Ch 8 + Recap March 18, 2019

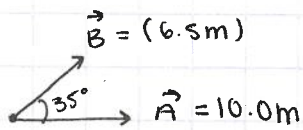
$\boxed{\text{Scalar Product, Dot Product}}$

is a scalar → has magnitude (number & units) but No direction.

* Definition of $\boxed{\vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta}$

$|\vec{A}|$ → magnitude of A
$|\vec{B}|$ → magnitude of B
θ → Angle between $\vec{A}$ + $\vec{B}$ (less than 180°)

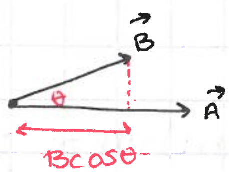
Ex



$\vec{A}\cdot\vec{B} = (10.0m)(6.5m)\cos 35°$

* $\hat{i}, \hat{j}, \hat{k}$ $|\hat{i}| = |\hat{j}| = |\hat{k}| = 1$

angle between $\hat{i}+\hat{k}$, $\hat{i}+\hat{j}$, $\hat{j}+k$, ... = 90°
$\hat{i}+\hat{i}$, $\hat{j}+\hat{j}$, $\hat{k}+\hat{k}$ = 0°



conceptually → $\vec{A}\cdot\vec{B}$ is magnitude of A times how much of $\vec{B}$ points in the direction of $\vec{A}$

$\hat{i}\cdot\hat{i} = \hat{j}\cdot\hat{j} = \hat{k}\cdot\hat{k} = (1)(1)\cos 0° = 1$
$\hat{i}\cdot\hat{j} = \hat{j}\cdot\hat{k} = \hat{k}\cdot\hat{i} = \hat{i}\cdot\hat{k} = \hat{k}\cdot\hat{j} = \hat{j}\cdot\hat{i} = (1)(1)\cos 90° = 0$

RECAP March 19, 2019

Scalar or Dot product of 2 vectors

$\vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta$

$|\vec{A}|$ → magnitude of vector $\vec{A}$
$|\vec{B}|$ → magnitude of vector $\vec{B}$
θ → Angle between $\vec{A}$ and $\vec{B}$

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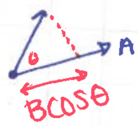


$\vec{A}\cdot\vec{B}$ = (length of $\vec{A}$) x (length of $\vec{B}$ in direction of $\vec{A}$)

unit vectors ⟶ $\hat{i}\cdot\hat{i} = \hat{j}\cdot\hat{j} = \hat{k}\cdot\hat{k} = (1)(1)\cos 0° = 1$

$\hat{i}\cdot\hat{j} = \hat{i}\cdot\hat{k} = \hat{j}\cdot\hat{k} = \hat{j}\cdot\hat{i} = \hat{k}\cdot\hat{i} = \hat{k}\cdot\hat{j} = (1)(1)\cos 90° = 0$

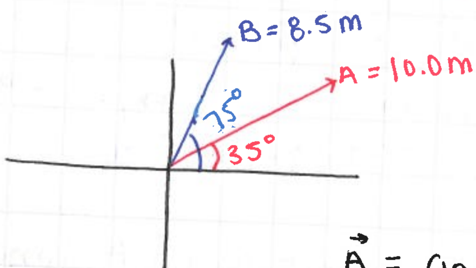
$$\vec{A}\cdot\vec{B} = (A_x\hat{i} + A_y\hat{j} + A_z\hat{k})\cdot(B_x\hat{i} + B_x\hat{j} + B_z\hat{k})$$

$$= A_xB_x\underbrace{\hat{i}\cdot\hat{i}}_{=1} + B_xB_y\underbrace{\hat{i}\cdot\hat{j}}_{=0} + B_xB_z\underbrace{\hat{i}\cdot\hat{k}}_{=0}$$

$$+ A_yB_x\underbrace{\hat{j}\cdot\hat{i}}_{=0} + A_yB_y\underbrace{\hat{j}\cdot\hat{j}}_{=1} + A_yB_z\underbrace{\hat{j}\cdot\hat{k}}_{=0}$$

$$+ A_zB_x\underbrace{\hat{k}\cdot\hat{i}}_{=0} + A_zB_y\underbrace{\hat{k}\cdot\hat{j}}_{=0} + A_zB_z\underbrace{\hat{k}\cdot\hat{k}}_{=1}$$

$$\boxed{\vec{A}\cdot\vec{B} = A_xB_x + A_yB_y + A_zB_z}$$



$$\vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta$$

$$= (10.0m)(8.5m)\cos 40°$$

$$= \underline{65.1 m^2}$$

$$\vec{A} = (10.0m)\cos 35°\hat{i} + (10.0m)\sin 35°\hat{j}$$

$$(8.19m)\hat{i} + (5.74m)\hat{j}$$

$$\vec{B} = (8.5m)\cos 75°\hat{i} + (8.5m)\sin 75°\hat{j}$$

$$(2.20m)\hat{i} + (8.21m)\hat{j}$$

$$\vec{A}\cdot\vec{B} = A_xB_x + A_yB_y + A_zB_z$$

$$= (8.19m)(2.20m) + (5.74m)(8.21m)$$

$$= \underline{65.1 m^2}$$

Reason we care ⟶ $W = \vec{F}\cdot(\Delta\vec{r})$

Problem 9.11A

$\vec{A} = 4\hat{i} - 2\hat{j}$ and $\vec{B} = -2\hat{i} - 3\hat{j}$

$(4)(-2) + (-2)(-3) = \underline{\underline{-2}}$

Problem 9.15

c) Angle is 90°, this means that the answer is 0°

d) $|A||B|\cos\theta$

$(3)(5)\cos 40° = \underline{\underline{11.5}}$

CH.9: Work & Kinetic Energy

- Energy overview

What is Energy?

↳ That property of an object or system that enables it to do work

Exerting a force on an object over a distance

System → defined collection of objects whose interactions we wish to study

Environment → Everything that is NOT part of the System

Internal forces → forces that objects within the System exert on each other

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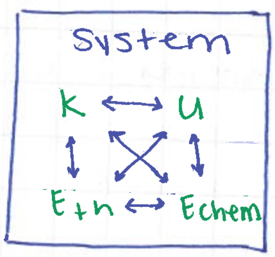
ternal Forces → Forces that objects in the environment exert on objects within the system

asic Energy Model

Environment

is

n



W<0
Energy is removed from the system

Energy within a system is transformed without loss (i.e. $U \rightarrow K \rightarrow E_{chem}$)

Energy can be transferred to or from the System by forces from the environment

- The forces do work on the System
- $W>0$ if energy is added to the system
- $W<0$ if energy is removed from the System

e in the
gy of the
tem.

$$\boxed{\Delta E_{system} = W_{ext}}$$

→ work done by external forces

for an isolated system ($W_{ext}=0$), $\Delta E_{system}=0$

$$\boxed{(E_{system})_f = (E_{system})_i}$$

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Forms of Energy:

K → kinetic energy (energy of motion)

$$\boxed{K = \tfrac{1}{2}mv^2}$$

U_g → gravitational potential energy (stored energy associated with an objects height).

$$\boxed{U_g = mgy}$$

U_{sp} → Elastic or spring potential energy (energy stored when an elastic object is stretched or compressed

$$\boxed{U_{sp} = \tfrac{1}{2}kx^2}$$

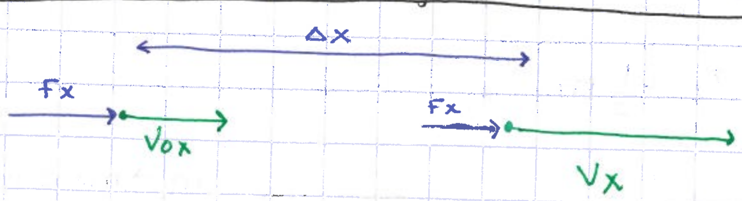
k → spring constant
x → How much spring is stretch or compressed

E_{th} → thermal energy (sum of kinetic & potential energies of all the atoms & molecules in an object)

$$\boxed{\Delta E_{th} = -f_k \cdot \Delta r}$$

E_{chem} → chemical Energy (Energy stored in the bonds between atoms & molecules)
↳ Energy gets released when bonds are broken and/or rearranged.

WORK & K.E. for a single particle (acted upon by a single force)



constant force F_x acting on an object over a displacement of Δx resulting in speed increasing

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$\sum \vec{F} = m\vec{a}$

one-dimensional motion

$\sum F_x = ma_x \longrightarrow F_x = ma_x$ (only one force)

$F_x = m\dfrac{dv_x}{dt}$

$\dfrac{dv_x}{dt} = \dfrac{dv_x}{dx}\dfrac{dx}{dt}$

$= \dfrac{dv_x}{dx} v_x$

$F_x = m\left(\dfrac{dv_x}{dx}\right) v_x$

$F_x = m v_x \dfrac{dv_x}{dx}$

$F_x\,dx = m v_x\,dv_x$

$\int_{x_0}^{x} F_x\,dx = \int_{v_{0x}}^{v_x} m v_x\,dv_x$

$= m\int_{v_{0x}}^{v_x} v_x\,dv_x$

$= m\left[\frac{1}{2}v_x^2\right]\Big|_{v_{0x}}^{v_x}$

$= \frac{1}{2}mv_x^2 - \frac{1}{2}mv_{0x}^2$

$\int_{x_0}^{x} F_x\,dx = \frac{1}{2}mv_x^2 - \frac{1}{2}mv_{0x}^2$

KINETIC ENERGY $\boxed{K = \frac{1}{2}mv^2}$

$m \rightarrow$ mass in kg
$v \rightarrow$ speed in m/s (Not velocity)

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$[K] = \frac{kg\,m^2}{s^2} = (kg\,m/s^2)m = Nm = \text{Joule (J)}$

$$\boxed{1J = 1Nm = 1\frac{kg\,m^2}{s^2}}$$

$$\boxed{\int_{x_0}^{x} F_x\,dx} = \Delta K = K_f - K_i$$

$$= \boxed{\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2}$$

→ change in kinetic Energy

How work is defined

$$W = \int_{x_0}^{x} F_x\,dx$$

→ work = Area under the curve of F vs x

ch 9 March 19, 2019

$[K] = kg\frac{m^2}{s^2} = (kg\, m/s^2)m = Nm = \text{Joule } (J)$

$$\boxed{1J = 1Nm = 1\frac{kg\,m^2}{s^2}}$$

$$\boxed{\int_{x_0}^{x} F_x\,dx} = \Delta K = K_f - K_i$$

$$= \boxed{\tfrac{1}{2}mv_f^2 - \tfrac{1}{2}mv_i^2}$$

→ change in kinetic Energy

How work is defined

$$W = \int_{x_0}^{x} F_x dx$$

→ work = Area under the curve of F vs x

RECAP

March 21, 2019

Dot product or scalar product:

$\boxed{A \cdot B = |\vec{A}||\vec{B}|\cos\theta}$ → Definition of $\vec{A}\cdot\vec{B}$

$$\hat{i}\cdot\hat{i} = \hat{j}\cdot\hat{j} = \hat{k}\cdot\hat{k} = 1$$

$$\hat{i}\cdot\hat{j} = \hat{j}\cdot\hat{k} = \hat{k}\cdot\hat{i} = \hat{i}\cdot\hat{k} = \hat{k}\cdot\hat{i} = \hat{j}\cdot\hat{i} = 0$$

$$\boxed{\vec{A}\cdot\vec{B} = A_xB_x + A_yB_y + A_zB_z}$$

Basic Energy model

Energy is transferred to or from a system by doing work on it.

Environment

Environment adds Energy to the system $W > 0$

System K U_g U_{el} E_{th} E_{chem}

$W < 0$ Environment removes energy from the system

Inside a system energy is transformed without loss.

RECAP + ch. 9 March 21, 2019

$\Delta E_{system} = W_{exp}$

Change in total energy of the System.

Work done by external forces

Work + KE for a single particle

$$\int_{x_0}^{x} F_x\,dx = \frac{1}{2}mV_x^2 - \frac{1}{2}mV_{0x}^2$$

$$\boxed{\int_{x_i}^{x_f} F_x\,dx} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

work done by external forces as object is displaced from x_0 to x

$[K] = [W] =$ Joule (J)

$1J = 1Nm = 1kg\,m^2/s^2$

Kinetic Energy $\boxed{K = \frac{1}{2}mv^2}$ v = speed not Velocity

$$\int_{x_0}^{x} F_x\,dx = \Delta K = K_f - K_i$$

change in kinetic energy of object

1cal = 4186J

1Cal = 1kcal

* The work done on a one-particle System causes the kinetic energy of the particle to change

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$$\int_{x_0}^{x} F_x\,dx = \tfrac{1}{2}mv_f^2 - \tfrac{1}{2}mv_i^2$$

← W = Area under curve of: F_x vs x

W_{ext} ΔK → Derived for a one-particle system but applies to any system.

$W_{total} = W_1 + W_2 + \cdots$ total work done by all forces

K total = total KE of all objects in the system $= K_1 + K_2 + \cdots$

Problem 9.21

$$W = \tfrac{1}{2}mv_f^2 - \tfrac{1}{2}mv_i^2$$

$m = 0.500\,kg$

$v_i = 2.0\,m/s$

v_f: ?

W: Area under the curve

= Area of rectangle (0–1m) + Area of triangle (1m–3m)

$= (1m)(15N) + \tfrac{1}{2}(2m)(15N) = 15J + 15J = 30J$

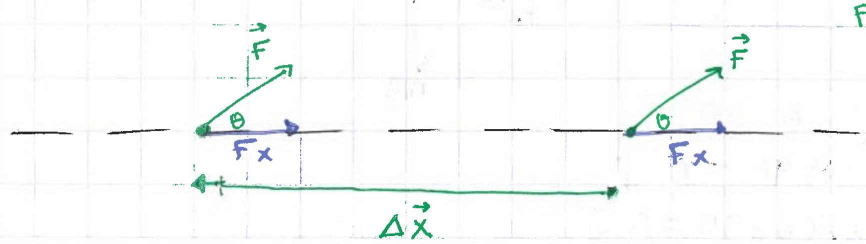
$$\tfrac{1}{2}mv_f^2 = W + \tfrac{1}{2}mv_i^2 \longrightarrow v_f^2 = \frac{2W}{m} + v_i^2 \longrightarrow v_f = \sqrt{\frac{2W}{m} + v_i^2}$$

$$v_f = \sqrt{\frac{2W}{m} + v_i^2} = \sqrt{\frac{2(30J)}{0.500k} + (2.0m/s)^2}$$

$v_f = 11\,m/s$ (speed) $\qquad \vec{v} = +11\,m/s$

Work done by a constant force

$\vec{F}$ = constant



Ch.9

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$$W = \int_{x_0}^{x} F_x \, dx$$

$$= \int_{x_0}^{x} (F\cos\theta)\, dx$$

$$= F\cos\theta \int_{x_0}^{x} dx = F\cos\theta \, (\underbrace{x - x_0}_{=\Delta x})$$

In one dimension, for a constant force: $\boxed{W = (F)(\Delta x)\cos\theta}$

- $F \rightarrow$ magnitude of force
- $\Delta x \rightarrow$ magnitude of displacement
- $\theta \rightarrow$ Angle between $\vec{F}$ and $\Delta\vec{x}$

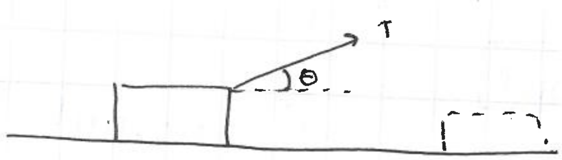
$\boxed{W = (F)(\Delta r)\cos\theta}$ $\rightarrow$ constant force

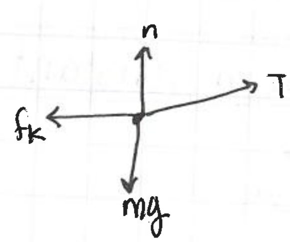
if $0 \le \theta < 90$ $\quad W > 0$ $\quad$ Force is adding energy to the System

if $\theta = 90°$ $\quad W = 0$ $\quad$ Force doesn't add or remove energy

if $90° < \theta \le 180°$ $\quad W < 0$ $\quad$ Force is removing energy from the System

EX





$W_T = (T)(\Delta x)\cos\theta > 0$

$W_n = n(\Delta x)\cos 90 = 0 \text{ J}$

$W_{mg} = mg(\Delta x)\cos 90 = 0 \text{ J}$

$W_{f_k} = (f_k)\cdot(\Delta x)\cos 180° < 0$

RECAP April , 1, 2019

RECAP CH9.

→ Scalar or Dot Product:

$$\boxed{\vec{A}\cdot\vec{B} = |\vec{A}|\,|\vec{B}|\,\cos\theta = A_xB_x + A_yB_y + A_zB_z}$$

→ Basic Energy Model
System
Environment.

$[W] = [J] = $ Joule

$1J = 1Nm = 1\,\frac{kg\,m^2}{s^2}$

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

$$\boxed{\Delta E_{system} = W_{ext}}$$

Total energy of System

work done by the environment

→ Work & KE for a single particle:

$$\boxed{\int_{x_i}^{x_f} F_x\,dx} = \Delta K = \boxed{\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2}$$

Work done by external force as particle is displaced from x_i to x_f

change in kinetic Energy of particle.

→ If there is more than one particle and more than than one force:

$$\boxed{W_{Total} = \Delta E_{system}}$$

Sum of work done by all external forces

Recap

April, 1, 2019

$\boxed{W_{Total} = \Delta K}$ if $\Delta E_{th} = 0$

Work $\boxed{W = \int_{x_i}^{x_f} F_x \, dx}$ → Always true

For a constant force → $\boxed{W = F(\Delta r)\cos\theta}$ → only true

$\boxed{W = \vec{F} \cdot \Delta \vec{r}}$ → if $\vec{F}$ is const.

$W > 0$ $\quad 0° \le \theta < 90°$

$W = 0$ $\quad 90°$

$W < 0$ $\quad 90° < \theta \le 180°$

Due This week:
Tues : PLC #9 due
Wed: lab #7 due
Thurs: Ch.9 HW / Quiz

Ex

$$W_{Total} = \Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

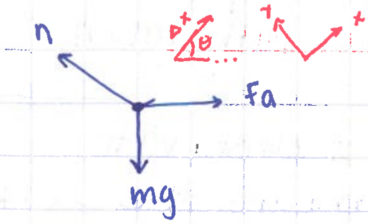
$0 \rightarrow 10\,m/s$

$10\,m/s \rightarrow 20\,m/s$

$$W_{Total} = \frac{1}{2}m(10\,m/s)^2 - \frac{1}{2}m(0)^2$$
$$= \frac{1}{2}m(100)$$

$$W_{Total} = \frac{1}{2}m(20\,m/s)^2 - \frac{1}{2}m(10\,m/s)^2$$
$$= \frac{1}{2}m(400) - \frac{1}{2}m(100)$$
$$= \frac{1}{2}m(300)$$

Problem 9.4



$$W_{total} = \Delta K = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 \; (=0)$$

$$W_{Total} = \frac{1}{2} m v_f^2$$

$$\underbrace{W_n + W_{Fa} + W_{mg}}_{\text{constants}} = \frac{1}{2} m v_f^2$$

$$W = (F)(\Delta r)\cos\theta$$

$n \rightarrow \theta = 90°$

$Fa \rightarrow \theta = 30°$

$mg \rightarrow \theta = 120°$

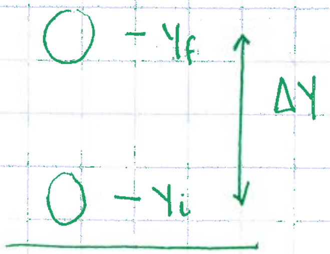
$$W_{Total} = W_n + W_{Fa} + W_{mg}$$
$$= (n)(\Delta x)\cos 90° + (Fa)(\Delta x)\cos 30° + (mg)(\Delta x)\cos 120°$$
$$= 0J + (20.0N)(0.500m)(\cos 30°) + (3.0kg)(9.80m/s^2)(0.500m) \cdot \cos 120°$$
$$= 1.31J$$

$$W_{Total} = \frac{1}{2} m v_f^2$$

$$v_f = \sqrt{\frac{2W_{Total}}{m}} \rightarrow v_f = \sqrt{\frac{2(1.31J)}{(3.0kg)}} \rightarrow \boxed{v_f = 0.935 \, m/s}$$

Conceptual Question 9.7

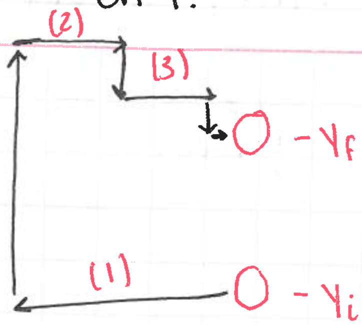
Answer:



$$W = (F)(\Delta r)\cos\theta$$
$$W = (mg)(\Delta Y)\cos 180°$$

$$\boxed{W_{gravity} = -mg\,\Delta Y}$$ → True if object moves straight upwards

Ch 9. April 1, 2019

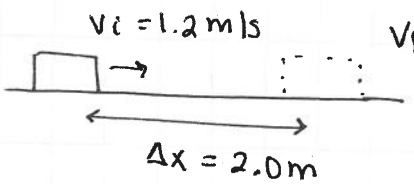


$W_{gravity} = -mg\Delta Y$ regardless of the path taken

(gravity is a conservative force which means the work is path independent

$W_1 = W_2 = W_3 = 0$

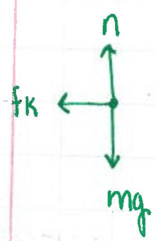
Ex Problem 9.33



$\mu_k = ?$

$m = 15\,kg$

$W_{Total} = \Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$



$\underbrace{W_n}_{=0 \text{ b/c } \theta=90°} + \underbrace{W_{mg}}_{=0 \text{ b/c } \theta=90°} + W_{fK} = \frac{1}{2}\underbrace{mv_f^2}_{=0} - \frac{1}{2}mv_i^2$

$W_{fK} = -\frac{1}{2}mv_i^2$

$(f_K)(\Delta x)\cos 180° = -\frac{1}{2}mv_i^2$

$\mu_K n(\Delta x)(-1) = -\frac{1}{2}mv_i^2$

$\mu_K n(\Delta x) = \frac{1}{2}mv_i^2$

$\mu_K (mg)\Delta x = \frac{1}{2}mv_i^2$

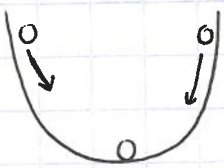
$\mu_K = \dfrac{\frac{1}{2}mv_i^2}{mg\,\Delta x} = \dfrac{v_i^2}{2g\Delta x} = \dfrac{(1.2\,m/s)^2}{2(9.80\,m/s^2)(2.0\,m)}$

$\mu_K = 0.037$

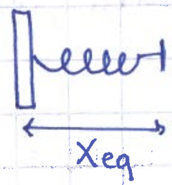
Restoring Forces & the work done by a Spring

Restoring Force → A force that restores a System to its equilibrium position

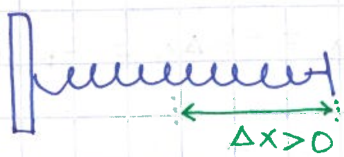
objects that exert restoring forces are called 'elastic'



↑ Equilibrium position: $\Sigma \vec{F} = 0$

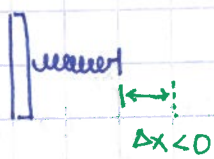


equilibrium length Xeq → Length of the Spring when It is unstretched & uncompressed.



→ spring is stretched

If $\Delta x > 0$, spring exerts a force to the left



→ if spring is compressed

If $\Delta x < 0$, spring exers a force to the right

* force ($\vec{F}_{sp}$) is in the opposite direction to the displacement
* As long as Δx is not too large, $(F_{sp})_x \propto \Delta x$

"Force of spring is proportional to Δx"

Hooke's Law → $\boxed{\vec{F}_{sp} = -k\Delta x}$

force Spring exerts

Δx → displacement from equilibrium position

$\Delta x = x - x_{eq}$

k → Spring Constant

↳ Number that describes how Stiff a spring is

$F = -k\Delta x \rightarrow$ Restoring force

Could you have a force such that
$F = k\Delta x$? NO

$F = -k\Delta x$

*since $(\vec{F}_{sp})$ is not constant, we can not use
$W = (F)(\Delta r)\cos\theta$

Work done by a Spring: $W = \int_{x_i}^{x_f} F_x\,dx$

$(F_{sp})_x = -k\Delta x = -k\,(x - x_{eq})$

$$W = \int_{x_i}^{x_f} (-k\Delta x)\,dx = \int_{x_i}^{x_f} -k\,(x - x_{eq})\,dx$$

$$= -k \int_{x_i}^{x_f} (x - x_{eq})\,dx$$

let $u: x - x_{eq}$
$du = dx$

$$W = -k \int_{\Delta x_i}^{\Delta x_f} u\,du = -\frac{1}{2} k u^2 \Big|_{\Delta x_i}^{\Delta x_f}$$

$$= -\frac{1}{2} k \left[(\Delta x_f)^2 - (\Delta x_i)^2 \right]$$

$$\boxed{W_{spring} = -\left[\frac{1}{2} k\,(\Delta x_f)^2 - \frac{1}{2} k\,(\Delta x_i)^2 \right]}$$

work done by a Spring

$\Delta x_i = x_i - x_{eq}$
$\Delta x_f = x_f - x_{eq}$

RECAP

April 2. 2019

Work & KE for a single particle acted upon by a single force:

$$\boxed{\int_{x_i}^{x_f} F_x dx = \Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2}$$

For more than one particle and/or forces:

$W_{ext} = \Delta E_{system} = \Delta K$ → K = sum of kinetic energy of all particles

↓ sum of work done by all external forces

$\boxed{W = \int_{x_i}^{x_f} F_x dx}$ → Always applies

$W = F(\Delta r)\cos\theta$
$W = \vec{F} \cdot (\Delta \vec{r})$ } ONLY applies if $\vec{F}$ is constant.

Restoring Forces

- sign indicates direction: $\vec{F}$ is always in the opposite direction of Δx

$\boxed{(F_{sp}) = -k\Delta x}$ $[k] = N/m$

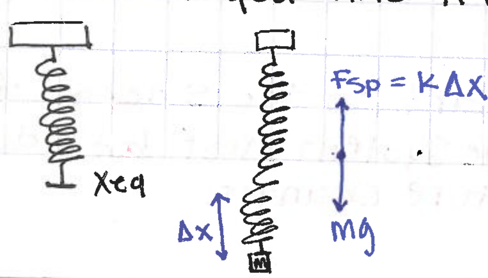
$\boxed{W_{spring} = -\left[\frac{1}{2}k(\Delta x_f)^2 - \frac{1}{2}k(\Delta x_i)^2\right]}$ $\boxed{\Delta x = x - x_{eq}}$

$k = 3.50\ N/m$

↳ It would take 3.5N of force to stretch the spring 1.0m

(the spring exerts 3.5N of force when it is stretched or compressed by 1.0m)

How would you find k of a spring?



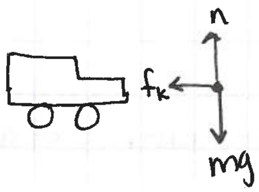
$\Sigma F_y = ma_y = 0$

$k\Delta x - mg = 0$

$k = \frac{mg}{\Delta x}$

$\boxed{W_{ext} = \Delta E_{sys} = \Delta K}$ → True for particles that don't interact so kinetic energy is the only form of energy

Ex



$$W_{fk} = \Delta K = \tfrac{1}{2}mv_f^2 - \tfrac{1}{2}mv_i^2$$
$$= -\tfrac{1}{2}mv_i^2$$

$$f_k \Delta x \cos 180 = -\tfrac{1}{2}mv_i^2$$
$$\mu_k n \Delta x (-1) = -\tfrac{1}{2}mv_i^2$$
$$\mu_k (mg) \Delta x = \tfrac{1}{2}mv_i^2$$
$$v_i^2 = 2\mu_k g \Delta x$$
$$v_i = \sqrt{2\mu_k g \Delta x}$$

$\boxed{W_{ext} = \Delta E_{sys} = \Delta K}$

↳ A macroscopic sized object also has another form of energy called thermal energy E_{th}

↳ The sum of the microscopic kinetic & potential energies of all the atoms & bonds that make up the object.

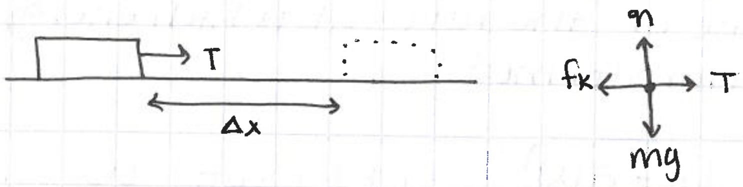
Work-energy principle:

$\boxed{W_{ext} = \Delta E_{sys} = \Delta K + \Delta E_{th}}$

* when including ΔE_{th} as part of the energy of a System, the definition of the System must include all the objects who temperature changes.

CH9. April 2, 2019

Ex Box pulled across rough floor at a constant velocity



System → box + Surface

$\Sigma F_x = ma_x = 0$

$T - f_k = 0$

$T = f_k$

$T = \mu_k n$

$T = \mu_k mg$

$W_{ext} = \Delta K + \Delta E_{th}$

↓

$W_T + \underbrace{W_{mg}}_{=0 \text{ b/c } \cos 90° = 0} = \underbrace{\Delta K}_{=0 \text{ (since vel. is const.)}} + \Delta E_{th}$

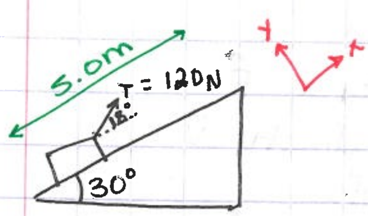
$W_T = \Delta E_{th} \longrightarrow T(\Delta x)\cos 0° = \Delta E_{th}$

$T\Delta x = \Delta E_{th}$

$\boxed{f_k \Delta x = \Delta E_{th}}$ → derived for this generic example but applies in general.

You will use this equation to calculate ΔE_{th}

Problem 34 on book.



$\mu_k = 0.25$

$m = 8.0kg$

a) W done by T, mg, n?

$W = (F)(\Delta r)\cos\theta$

$W_T = 120 \cdot 5.0m \cos 18° = 0.57kJ$

$W_{mg} = -(mg\Delta y)$ $\Delta y = (5.0m)\sin 30° = 2.5m$

$= -(8.0kg)(9.80 m/s^2)(2.5m)$

$= -.20kJ$

OR $W_{mg} = mg(\Delta r)\cos 120°$

$W_n = 0$ b/c $\cos 90° = 0$

b) $\Delta E_{th} = f_k \Delta x$

$= \mu_k n \Delta x$

$\Delta E_{th} = (0.25)(30.81N) \cdot 5.0m$

$\boxed{\Delta E_{th} = 39J}$

$n = mg\cos\theta - T\sin 18°$

$n = (8.0kg)(9.80m/s^2)\cos 30° - 120N\sin 18°$

$n = 30.81N$

CH9

April 2, 2019

Power → Describes the rate at which work is done or the rate at which energy is transformed

$$\boxed{P = \frac{dE_{sys}}{dt}} \quad \text{or} \quad \boxed{P = \frac{dW}{dt}}$$

$[P] = \text{watt} \quad W$

$1W \rightarrow 1 J/s$

100 W light bulb → Every second, 100 J of energy are being transformed
(electrical energy → light & heat)

$$P = \frac{dW}{dt} \qquad W = \vec{F} \cdot \Delta \vec{r}$$

$$dW = \vec{F} \cdot d\vec{r}$$

→ small amount of work done when force $\vec{F}$ acts over a small displacement $d\vec{r}$ (assuming $\vec{F}$ is constant)

$$P = \frac{\vec{F} \cdot d\vec{r}}{dt} = \vec{F} \cdot \frac{d\vec{r}}{dt} = \vec{F} \cdot \vec{v}$$

$$\boxed{P = Fv\cos\theta}$$

F → Magnitude of Force $\vec{F}$
v → Magnitude of velocity $\vec{v}$
θ → angle b/w $\vec{F}$ & $\vec{v}$
P → Rate at which force $\vec{F}$ is doing work.

Chapter 10: Interactions & Potential Energy April 2, 2019

doing in different order than book & simplifying

work-energy principle → $W_{ext} = \Delta E_{syst}$

$= \Delta K + \Delta U_g + \Delta U_{sp} + \Delta E_{th}$

change in gravitational potential energy

change in elastic potential energy