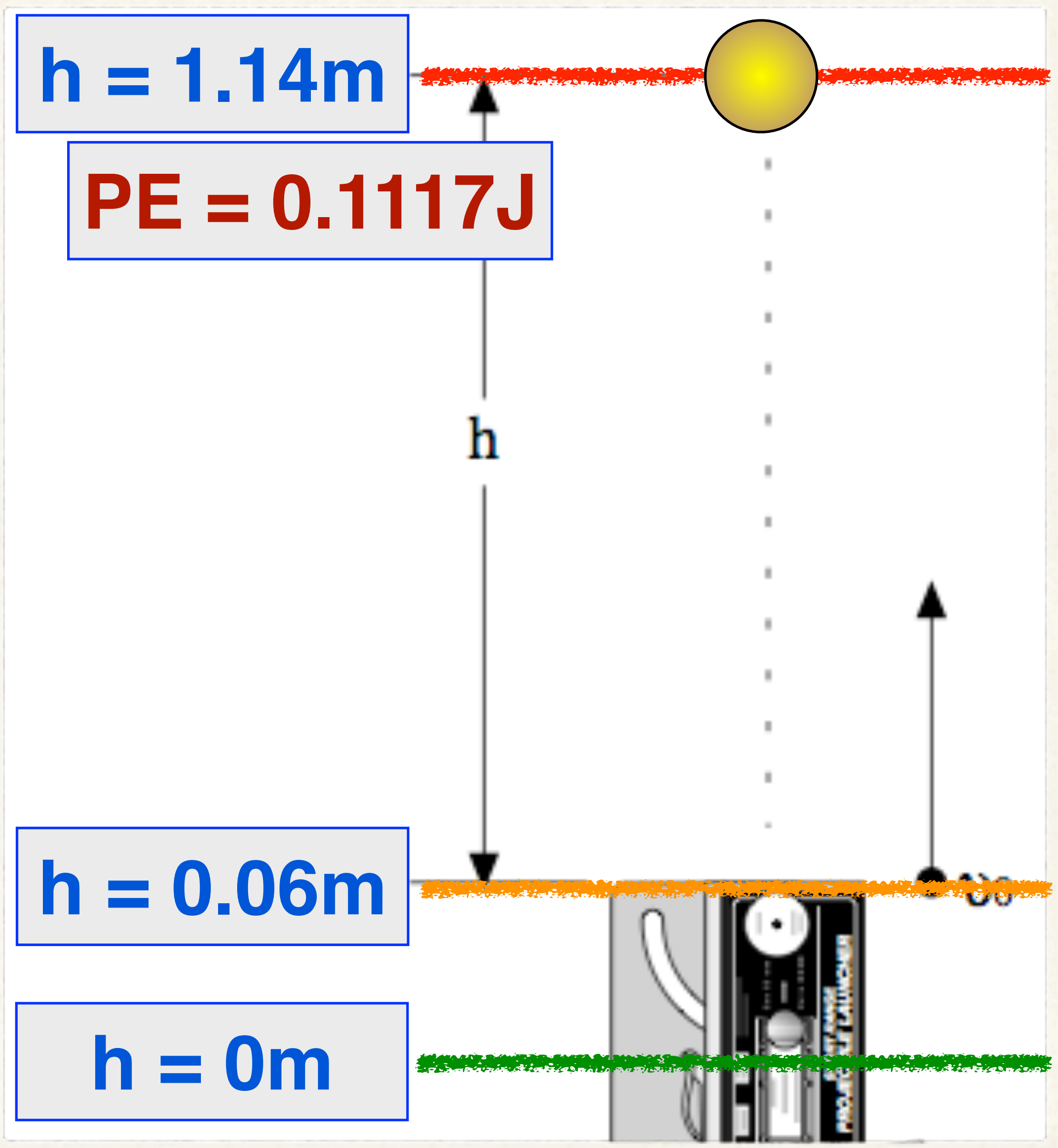
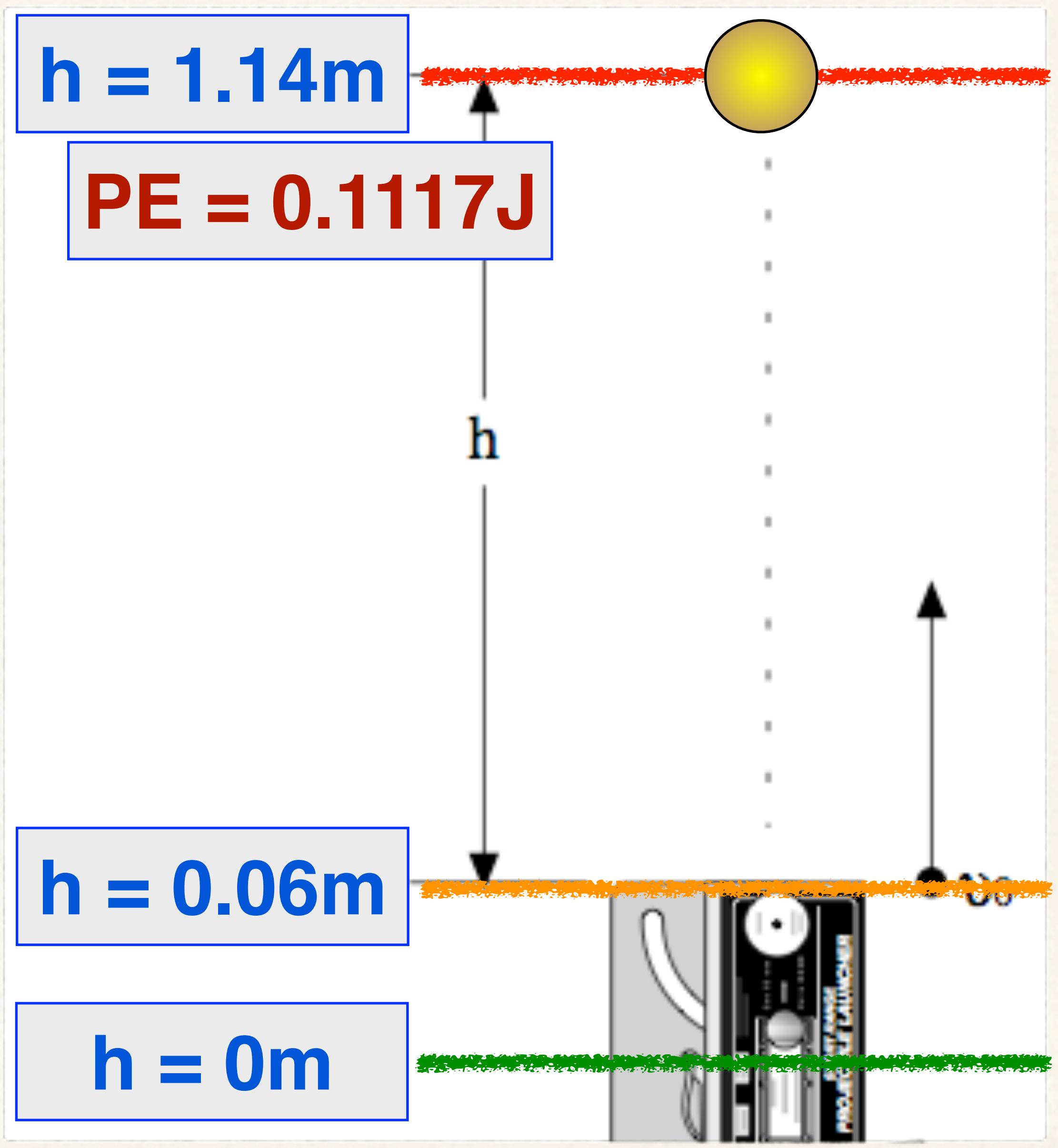


- Find the Spring Constant k
- Elastic PE = ½kx^2

Elastic Potential

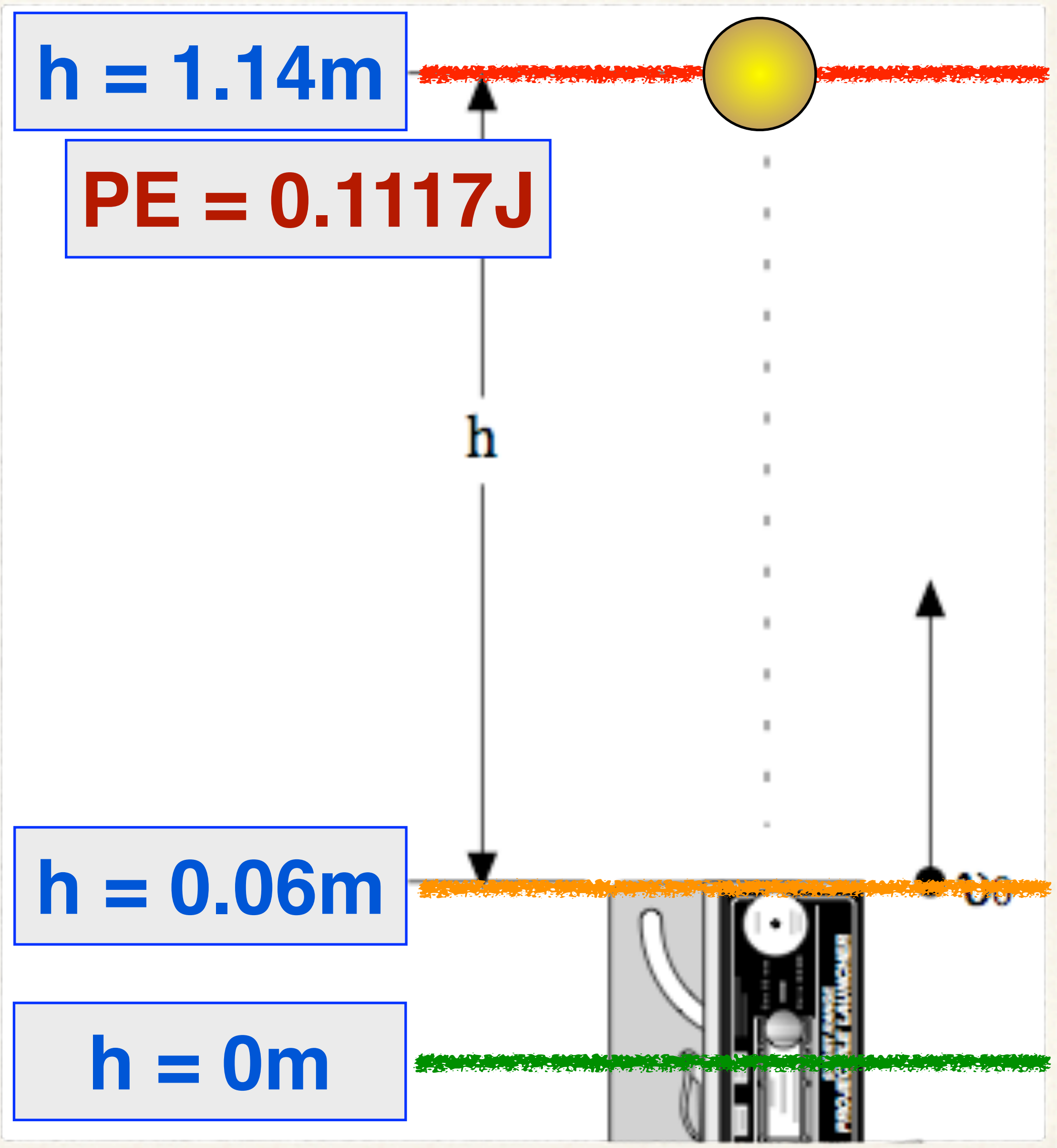
- In lab, you compressed a spring a distance of 6cm. The 10g ball went up 1.08m.



- Find the Spring Constant k
- Elastic PE = $\frac{1}{2}kx^2$
- $0.1117J = \frac{1}{2} k (0.06)^2$

Elastic Potential

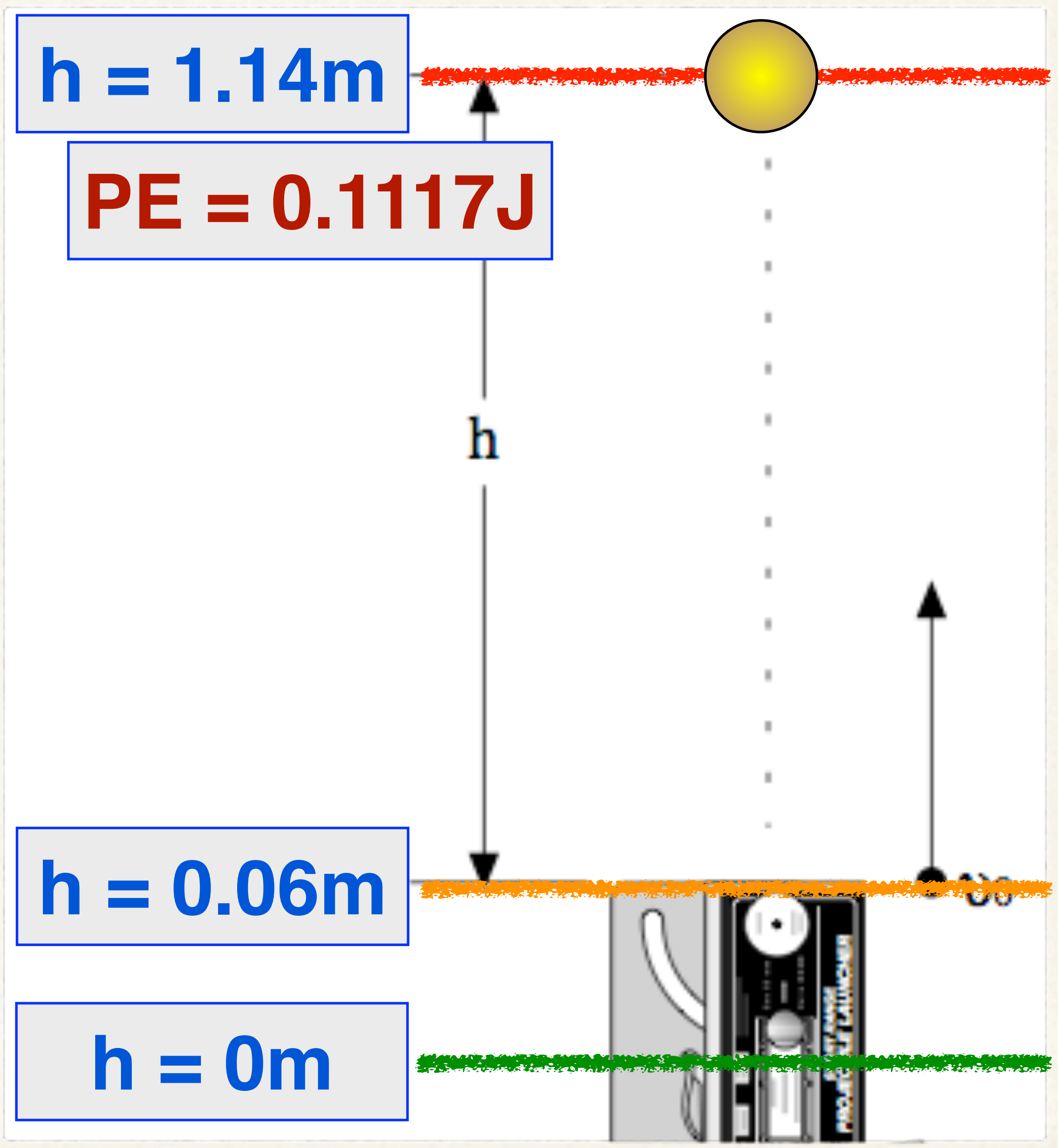
- In lab, you compressed a spring a distance of 6cm. The 10g ball went up 1.08m.



- Find the Spring Constant k
- Elastic PE = $\frac{1}{2}kx^2$
- 0.1117J = $\frac{1}{2}$ k $(0.06)^2$
- k = 62.06 N/m

Elastic Potential

- In lab, you compressed a spring a distance of 6cm. The 10g ball went up 1.08m.



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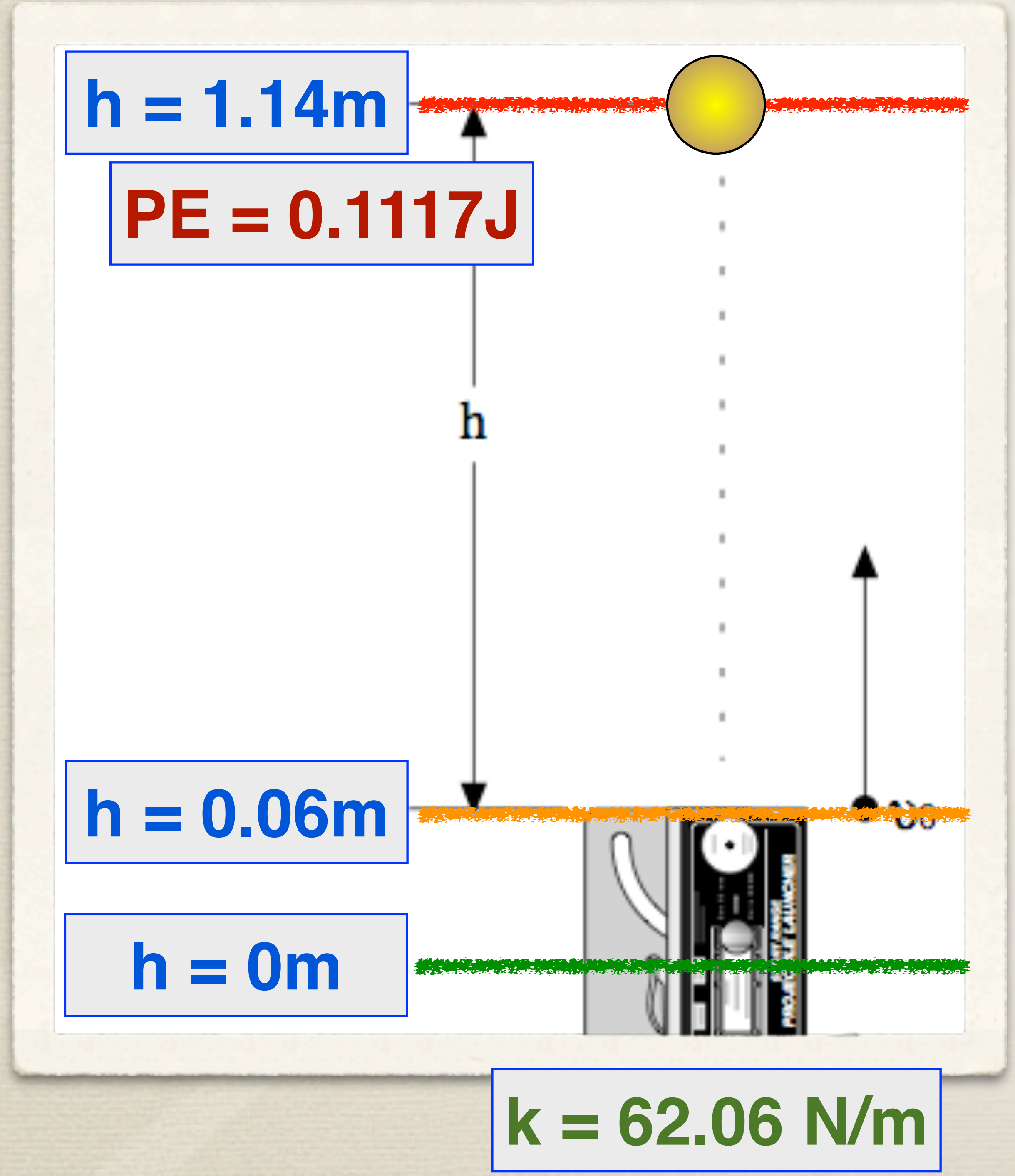
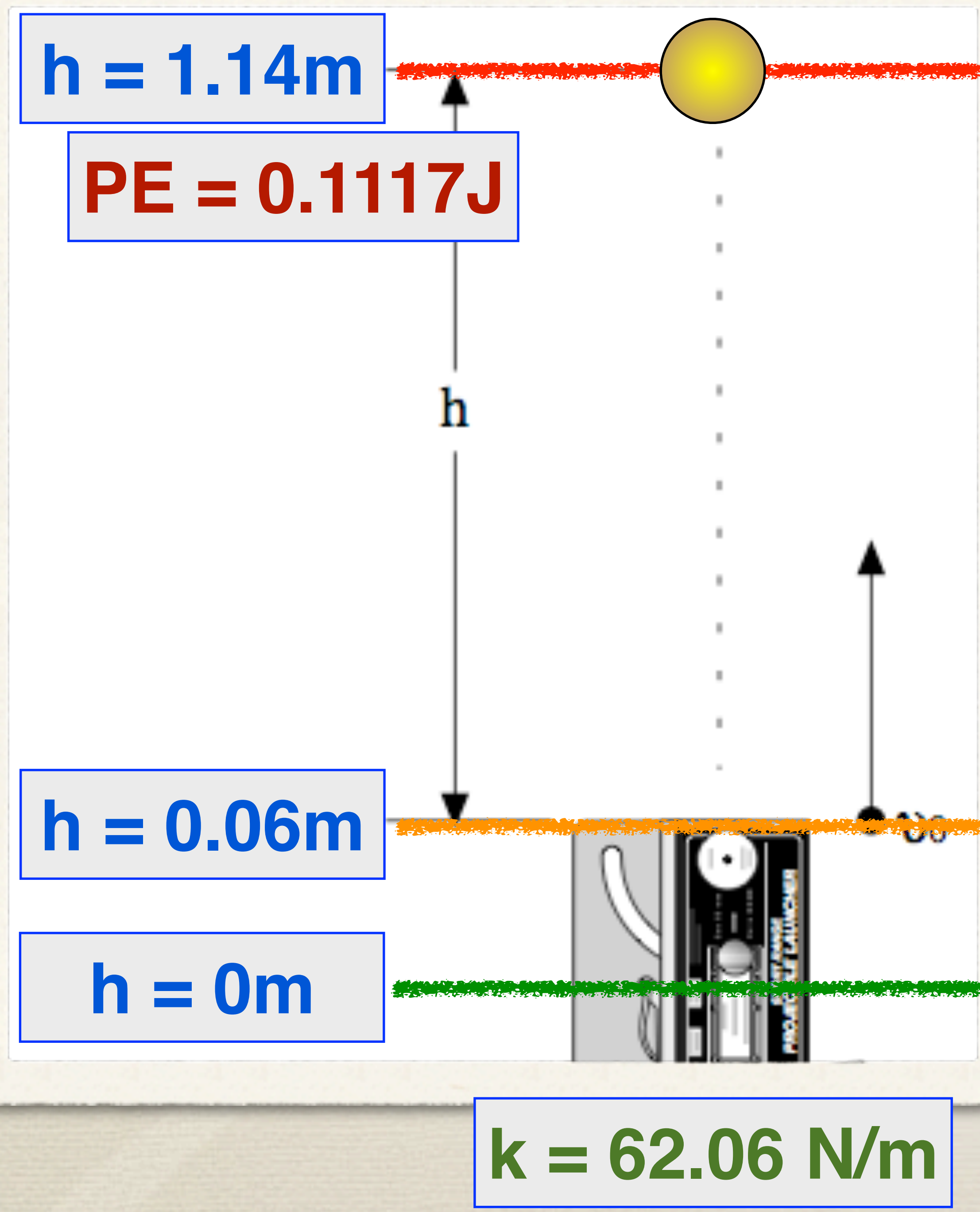


- Find the KE and the velocity

Elastic Potential

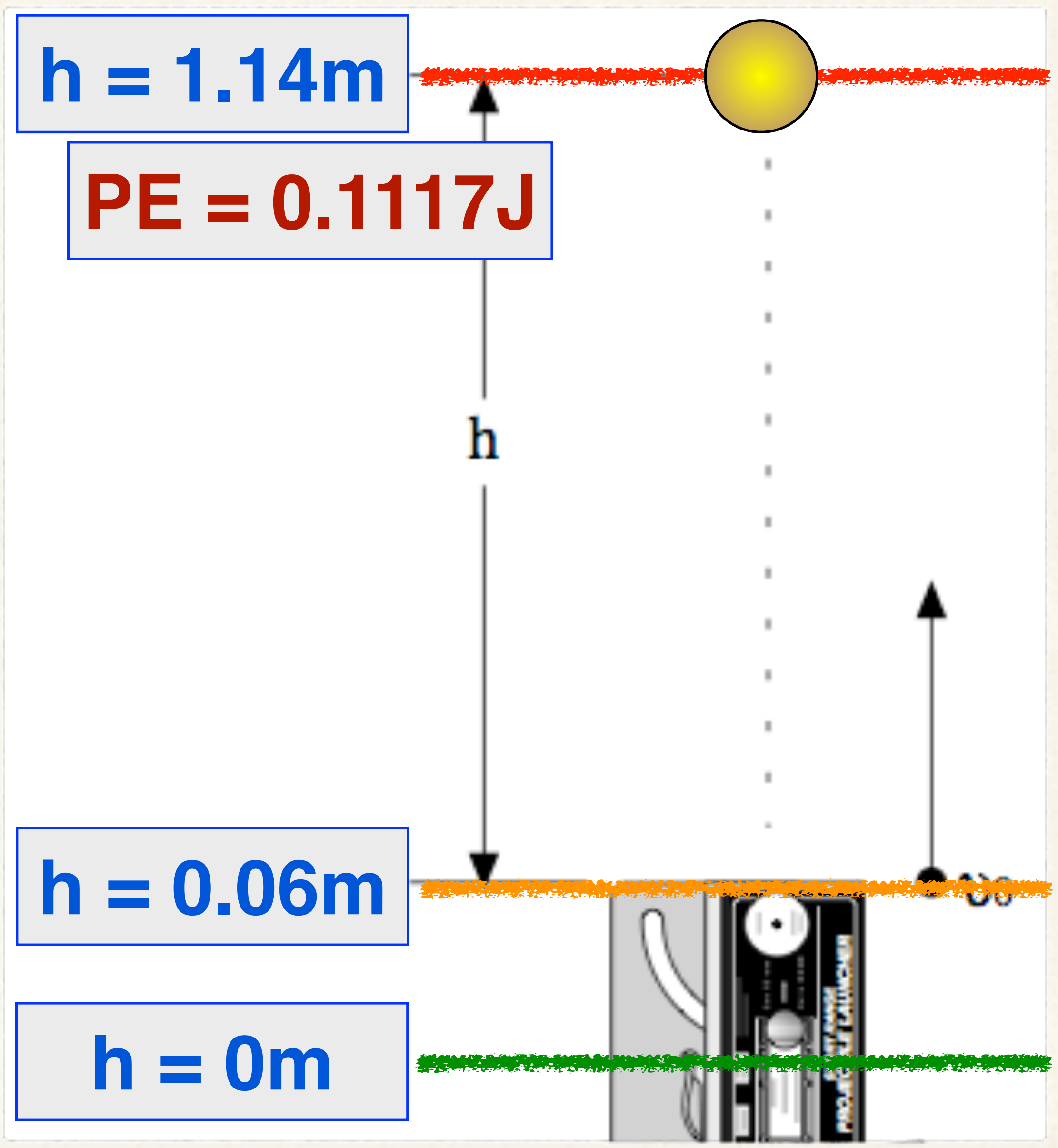
- In lab, you compressed a spring a distance of 6cm. The 10g ball went up 1.08m.



- Find the KE and the velocity
- **PE** = (0.010kg)(9.8)(0.06)

Elastic Potential

- In lab, you compressed a spring a distance of 6cm. The 10g ball went up 1.08m.



k = 62.06 N/m

- Find the KE and the velocity
- **PE** = (0.010kg)(9.8)(0.06)
- PE = 0.00588 J = 5.88 mJ

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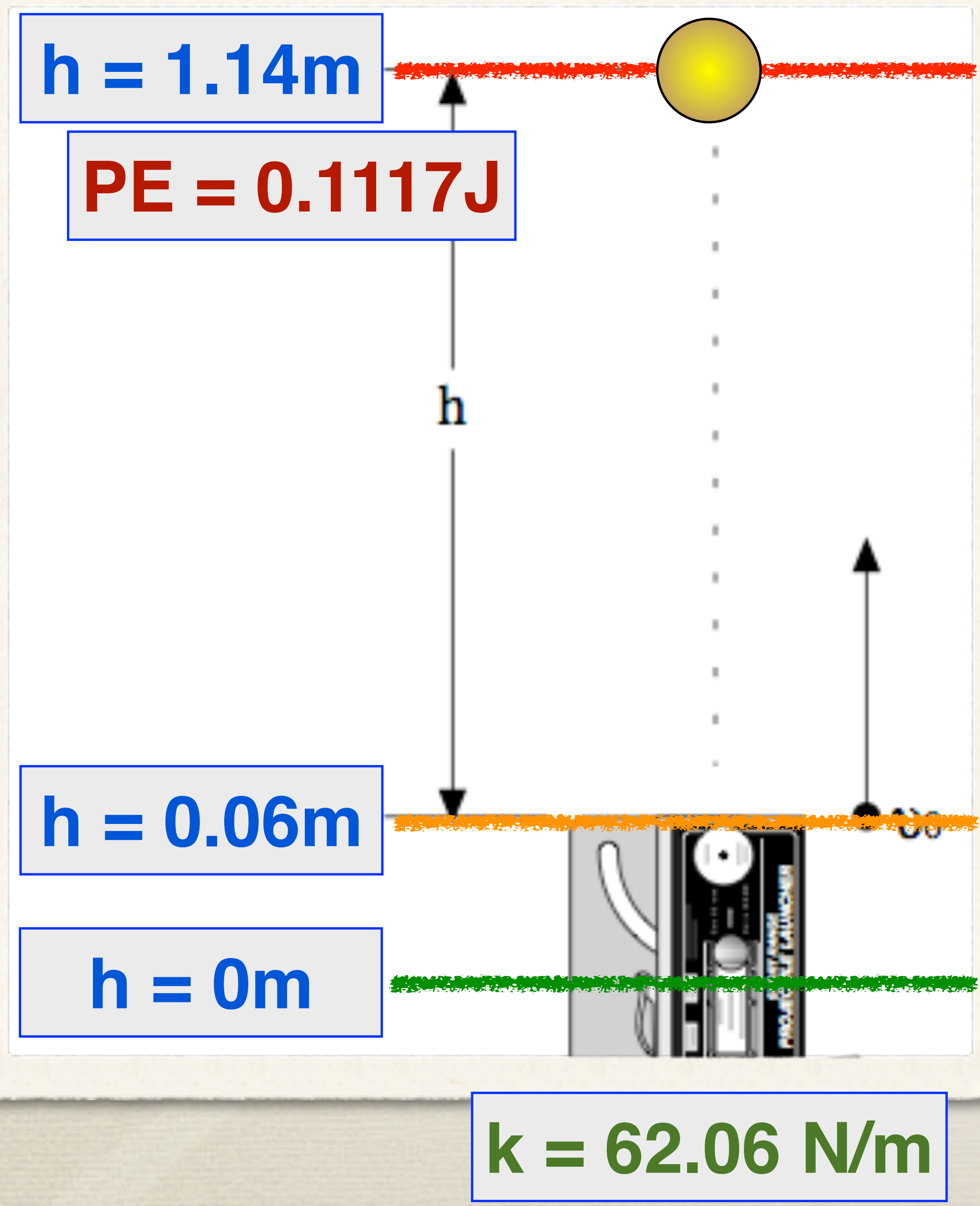

- Find the KE and the velocity
- **PE** = (0.010kg)(9.8)(0.06)
- PE = 0.00588 J = 5.88 mJ
- **KE** = 0.1117- 0.00588 = 0.1058 J

Elastic Potential

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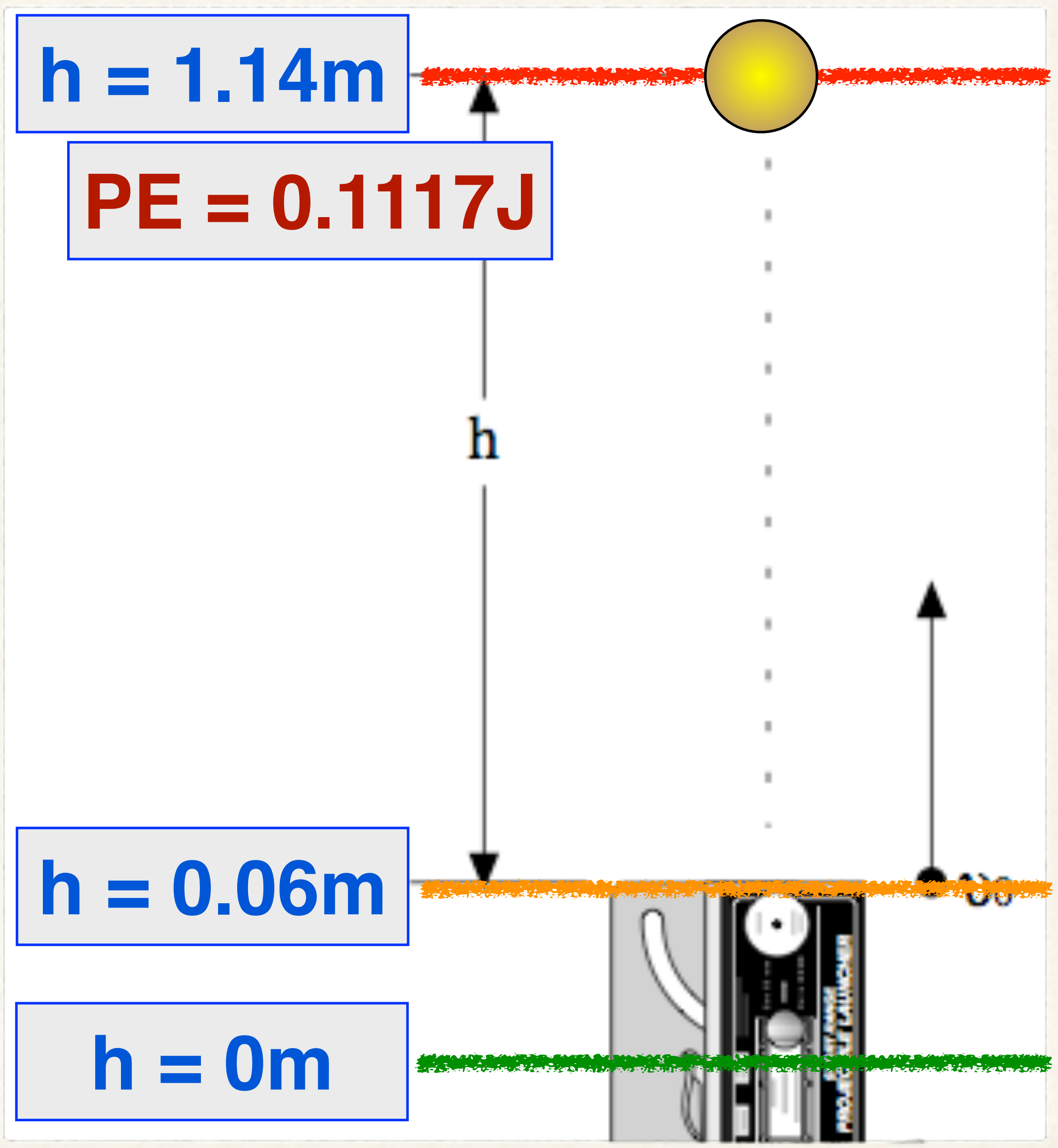

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- Find the KE and the velocity
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- PE = 0.00588 J = 5.88 mJ
- **KE** = 0.1117- 0.00588 = 0.1058 J
- 0.1058 J = ½(mv^2)

Elastic Potential

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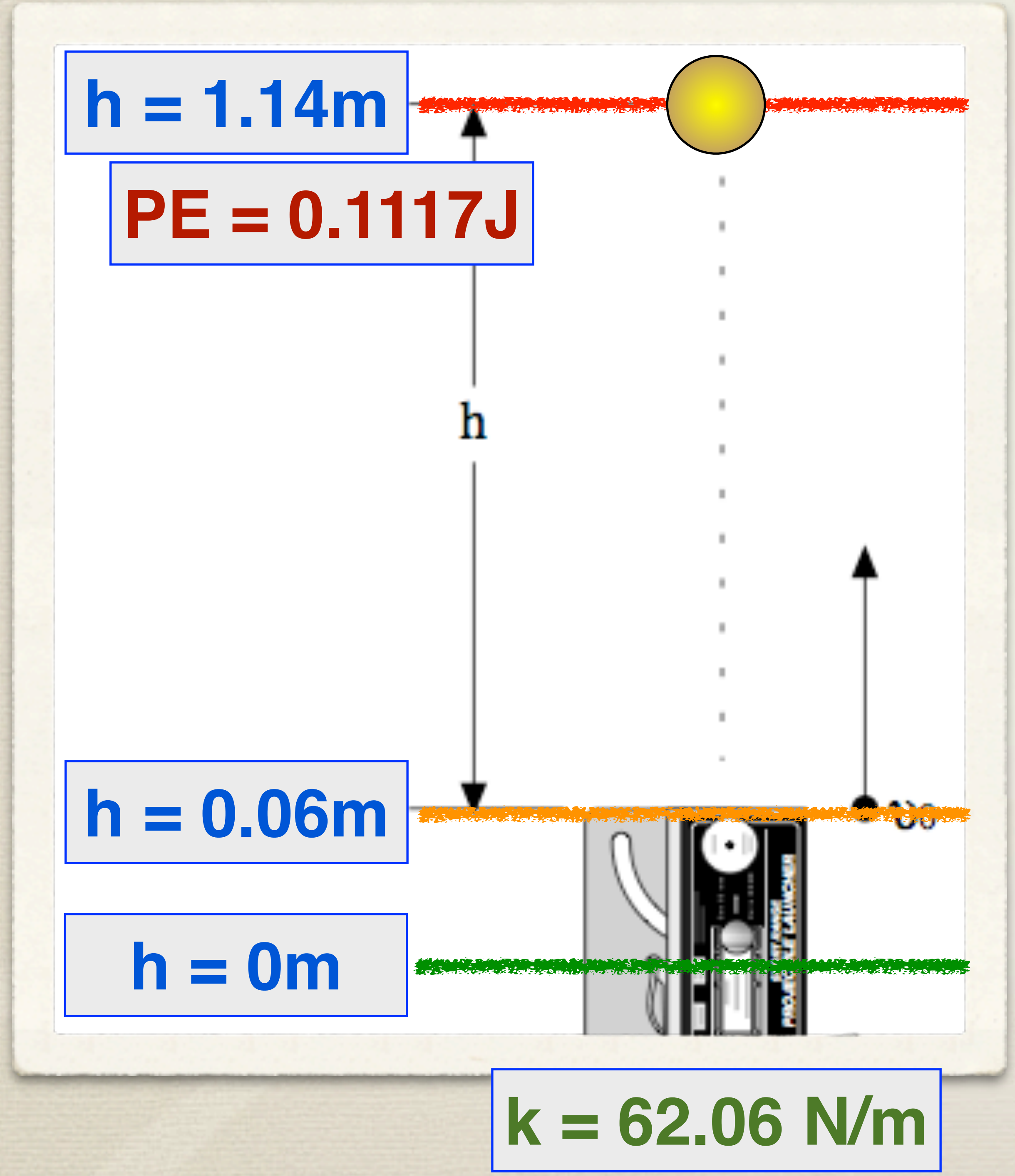

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- 0.1058 J = ½ (0.010) v^2

Elastic Potential

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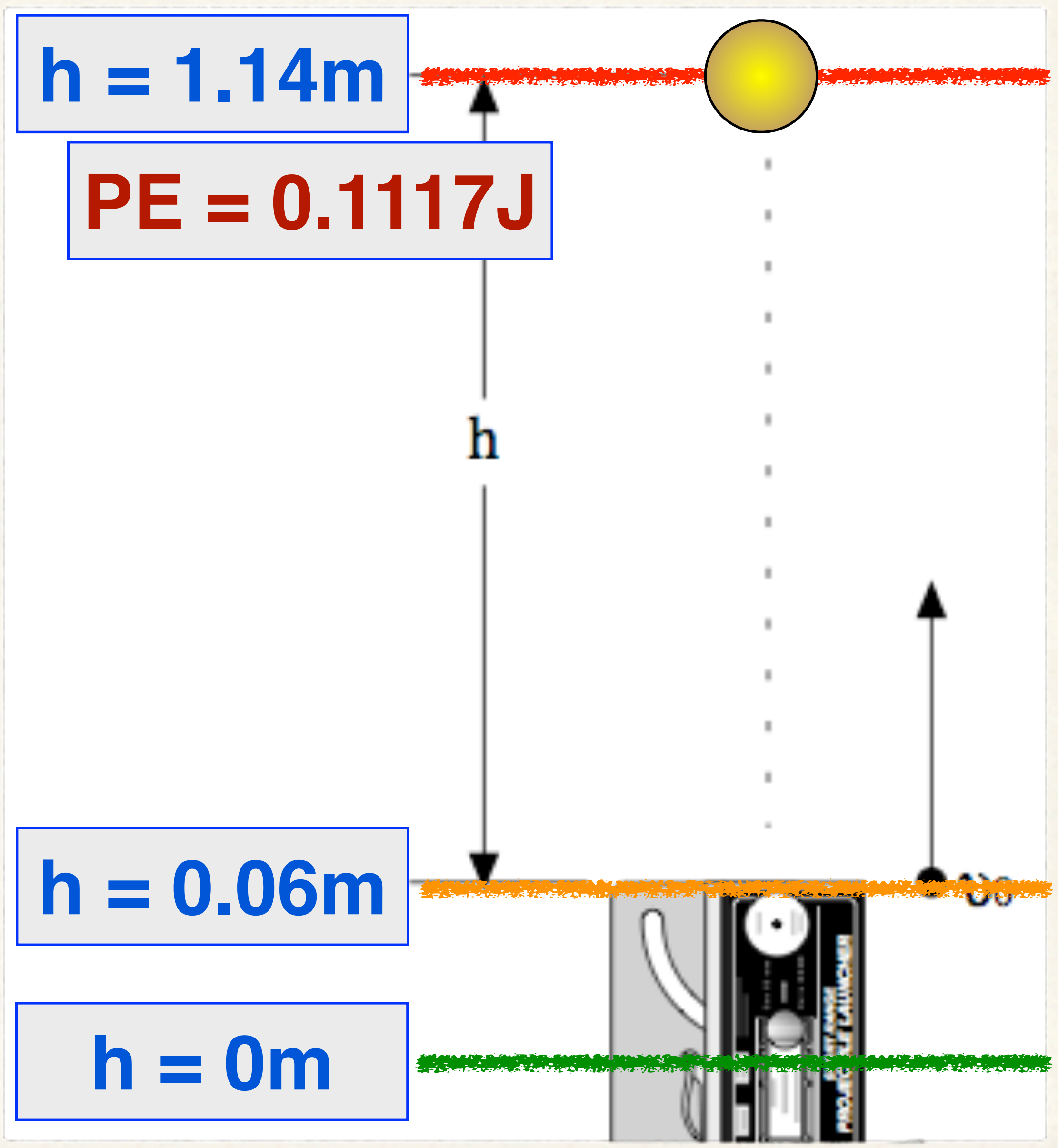

k = 62.06 N/m

- Find the KE and the velocity
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- **KE** = 0.1117- 0.00588 = 0.1058 J
- 0.1058 J = ½(mv^2)
- 0.1058 J = ½ (0.010) v^2
- **v = 4.6 m/s**

Elastic Potential

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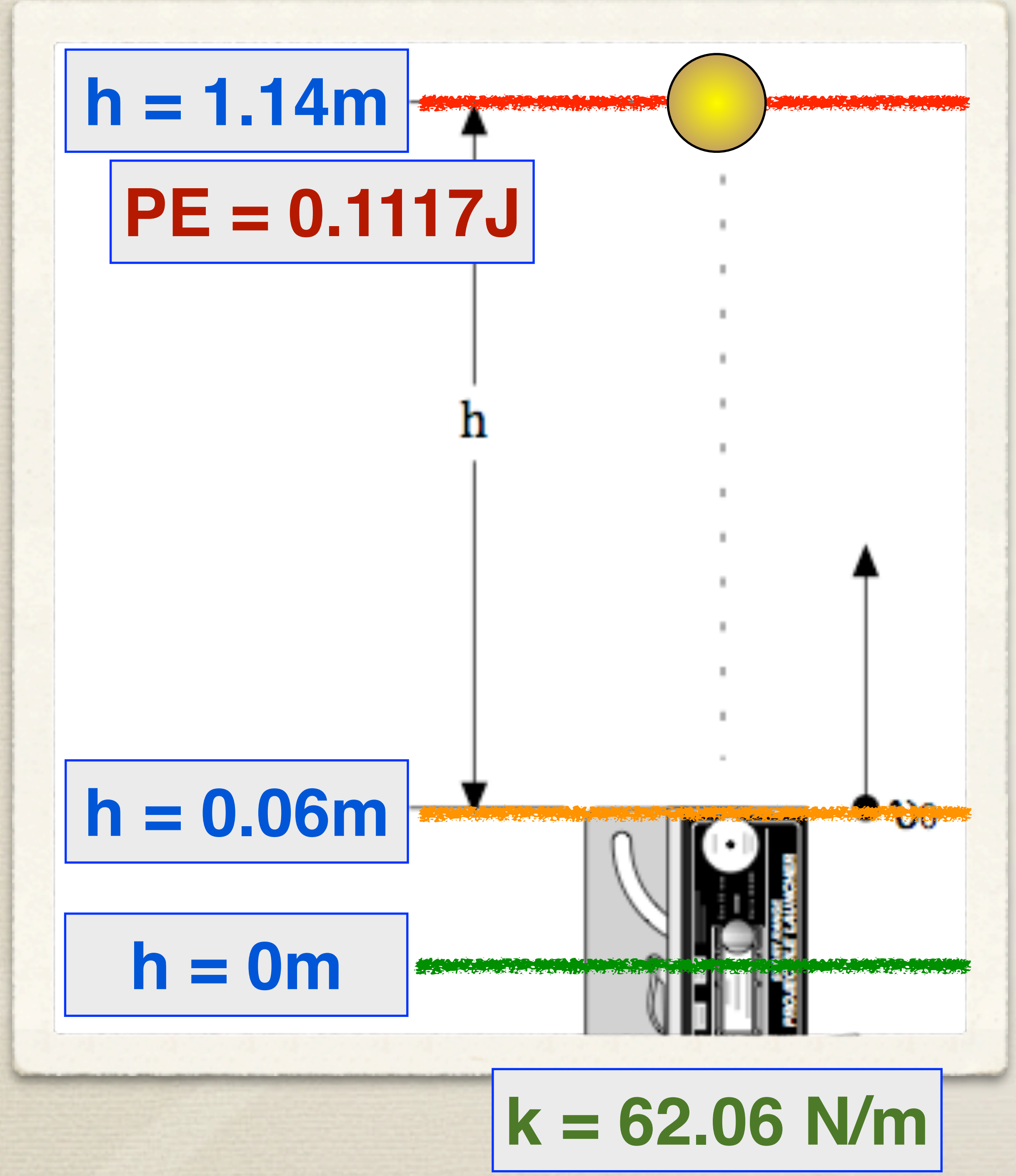
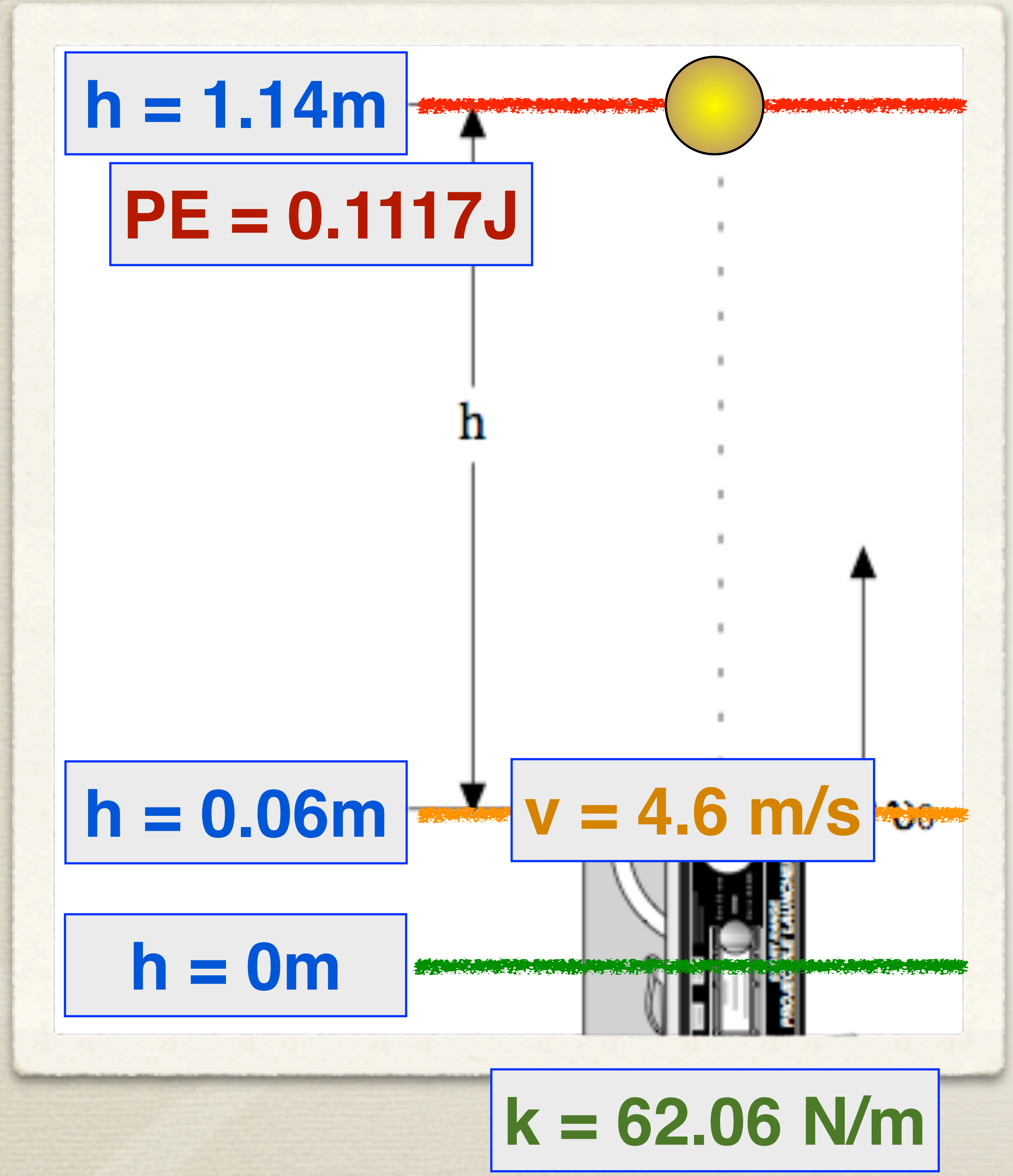


- Find the KE and the velocity
- **PE** = (0.010kg)(9.8)(0.06)
- PE = 0.00588 J = 5.88 mJ
- **KE** = 0.1117- 0.00588 = 0.1058 J
- 0.1058 J = ½(mv^2)
- 0.1058 J = ½ (0.010) v^2
- **v = 4.6 m/s**

and that is about what you calculated using old equations before

Elastic Potential

- In lab, you compressed a spring a distance of 6cm. The 10g ball went up 1.08m.



Elastic Potential

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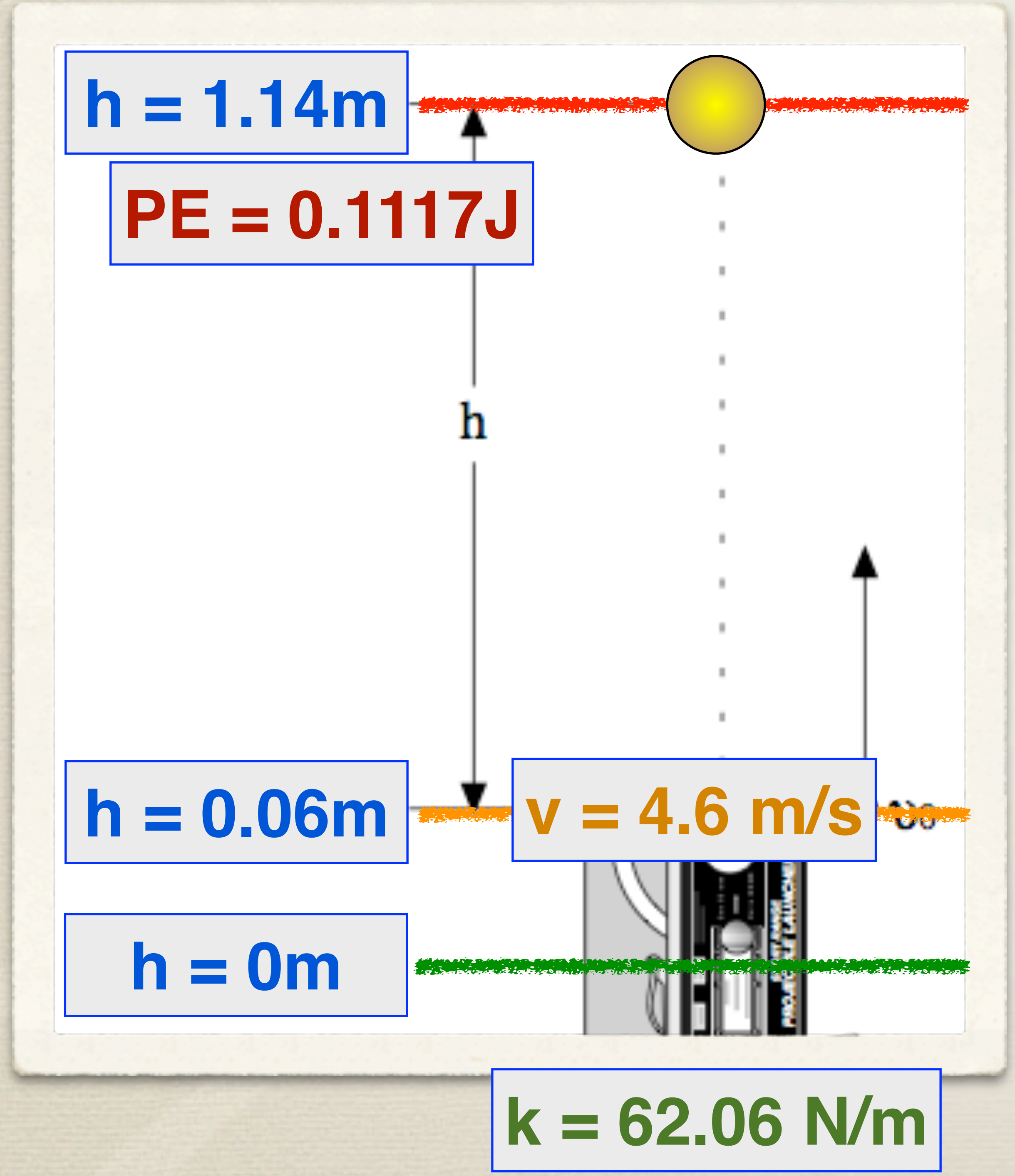
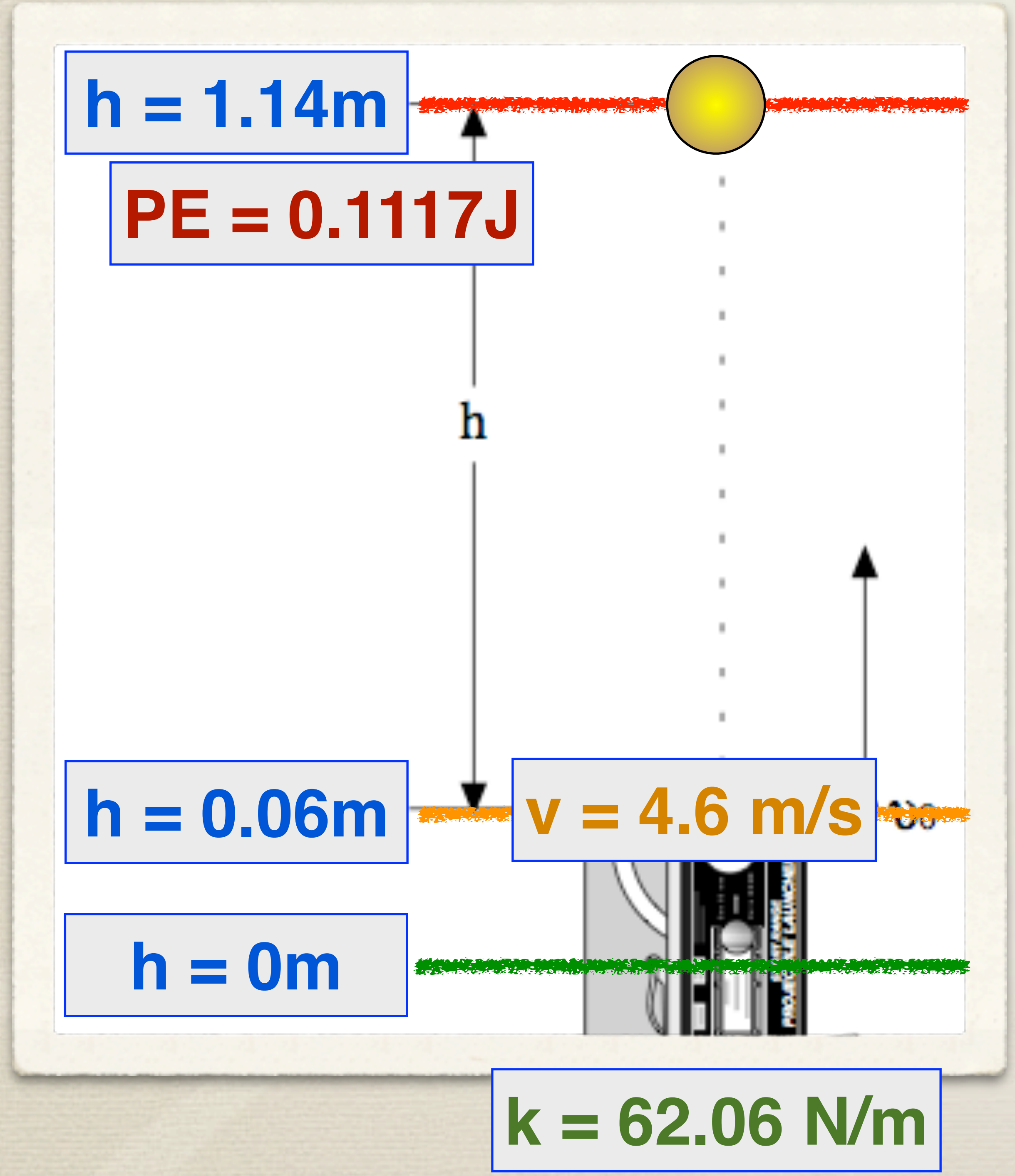


- Find the maximum force used to push the spring

Elastic Potential

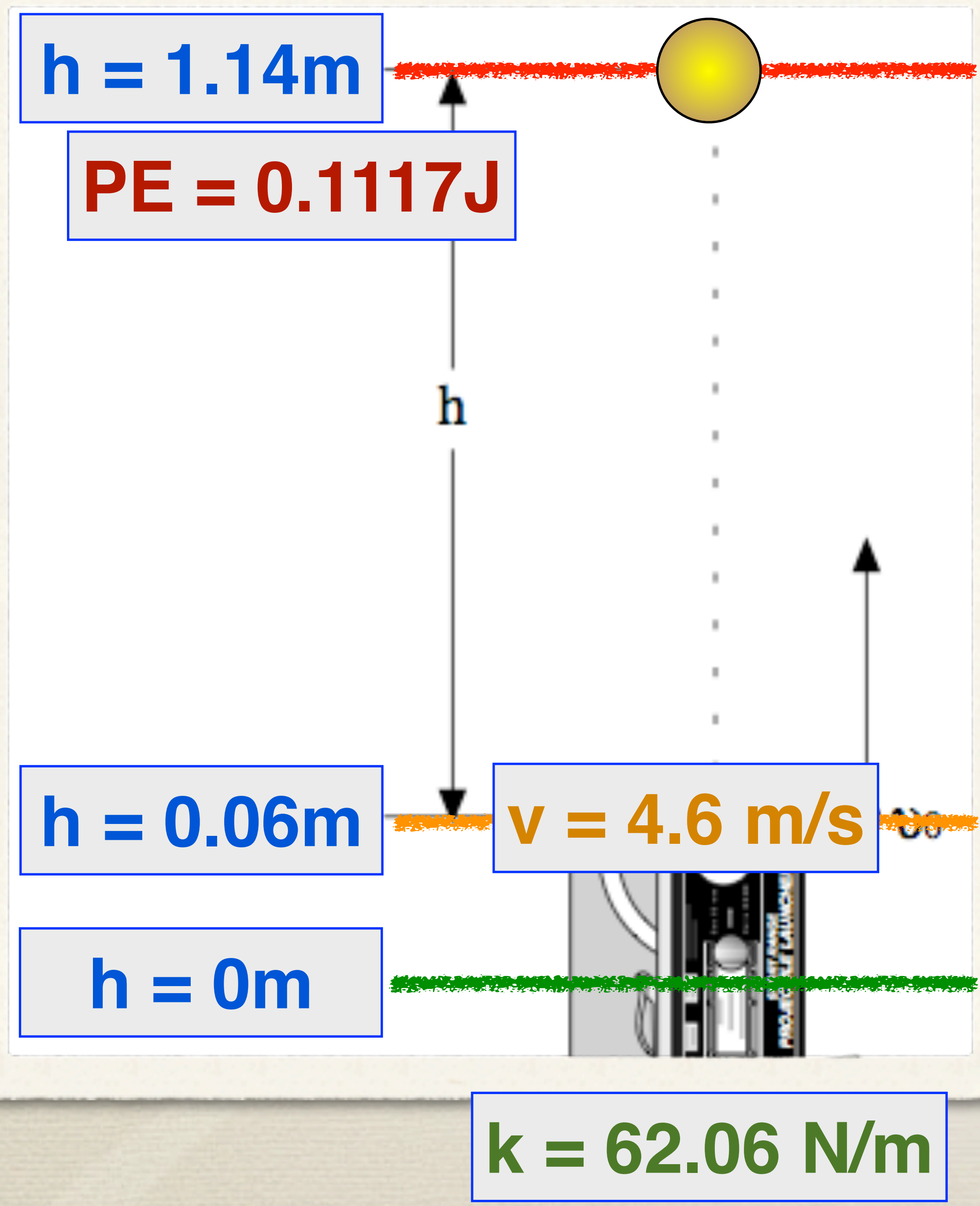
- In lab, you compressed a spring a distance of 6cm. The 10g ball went up 1.08m.



- Find the maximum force used to push the spring
- **F = k x**

Elastic Potential

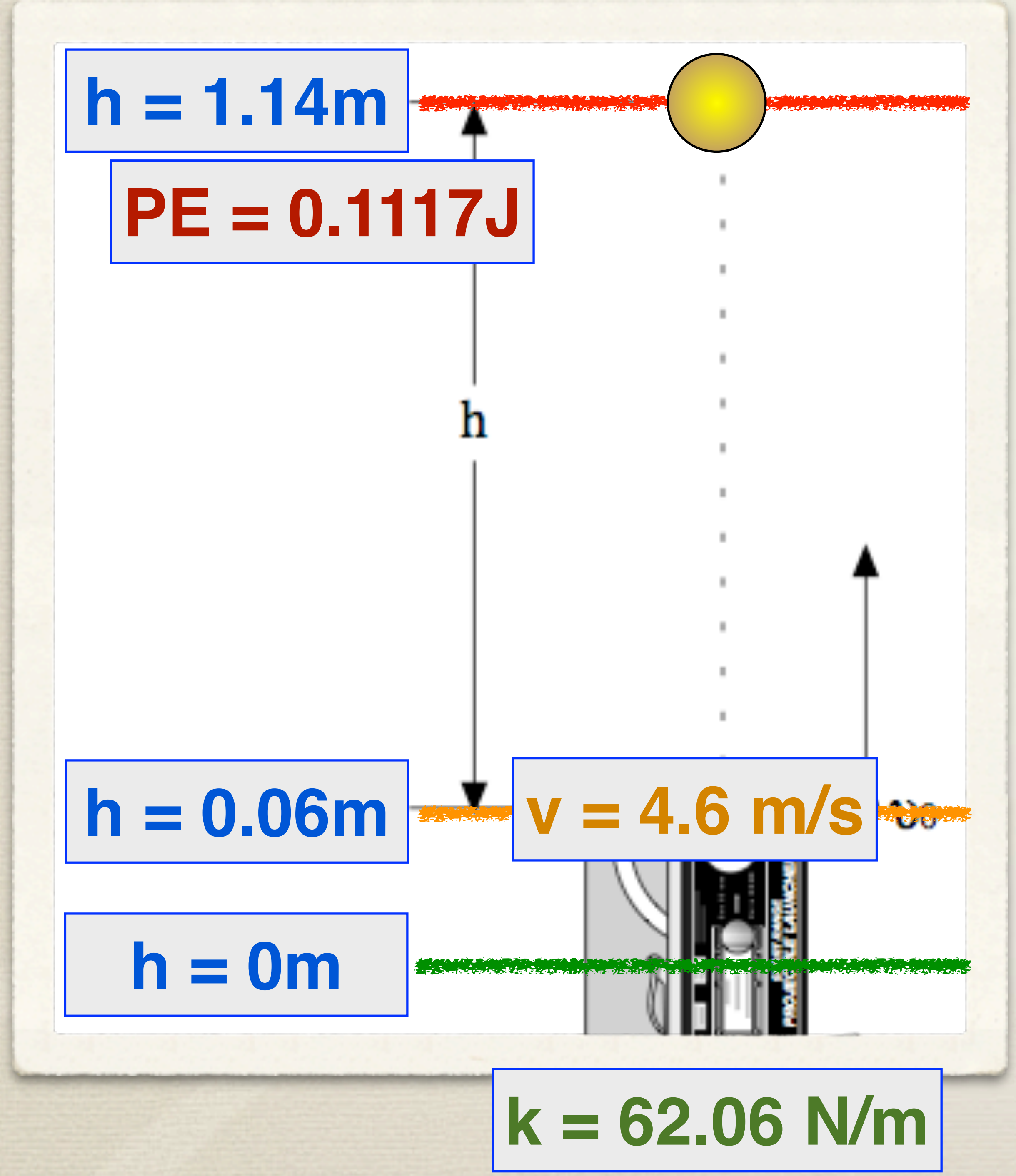
- In lab, you compressed a spring a distance of 6cm. The 10g ball went up 1.08m.



- Find the maximum force used to push the spring
- **F = k x**
- **F = (62.06 N/m) (0.06m)**

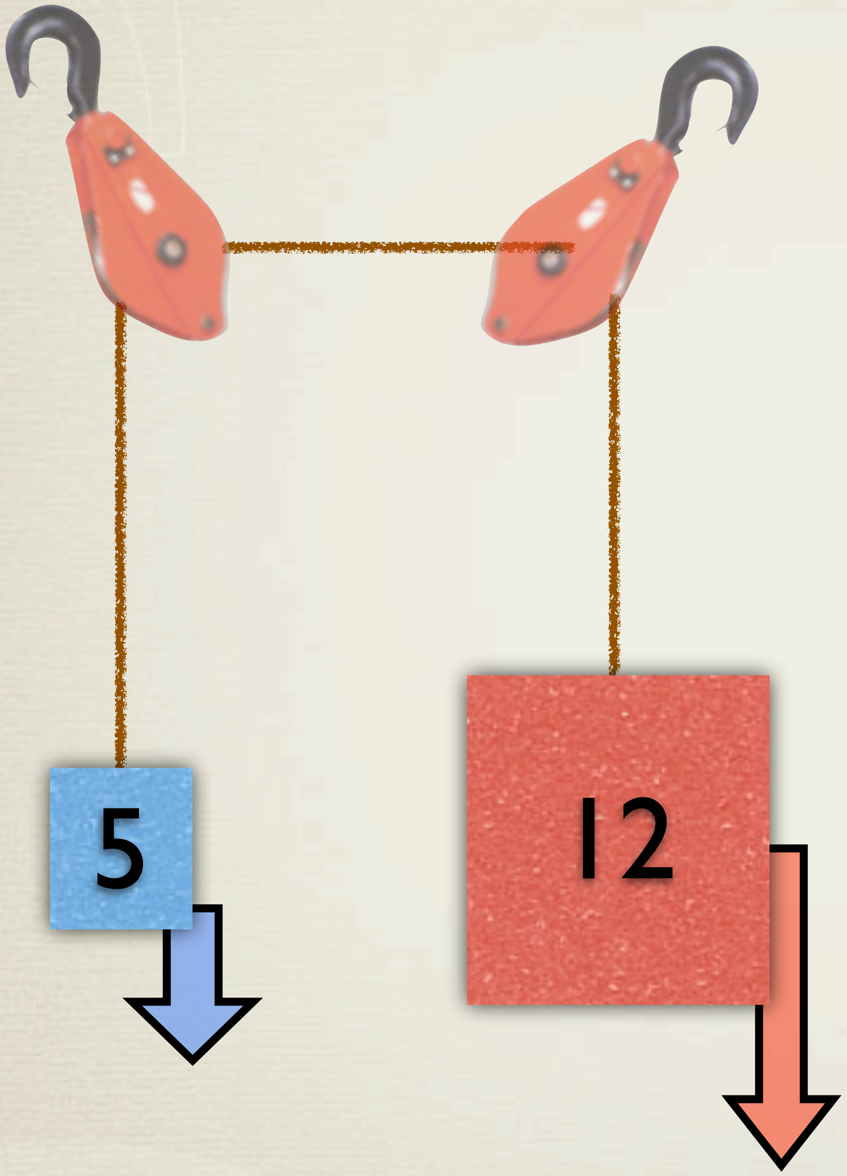
Elastic Potential

- In lab, you compressed a spring a distance of 6cm. The 10g ball went up 1.08m.



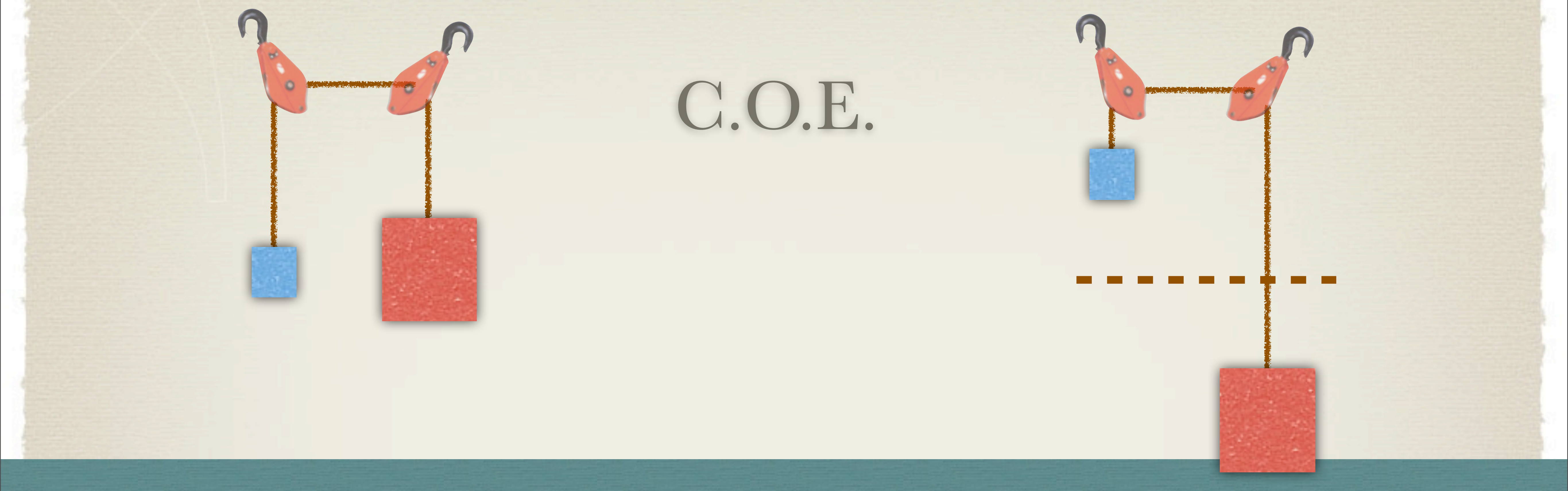
- Find the maximum force used to push the spring
- **F = k x**
- **F = (62.06 N/m) (0.06m)**
- **F = 3.7236 N**

The Atwood Machine

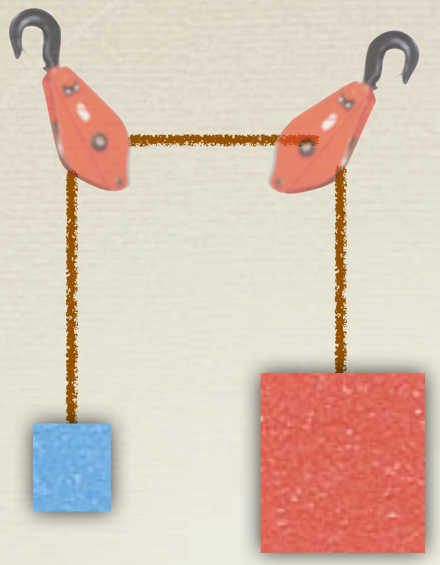


- Find the velocity of the red block as it hits the ground 3 m below.

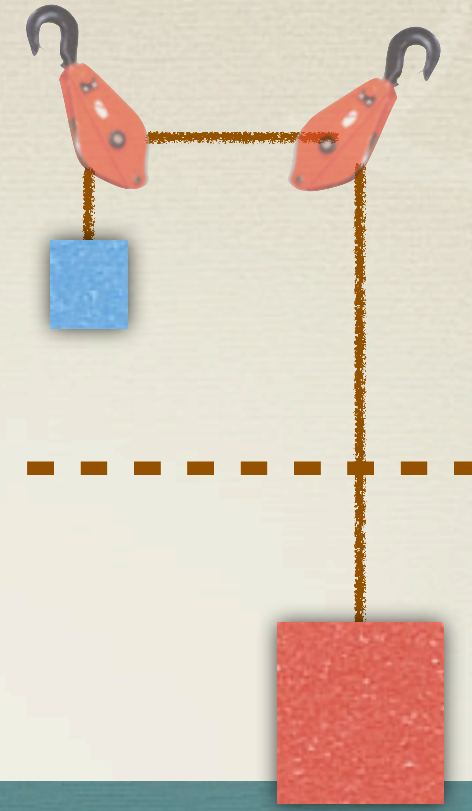
Conservation Of Energy

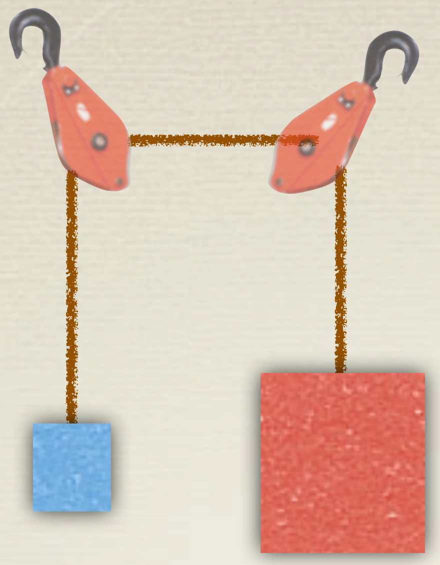


- Initial: Not moving, both have a height of 3m.
- Final: Both moving, Blue is at 6m, Red is at 0m.



C.O.E.





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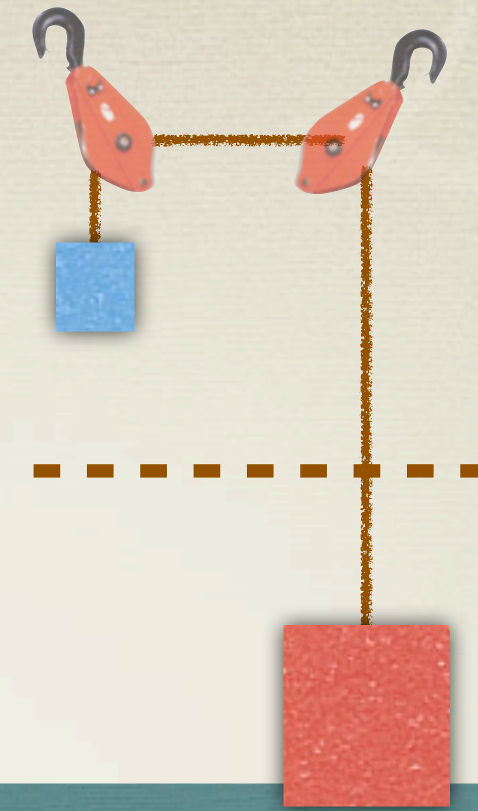
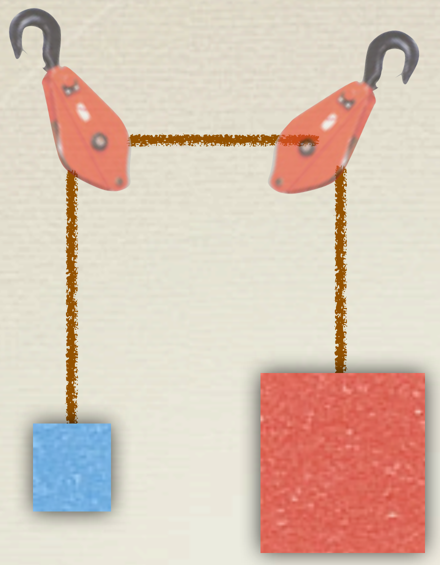


PE + PE = PE + KE + KE



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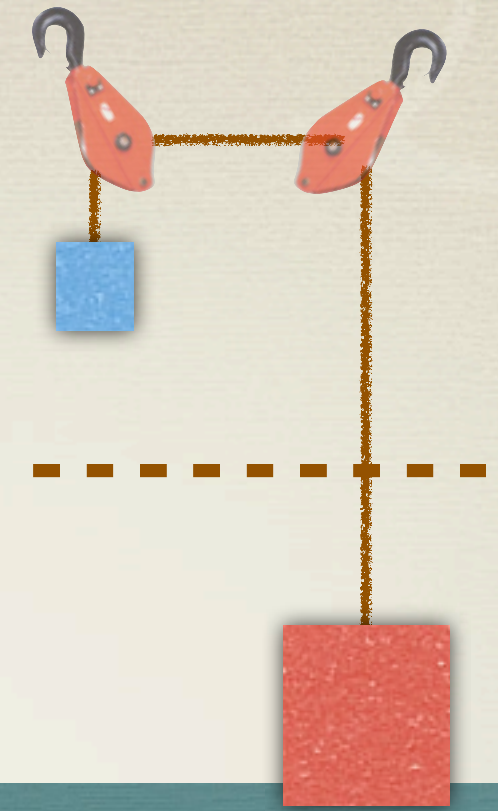
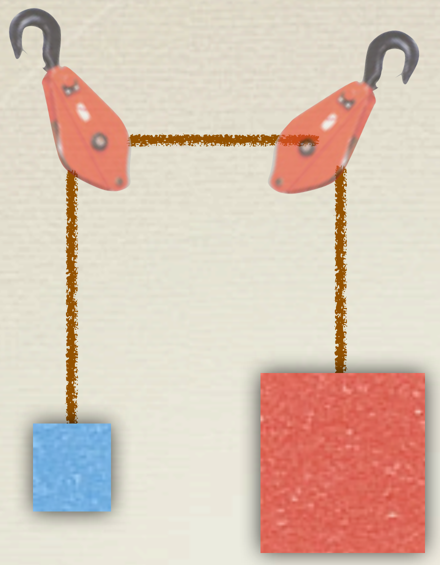


$$PE + PE = PE + KE + KE$$

$$mgh + mgh = mgh + \tfrac{1}{2}(mv^2) + \tfrac{1}{2}(mv^2)$$



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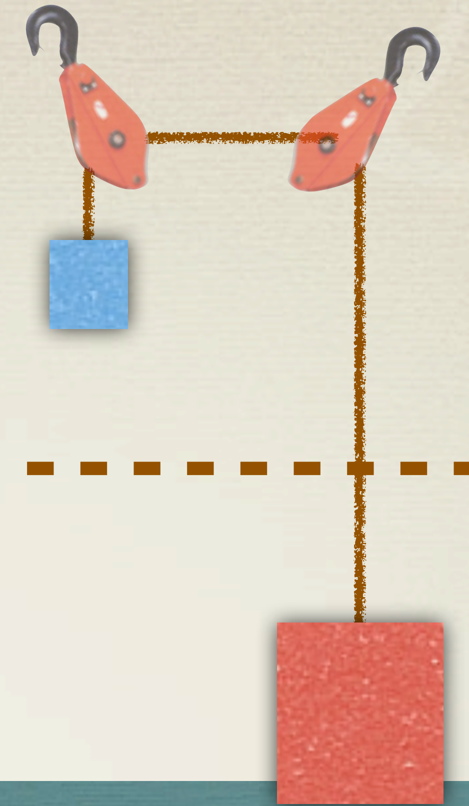
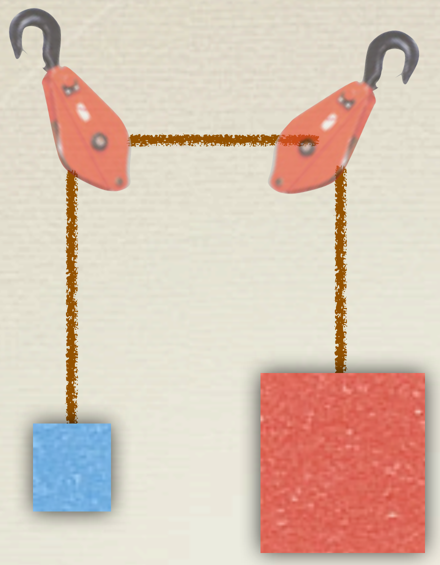


$$PE + PE = PE + KE + KE$$

$$mgh + mgh = mgh + \frac{1}{2}(mv^2) + \frac{1}{2}(mv^2)$$

$$5(9.8)(3) + 12(9.8)(3) = 5(9.8)(6) + \frac{1}{2}(5v^2) + \frac{1}{2}(12v^2)$$



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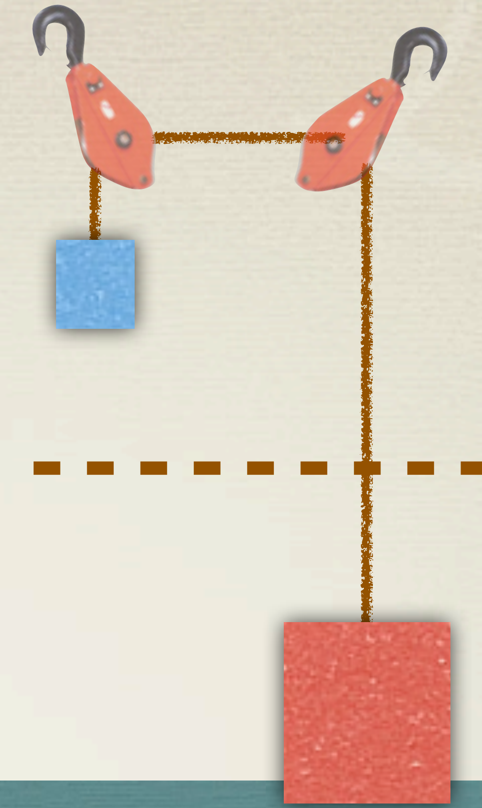

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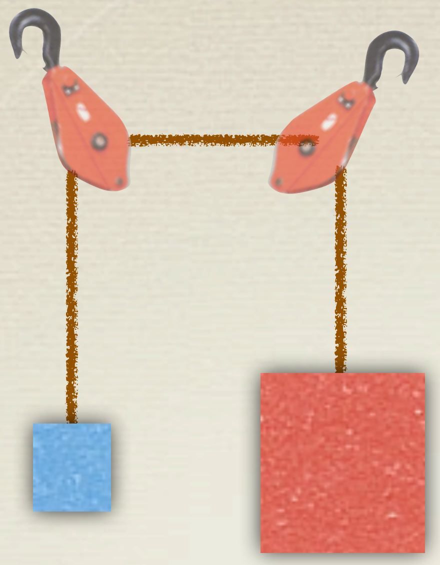
$$147 + 352.8 = 294 + 2.5v^2 + 6v^2$$



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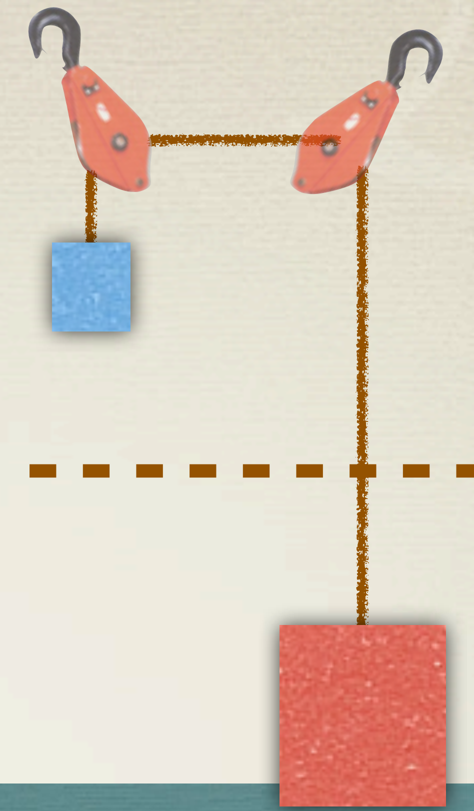

$$PE + PE = PE + KE + KE$$

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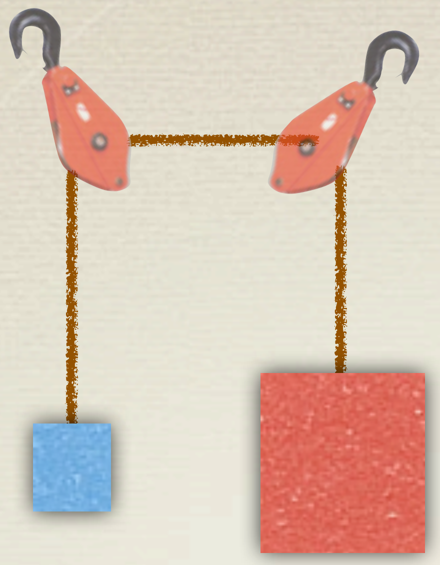
$$205.8 = 8.5v^2$$



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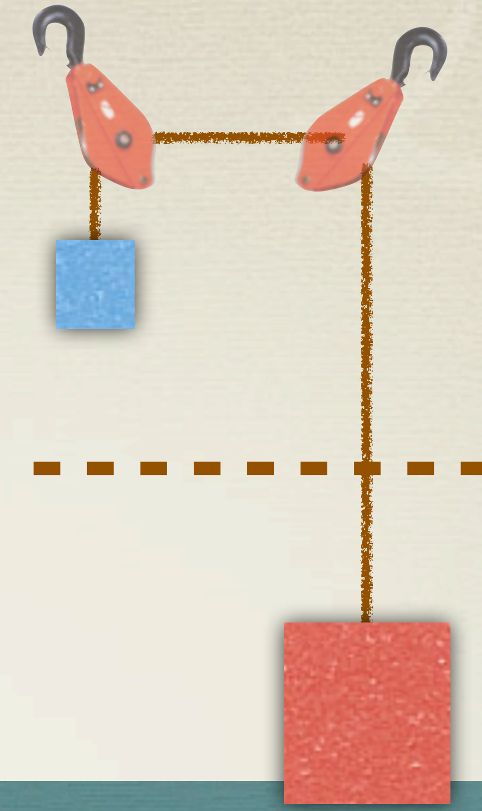

$$PE + PE = PE + KE + KE$$

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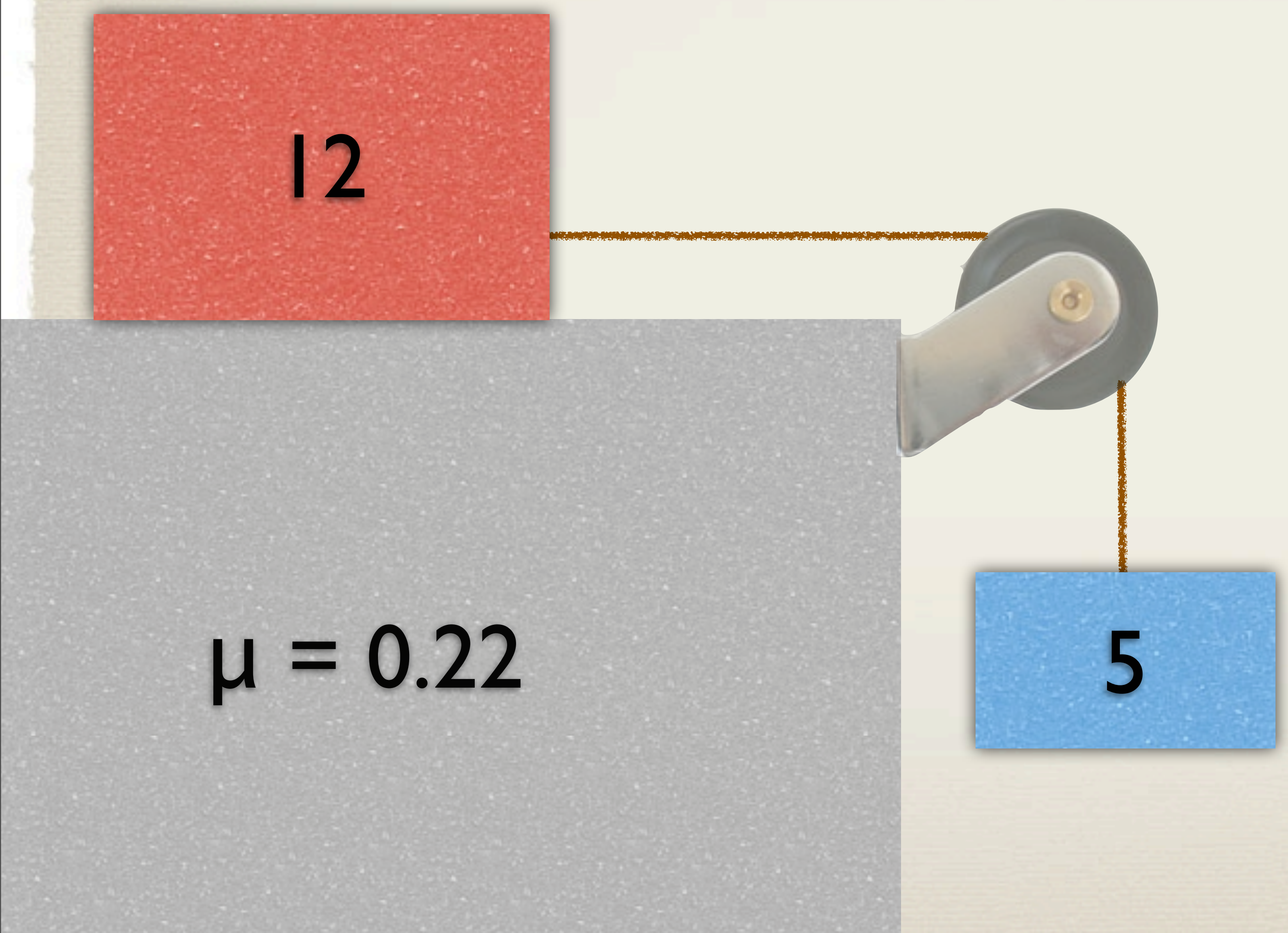
$$147 + 352.8 = 294 + 2.5v^2 + 6v^2$$

$$205.8 = 8.5v^2$$

$$4.92 = v$$

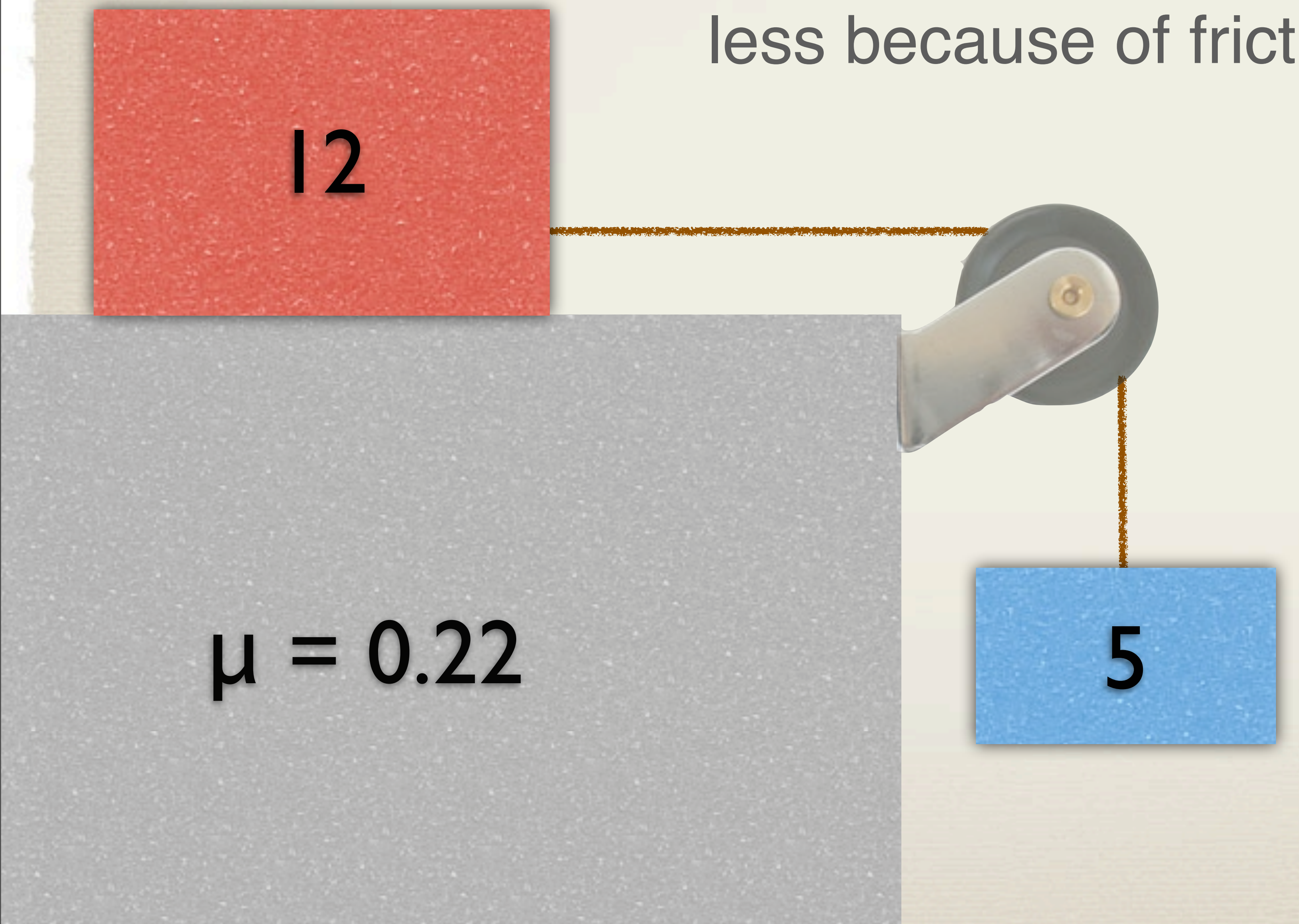
Energy Lost to Friction

- Find the velocity of the blue block as it hits the ground 8m below.



Energy Lost to Friction

- Initial; the blue block has potential energy.
- Final; both blocks have kinetic, and TE is less because of friction.



Energy Lost to Friction

Energy Lost to Friction

$$PE = W_f + KE + KE$$

Energy Lost to Friction

$$PE = W_f + KE + KE$$

$$mgh = (\mu N)d + \tfrac{1}{2}(mv^2) + \tfrac{1}{2}(mv^2)$$

Energy Lost to Friction

$$PE = W_f + KE + KE$$

$$mgh = (\mu N)d + \tfrac{1}{2}(mv^2) + \tfrac{1}{2}(mv^2)$$

$$5(9.8)(8) = (0.22)(12(9.8))(8) + \tfrac{1}{2}(5v^2) + \tfrac{1}{2}(12v^2)$$

Energy Lost to Friction

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$$392 = 206.98 + 2.5v^2 + 6v^2$$

Energy Lost to Friction

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$$185 = 8.5v^2$$

Energy Lost to Friction

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$$392 = 206.98 + 2.5v^2 + 6v^2$$

$$185 = 8.5v^2$$

$$4.67\ m/s = v$$

Academic Assignment

Academic Physics

Set 1 - Chapter 10

1, 2, 3, 5, 6, 7, 25, 26, 27, 28, 52, 53, 56, 57

Academic Physics

Set 2 - Chapter 10

60, 63, 67, 70, 71, 76, 79, 81, 83, 84, 85, 90, 93

Hooke’s Law

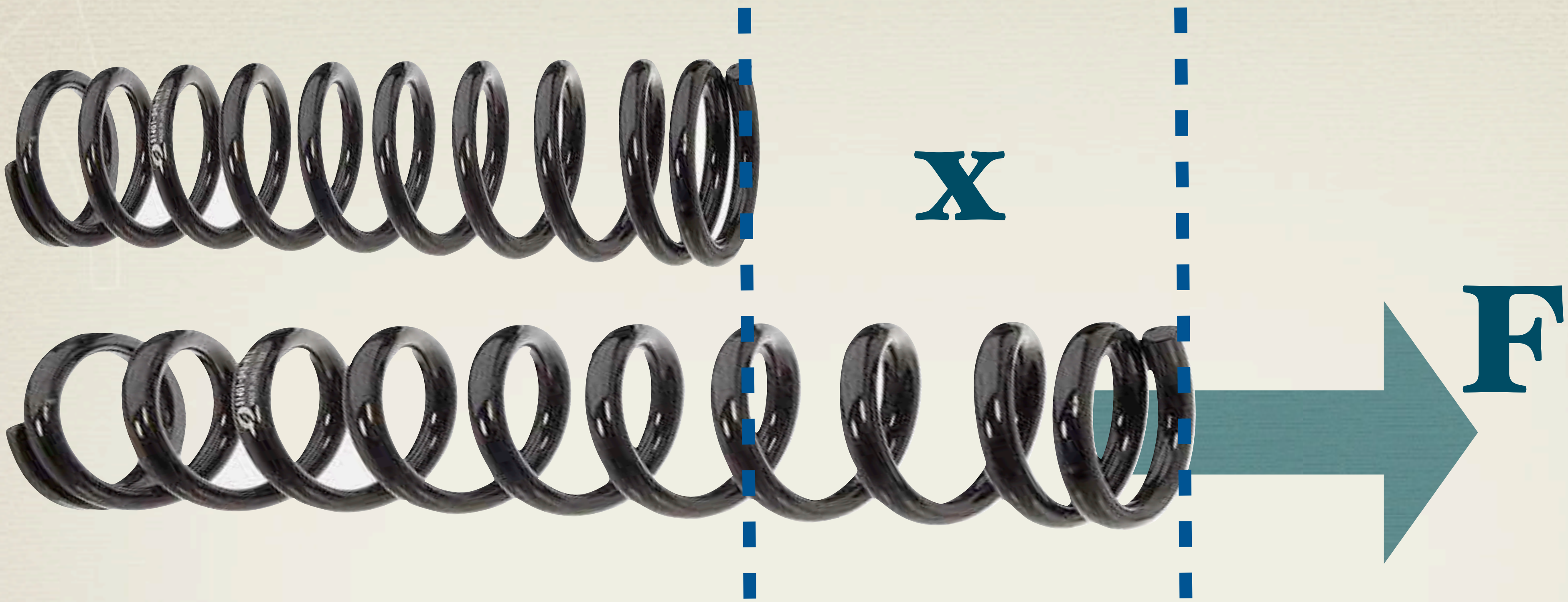

POCKET
BALANCE


ROBERT HOOKE
1635-1703
Scientist
Architect
Engineer

$F = (-)\,k\,x$

- Force - required to stretch the spring, or restoring force. Often the weight (N)
- k - Spring Constant - How “tight” the spring is. (N/m)
- x - Stretch - a change in length (m)

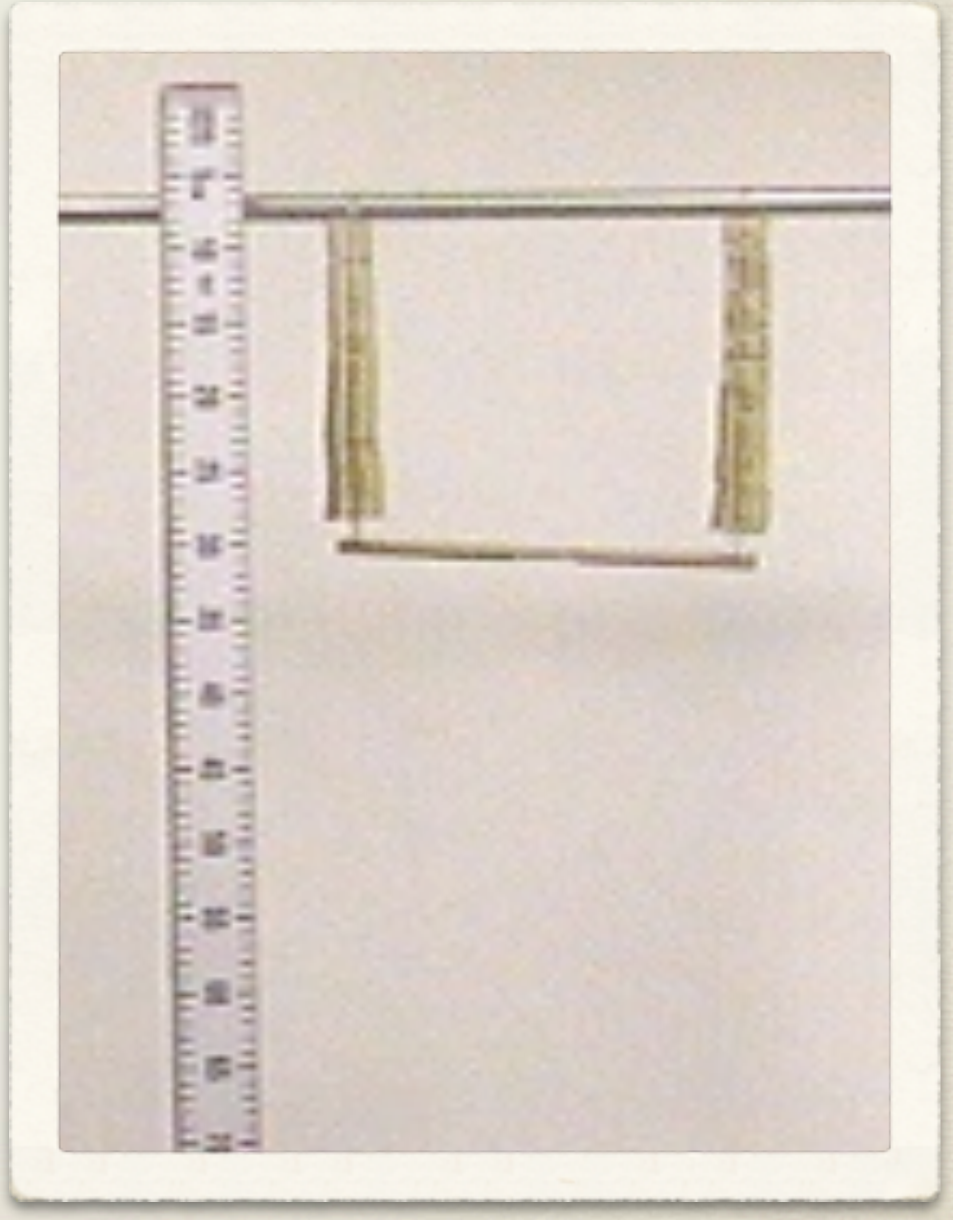
F = (-) k x



- Force - required to stretch the spring, or restoring force. Often the weight (N)
- k - Spring Constant - How “tight” the spring is. (N/m)
- x - Stretch - a change in length (m)

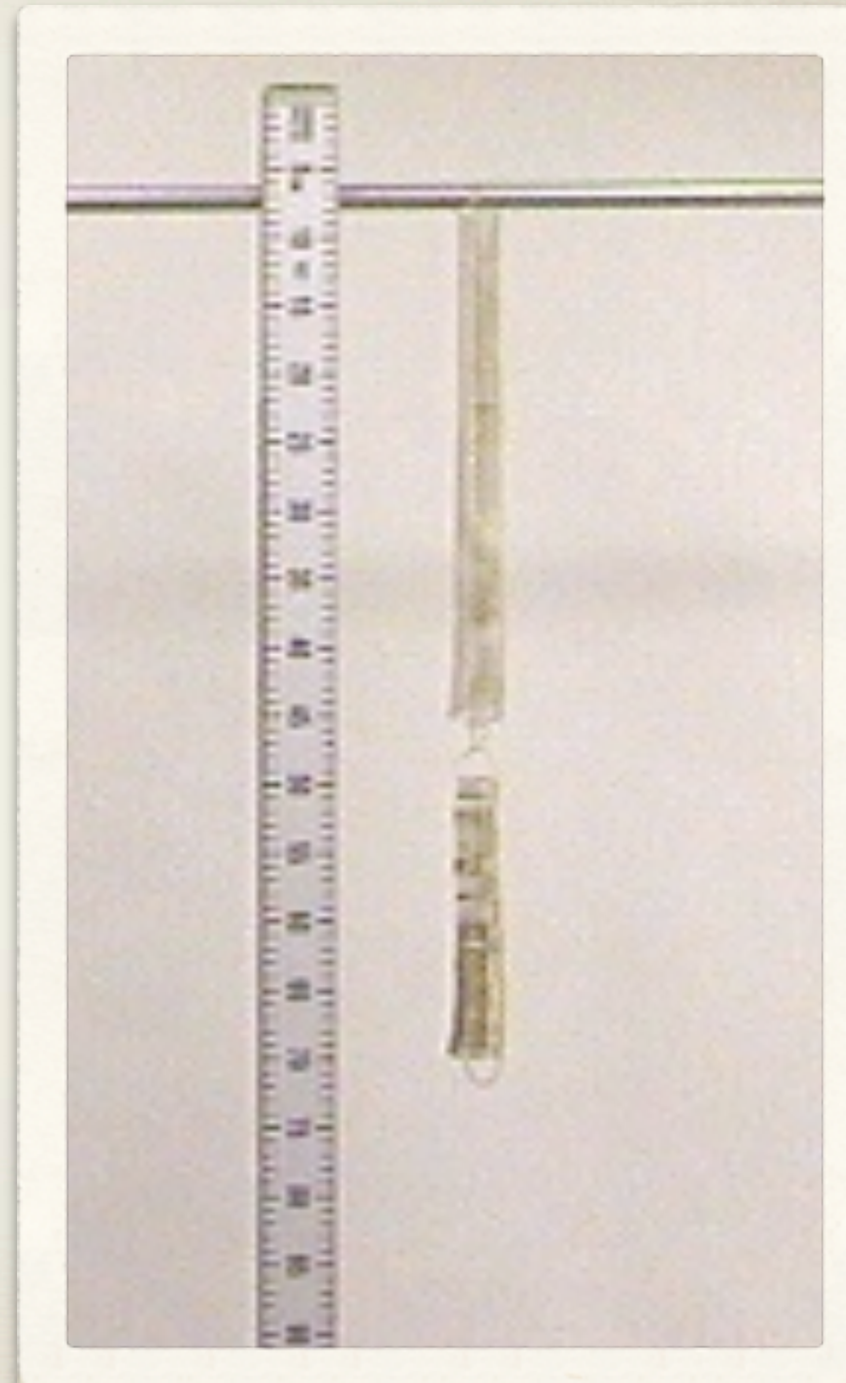
Springs in Parallel

- The same force is supported by two springs so neither has to stretch as far...
- ...or, it is harder to stretch two springs so the constant is increased
- $k = k_1 + k_2$



Springs in Series

- Both springs support the same amount of weight (not split in two like before)...
- or... it is easier to stretch
- $1/k = 1/k_1 + 1/k_2$



What is the spring constant?

- Up a track