Phy 2A 5/15

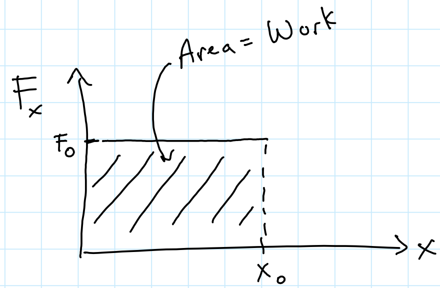
Monday, May 15, 2017 9:09 AM

Goals for the Lecture:

1) Be able to calculate work done by constant forces
2) Be able to calculate the scalar product (dot product) of two vectors
3) Use the Work – Kinetic Energy Theorem to solve problems
4) Understand how defining your system can affect the work done on the system or by the system
5) Calculate kinetic and potential energy

Work

Constant force

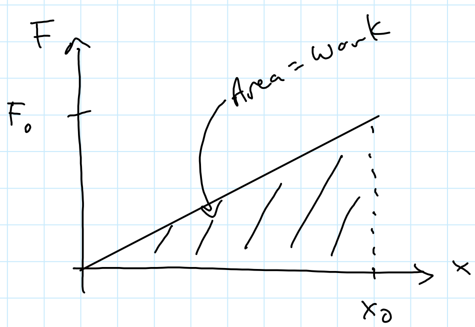


work done on the object by F_0:

$W =$ Area under F vs X curve

$= F_0 X_0$

Non-constant force (like a spring)



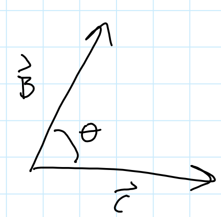
$W =$ Area under curve

$= \frac{1}{2} x_0 F_0$

Dot Product:

$A = \vec{B} \cdot \vec{C}$

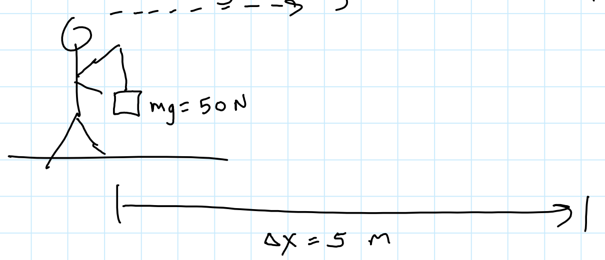
$= |\vec{B}||\vec{C}| \cos\theta$

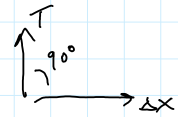


Work: $W = \vec{F} \cdot \Delta\vec{X}$ For a constant force

Find the work done on the box by the string: (box always moves at constant speed)

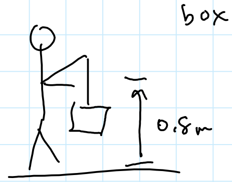
1) walking slowly at constant speed

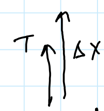




$W = T\,\Delta x \cos 90° = 0$

2) box is lifted 0.8 m at constant speed



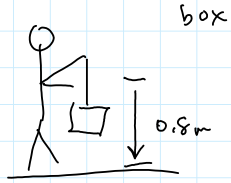


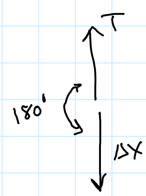
$\theta = 0°$

$W = T\,\Delta x \cos 0°$

$= T\,\Delta x = (50\text{ N})(0.8) = 40\text{ J}$

3) box is lowered 0.8 m at constant speed

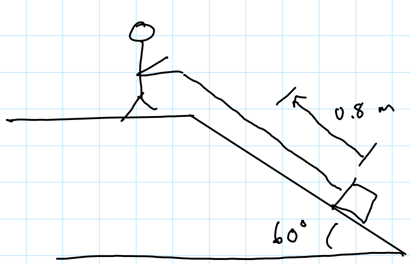




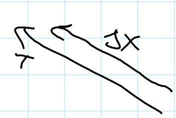
$W = T\,\Delta x \cos 180°$

$= -40\text{ J}$

4)



pulled up incline at constant speed



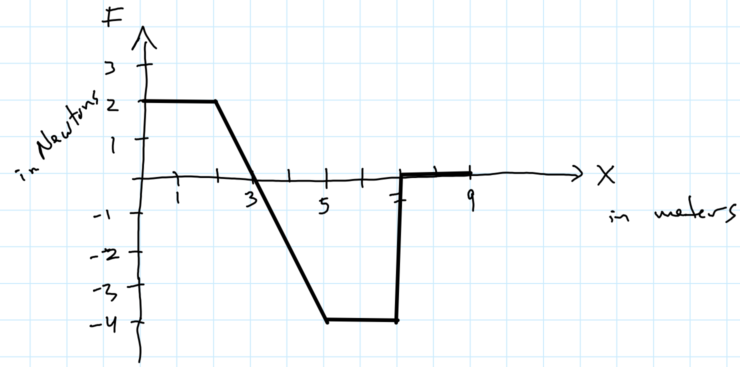
$\theta = 0°$

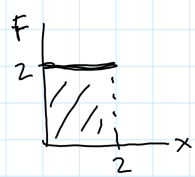
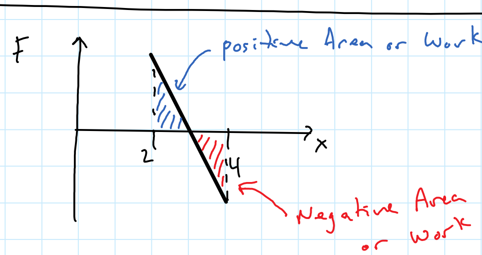
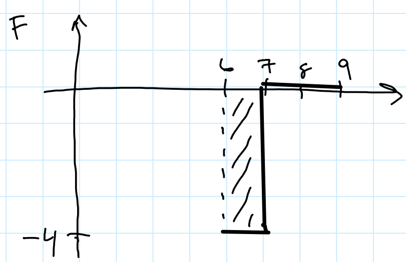
$W = T\,\Delta x \cos 0°$

$= 50\,(0.8)$

$= 40 \text{ J}$

Find the work done on an object by F for each of the intervals:

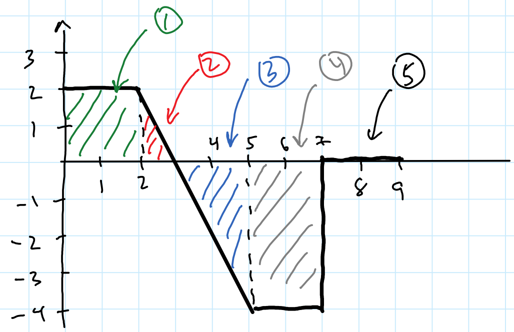


interval	work done on the object	Did it gain or lose speed?
$0 < x < 2$	 $W = \text{Area} = (2)(2) = 4 \text{ J}$	gained (w is positive)
$2 < x < 4$	 $W = +1 - 1 = 0$	stays the same speed
$6 < x < 9$	 $W = W_{6\to7} + W_{7\to9} = -4 + 0 = -4 \text{ J}$	slowed down (negative work)

$0 < x < 9$

①

$0 < x < 9$



Area under the curve

① $A_1 = (2)(2) = 4 \text{ J}$

② $A_2 = \frac{1}{2}(1)(2) = 1 \text{ J}$

③ $A_3 = -\frac{1}{2}(2)(4) = -4 \text{ J}$

④ $A_4 = -(2)(4) = -8 \text{ J}$

⑤ $A_5 = 0$

Total Area $= W = (4+1-4-8+0) = -7 \text{ J}$

Use work to find v_f, given: $m = 10$ kg

$g = 9.8 \ m/s^2$

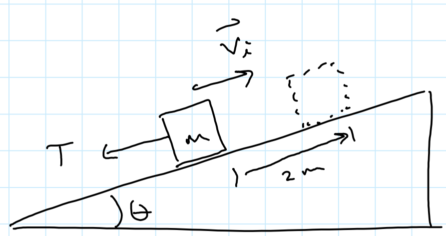
$\theta = 30°$

$V_i = 12 \ \frac{m}{s}$

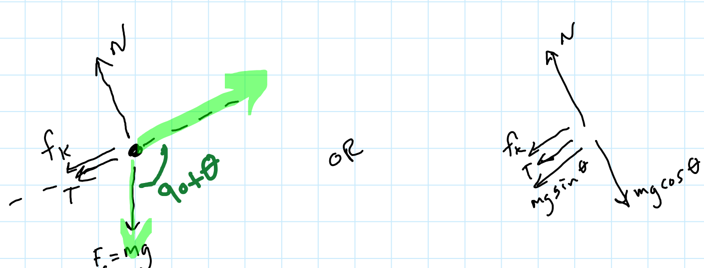
$\Delta x = 2$ m

$T = 5$ N

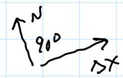
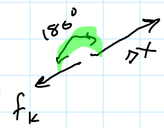
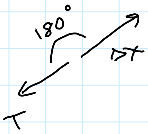
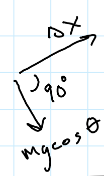
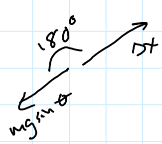
$\mu_k = 0.15$



1) Draw FBD:



2) Find work done on the box by every force acting on the box

Force	Work done on box
N	 $W = N(\Delta x)\cancel{\cos 90°}^{0} = 0$
f_k	 $W = f_k(\Delta x)\cos 180°$ ← different angles $= \mu_k N\ \Delta x\ (-1)$ $= (0.15)(mg\cos\theta)(2)(-1)$ $= (0.15)(10)(9.8)(\cos 30)(2)(-1)$ $= -25\ \text{J}$
T	 $W = T(\Delta x)\cos 180°$ $= (5)(2)(-1)$ $= -10\ \text{J}$
$(F_g)_\perp$	 $W = (mg\cos\theta)(\Delta x)\cancel{\cos 90°}^{0}$ $= 0$
$(F_g)_{//}$	 $W = (mg\sin\theta)(\Delta x)\cos 180°$ $= (10)(9.8)(\sin 30)(2)(-1)$ $= -98\ \text{J}$

$$W_{Net} = W_N + W_{f_k} + W_T + W_{F_g} = 0 - 25 - 10 + 0 - 98$$

$$= -133\ \text{J}$$

$$W_{Net} = \Delta K$$

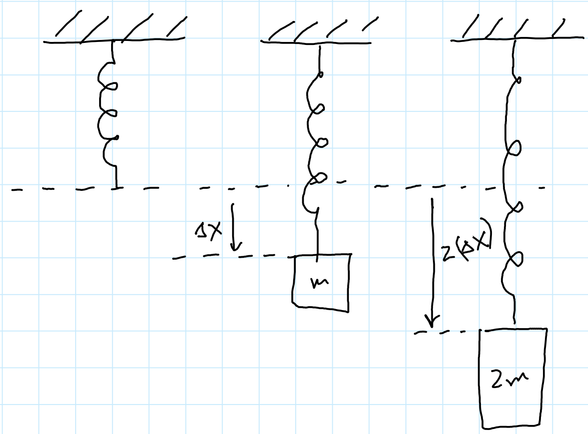
$$= K_f - K_i$$

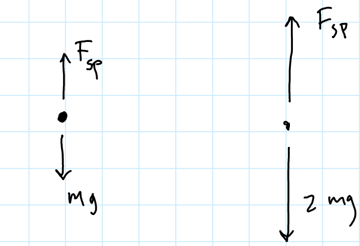
$$= \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$$

$$-133 = \frac{1}{2}(10)v_f^2 - \frac{1}{2}(10)(12)^2$$

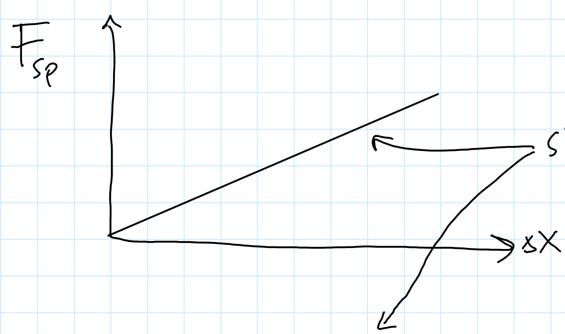
$$v_f = 10.8 \ \frac{m}{s}$$

Springs:





$F_{sp} = mg$ $\qquad$ $F_{sp} = 2\,mg$



slope of line = k = spring constant

Hooke's Law: $F_{sp} = k\,(\Delta X)$

vector form: $\vec{F}_{sp} = -k\,\vec{\Delta X}$

$$F_{sp} = k\,\Delta X$$

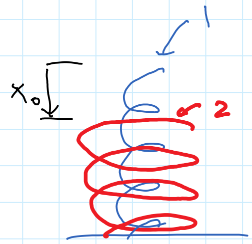
or

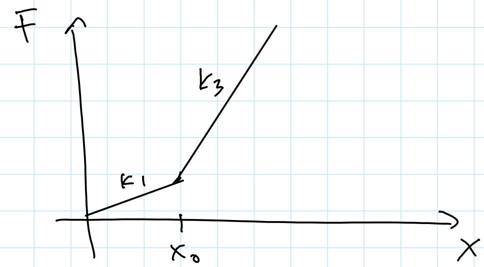
$$F_{sp} = k\,X$$

Amount spring is stretched or compressed

$F_{sp} = k\,x$

spring constant (depends on the spring)





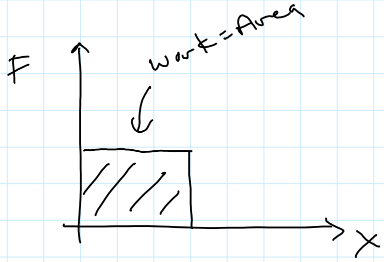
$k_1 < k_2$

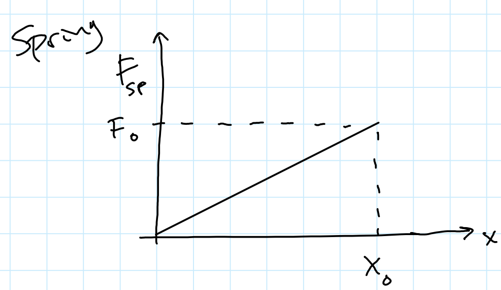
spring constant for spring 1

spring constant for spring 2

k_3 is a combination of k_1 and k_2

Work





$$W = \frac{1}{2} x_0 F_0$$

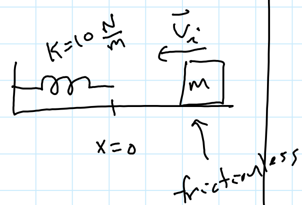
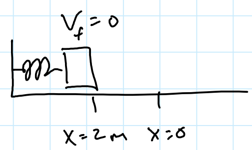
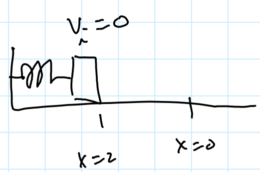
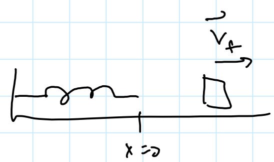
$F_0 = k x_0$

$$W = \frac{1}{2} k x_0^2$$

In general:

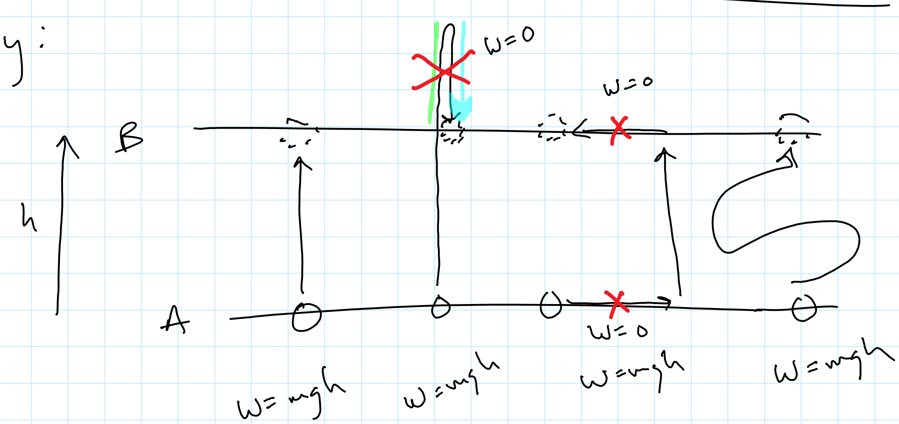
$$\boxed{W_{spring} = \pm \frac{1}{2} k x^2}$$

Spring Examples

	initial	final	Work done on the box by the spring
1)			$\lvert W \rvert = \frac{1}{2}(10)(2)^2$ $\lvert W \rvert = 20\ J$ W is Negative in this case (slowing the box down) $W = -20\ J$
2)			$W = \pm \frac{1}{2} k x^2$ in general $W = +\frac{1}{2} k x^2$ in this case W is positive (speeding the box up) $W = \frac{1}{2}(10)\, 2^2$ $= +20\ J$

Potential Energy:

conservative forces



For every conservative force we make a

For every conservative force we make a Potential Energy term:

can be positive or Negative

gravity: $U_g = mgy$

spring: $U_{sp} = \frac{1}{2} k x^2$

Always positive

Using Energy to solve Problems:

E = mechanical energy

$= K + U_g + U_{sp}$

$$E_i + W_{friction} + W_{ext} = E_f$$

since this is Negative it goes on Left side of equation