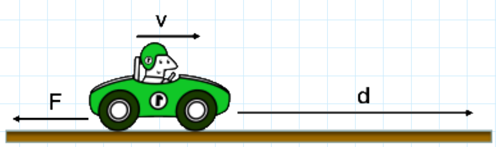
Phy 4A 10/24

Monday, October 24, 2016 9:18 AM

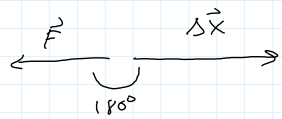
Goals for the Lecture:

1) Be able to calculate work done by constant and variable forces
2) Be able to calculate the scalar product (dot product) of two vectors
3) Understand how defining your system can affect the work done on the system or by the system

A car traveling to the right with a speed v brakes to a stop in a distance d. What is the work done on the car by the frictional force F? (Assume that the frictional force is constant).

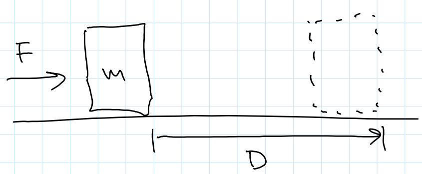


1. W = F*d
2. W = -F*d
3. W = 0
4. W = F*v
5. W = - F*v



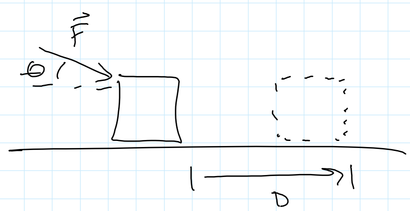
Examples

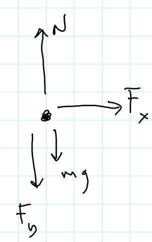
1)



$W = FD$ since F is constant and it points in same direction as $\Delta\vec{x}$

2)

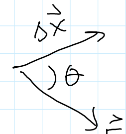




$W = F_x D = F\cos\theta\, D$

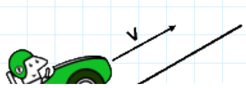
In general: (constant Forces) $W = \vec{F} \cdot \Delta\vec{x}$

$W = |\vec{F}||\Delta\vec{x}|\cos\theta$

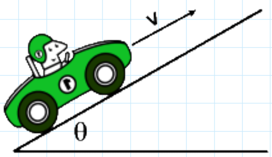


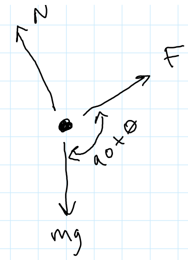
units for work: joule (J)

A car travels with ***a constant velocity v*** for a distance d up a hill that makes an angle θ with respect to the horizontal. What is the work done by the sum of the gravitational force plus the constant upward frictional force F that the hill exerts on the tires of the car?

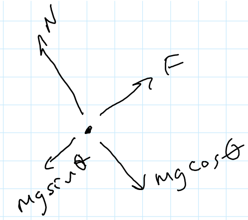


on the tires of the car?





OR



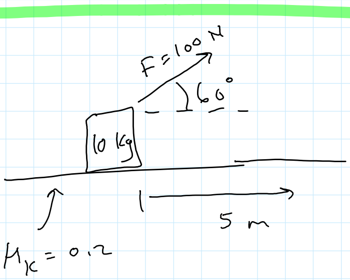
1. W = (mgsinθ)d
2. W = -(mgsinθ)d
3. W = 0
4. W = Fd
5. W = -Fd

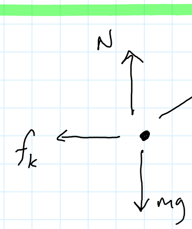
Force	Work done on car
N	$W = N(\Delta x)\cos 90° = 0$
F	$F\,\Delta x \cos 0° = F d$
gravity	$mg\,(\Delta x)\cos(90+\theta) = -mg\sin\theta\, d$
F_{Net}	$W_N + W_F + W_{mg} = \underbrace{0 + Fd - mg\sin\theta\, d}_{\text{must be zero because speed is not changing}}$

$$\boxed{\text{Kinetic energy}: \quad K = \frac{1}{2} m v^2}$$

$$\boxed{\text{Work – KE Theorem}: \quad \sum W = \Delta K}$$

Example





Find the work done by every force acting on the box and the Net work done on the box

Force	Work done on the box
N	$W_N = N(\Delta x)\cancel{\cos 90°}^{0} = 0$
mg	$W_{mg} = (mg)(\Delta x)\cancel{\cos 90°}^{0} = 0$
F	$W_F = F(\Delta x)\cos 60° = 250\ J$
f_k	$W_{f_k} = f_k(\Delta x)\cos 180° = \mu_k N\,\Delta x(-1) = -14\ J$
Net Work	$W_{Net} = W_N + W_{mg} + W_F + W_{f_k}$

Find N:

$\sum F_\perp = 0$

$N + F\sin\theta - mg = 0$

$N = mg - F\sin\theta$

$= 100 - 86$

$= 14$

$= 0 + 0 + 250 - 14$

$= +236 \text{ J}$

if box started from rest, how fast is it moving after 5 m?

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

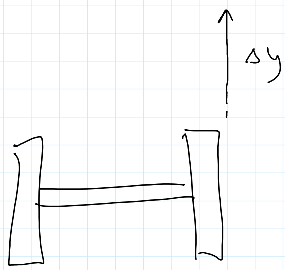
$$= K_f - K_i$$

$$= \frac{1}{2} m v_f^2 - \frac{1}{2} m \cancel{v_i}^{\,0}$$

$$236 = \frac{1}{2}(10) v_f^2$$

$$v_f = 6.9 \text{ m/s}$$

Lifting weights:



work done by you on the barbell
(lift at constant speed)

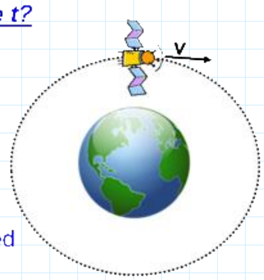
$$W_{up} = mg\,\Delta y \cos 0° = mg\,\Delta y$$

Lower the barbell

$$W_{down} = mg\,\Delta y \cos 180° = -mg\,\Delta y$$

$$W_{Net} = 0$$

A satellite travels with a constant speed |**v**| as it moves around a circle centered on the earth. How much work is done by the gravitational force F on the satellite ***after it travels half way around the earth in time t?***

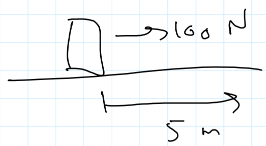


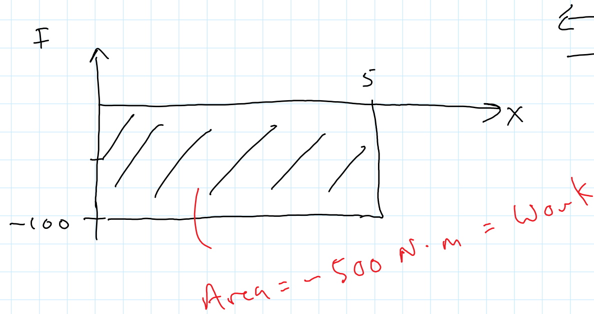
1. Cannot be determined
2. W = 0
3. W = F * |v|t
4. W = -F * |v|t

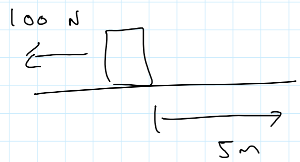
Because $F_g \perp \Delta x$

= work

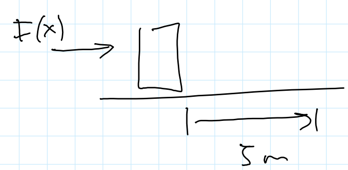
4. W = -F * |v|t





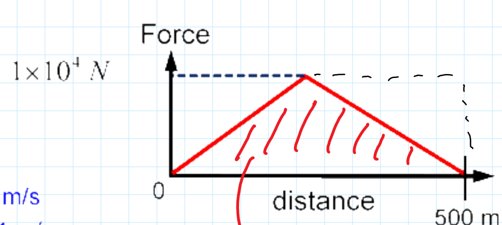


if I give you F vs X graph, find work done:



find work done on box: $w = \frac{1}{2}(100)(5) = 250$ J

The engine of a 1000 kg sports car rotates the tires, creating a forward pushing force F on the tires of the car that varies as a function of distance. The force is shown below. If the car starts at rest, what is the speed of the car after traveling 500 meters?



1. 0 m/s
2. 71 m/s
3. 100 m/s
4. 141 m/s
5. 200 m/s

Area $= \frac{1}{2}(10{,}000)(500) = 2{,}500{,}000 = W_{Net}$

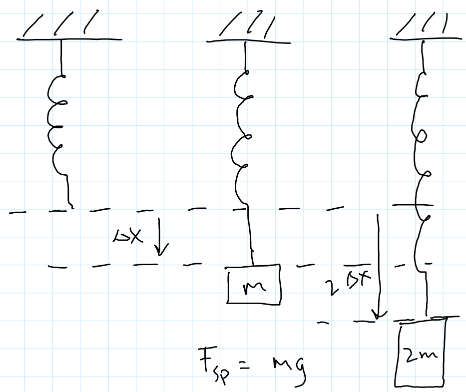
$W_{Net} = \Delta K$

$= \frac{1}{2}mV_f^2 - \frac{1}{2}m\cancel{V_i^2}^{\,0}$

5. 200 m/s

$$W_{net} = \Delta K$$
$$= \frac{1}{2} m v_f^2 - \frac{1}{2} m \cancel{v_i^2} \rightarrow 0$$
$$2{,}500{,}000 = \frac{1}{2}(1000)\, v_f^2$$
$$v_f = 71 \ \frac{m}{s}$$

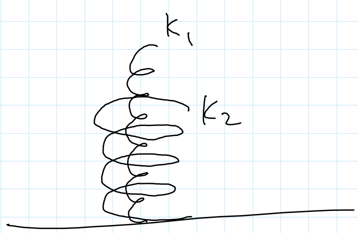
Springs:

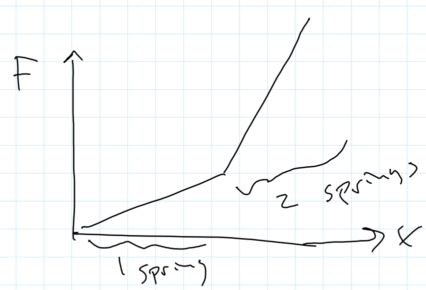


$F_{sp} = 2mg$

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

spring constant





Find the change in KE of each ball:

	initial	final	ΔK
1)	2 kg → 3 m/s	→ 1 m/s	

$$\Delta K = K_f - K_i$$
$$= \frac{1}{2} m v_f^2 - \frac{1}{2} m_i^2$$
$$= \frac{1}{2}(2)(1)^2 - \frac{1}{2}(2)(3)^2$$

$= 1 - 9$

$= -8 \text{ J}$

2) 2 kg

$3\ \frac{m}{s} \quad\quad 5\ \frac{m}{s}$

$\Delta K = K_f - K_i$

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

$= 25 - 9$

$= 16 \text{ J}$

3) 2 kg

$3\ \frac{m}{s} \quad\quad 3\ \frac{m}{s}$

$\Delta K = K_f - K_i$

$= 9 - 9$

$= 0 \text{ J}$

4) 2 kg

$3\ \frac{m}{s} \quad\quad 0\ \frac{m}{s}$

$\Delta K = K_f - K_i$

$= 0 - 9$

$= -9 \text{ J}$

5)

$0\ \frac{m}{s} \quad\quad 3\ \frac{m}{s}$

$\Delta K = K_f - K_i$

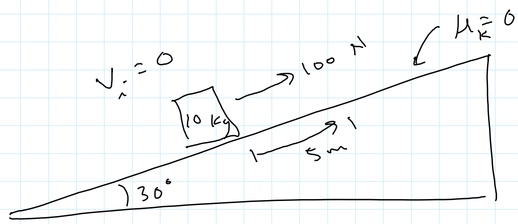
$= 9 - 0$

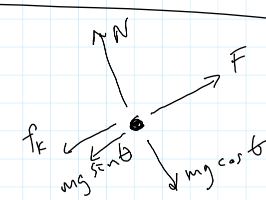
$= +9 \text{ J}$

together 0 J

These 2 together are the same as 3)

Example





Find the work done by every force acting on the box and the final speed of the box

Force	Work Done on Box
N	0
f_k	$f_k (\Delta x) \cos 180°$ $\mu_k (mg \cos 30°)(5)(-1)$ -87 J

	$\mu_k (mg\cos 30^\circ)(5)(-1)$
	$-87\ J$
$mg\sin\theta$	$(mg\sin\theta)(\Delta x)\ \cos 180^\circ$
	$50\ (5)(-1)$
	$-250\ J$
$mg\cos\theta$	0
F	$(100)(5)(\cos 0^\circ)$
	$500\ J$

$$W_{Net} = 0 - 87 + 0 - 250 + 500$$

$$= +163\ J$$

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

$$= K_f - K_i$$

$$= \frac{1}{2} m v_f^2 - \cancel{\frac{1}{2} m v_i^2}^{\,0}$$

$$163 = \frac{1}{2}(10)\ v_f^2$$

$$v_f = 5.7\ \frac{m}{s}$$