Physics 101
Prof. Bob Ekey
Final

10:00 AM Monday (12/12) 1 PM – 4 PM

Final Review – Part II

Chapters 12, 15 + Thermo (14,18,19)

This is not all inclusive - hits salient points.

Chapter 14,18,19: Thermo

Macroscopic Systems

Characterized as gas, liquid or solid

3 most common phases of matter

Bulk Properties

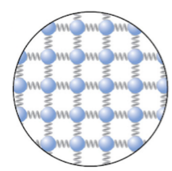
volume, density, pressure, temperature…

Density = mass/volume **Units:** kg/m^3

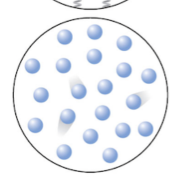
See book table 14.1

Two copper spheres (ρ_{copper}=8920 kg/m^3) of

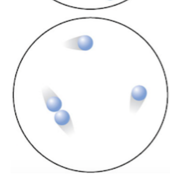
Solid:
Rigid, definite shape
Nearly incompressible



Liquid:
Molecules/Atoms loosely held together
Nearly incompressible



Gas:
Molecules move freely
Collide occasionally
Compressible



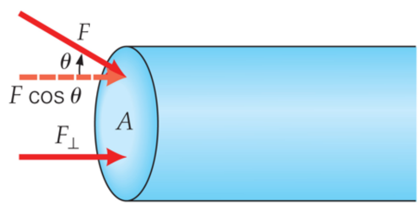
Pressure:

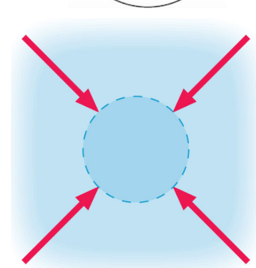
Units: N/m^2 or Pascal (Pa)

Force per unit area

$$p = \frac{F_\perp}{A} = \frac{F\cos\theta}{A}$$

Force acts normal (perpendicular) to the surface area





The forces of a fluid push in *all* directions.

Why can you walk across the snow in snowshoes,

Avg. Atmospheric pressure at sea level
1 atm = 760 mm Hg = 1.013 x 10^5 N/m^2

Total Force from Pressue differernces: $F_{tot,pressure} = \sum_i p_i A = \Delta p A$ (*typically*)

"Vacuum" refers to zero Pressure

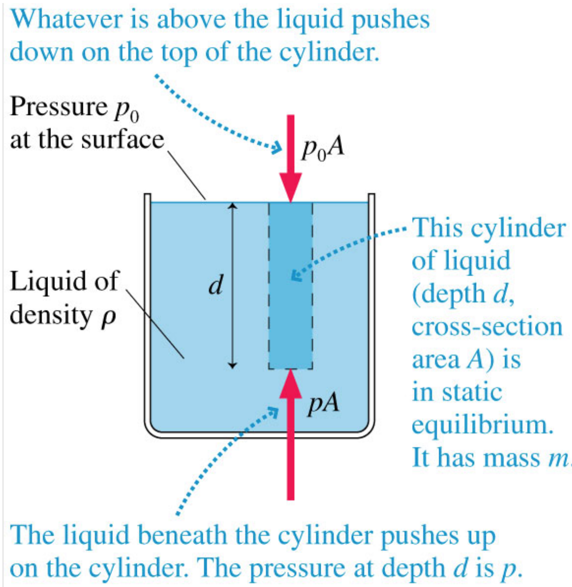
Hydrostatic pressure as a function of depth

Pressure at bottom of a glass of liquid, depends on the force of gravity acting on all particles above the area.

$$p = p_o + \rho g d$$

p_o - air pressure above liquid surface (usually atm press)

Valid for an incompressible fluid with constant density



Ideal Gas Law: What is that constant anyway?

$$\frac{pV}{T} = \text{Constant} = Nk_b$$

k_b - Boltzmann's constant = 1.38 x 10^{-23} J/K
N - number of molecules in the gas

Need to have pressure in Pa (N/m^2), Volume in m^3 and Temperature in K

Also expressed as number of moles (mol) $n = N/N_A$

Advagadro's number: N_A = 6.02 x 10^{23} particles per mol

Ideal gas in terms of n. $R = N_A k_b$

$$pV = Nk_bT = nRT$$

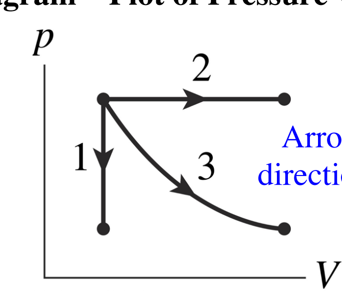
n – number of moles of the gas.
R – universal gas constant = 8.31 J/(mol K)

Ideal-gas process: The means by which the gas changes from one state (V, p, T) to another. Assume that N or n doesn't change.

$$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$$

#1 : Isochoric (constant V) – P, T change
#2 : Isobaric (constant P) – V, T change
#3 : Isothermal (constant T) - P, V change

pV diagram – Plot of Pressure vs Volume

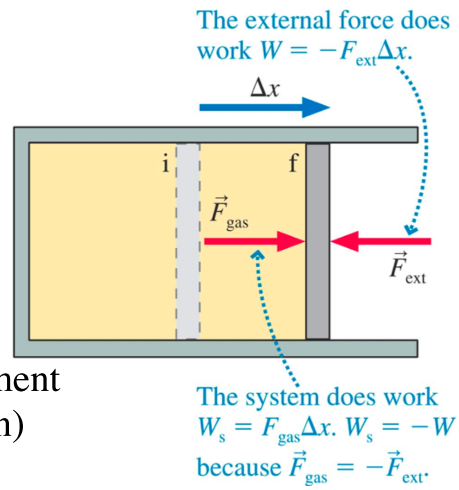


Arrow indicates direction of process

Work: Thermo-style

Moveable piston of area, A.
Net force causes piston to move.
Force external and/or from pressure

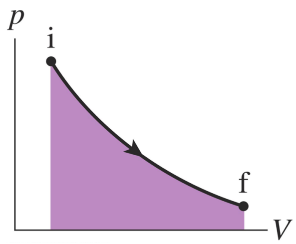
$$W = \int_i^f F ds = \int_i^f (F/A) A ds = \int_{V_i}^{V_f} p dV$$



Either think of the gas doing work on environment or work being done on the gas (opposite in sign)

Work done on the gas
Chapter 19

$$W = -\int_{V_i}^{V_f} p dV$$



W = =area under the pV curve between Vi and Vf

W > 0 Gas Compressed
Energy trans from env to gas (sys)

W < 0 Gas Expands
Energy trans from gas (sys) to env

W = 0 No work is done
volume = constant

Work done by the gas W_s = -W

$$W_s = \int_{V_i}^{V_f} p dV$$

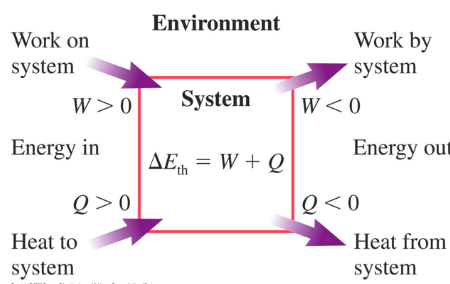
Be sure to check your signs

First Law of Thermodynamics

Energy Conservation (ch11)

$$W_{External} = \Delta E_{mech} + \Delta E_{th}$$

+ Q – Energy transferred in thermal interactions
Ignore Mechanical energy ($\Delta E_{mech} = 0$)



First 1st law of Thermo

$$\Delta E_{th} = W + Q$$

The change in thermal energy, depends on the sum of the total energy exchanged through Work on the system/gas (W) and Heat transferred to the system (Q), not the process.

This table is huge… seriously not just in size, but in application as well.

Process	Definition	Stays constant	Work	Heat
Isochoric	$\Delta V = 0$	V and p/T	$W = 0$	$Q = nC_V\Delta T$
Isobaric	$\Delta p = 0$	p and V/T	$W = -p\Delta V$	$Q = nC_P\Delta T$
Isothermal	$\Delta T = 0$	T and pV	$W = -nRT\ln(V_f/V_i)$	$\Delta E_{th} = 0$
Adiabatic	$Q = 0$	pV^γ	$W = \Delta E_{th}$	$Q = 0$
All gas processes	First law $\Delta E_{th} = W + Q = nC_V\Delta T$		Ideal-gas law $pV = nRT$	

Molar Specific Heat of Ideal Gases

Change in thermal energy of gas (ΔEth) same for any two processes that have the same ΔT

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

C_V = molar specific heat at const. volume

C_V= 12.5 J/(mol K) for any monatomic gas

$C_P = C_V + R$ = molar specific heat at const. pressure

See table 19.4 for other Molar Specific Heats

Heat needed at constant Volume for ΔT

$$Q = nC_V \Delta T$$

Heat needed at constant Pressure for ΔT

$$Q = nC_P \Delta T$$

Adiabatic Process (Q=0)

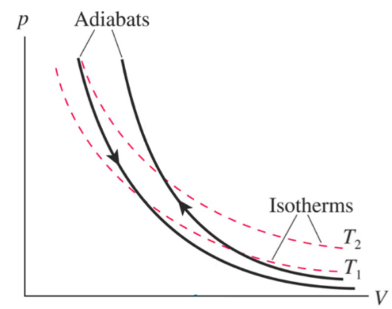
no heat exchange (rapid or well insulated process)

$$p_f V_f^\gamma = p_i V_i^\gamma$$

$$T_f V_f^{\gamma-1} = T_i V_i^{\gamma-1}$$

$$\gamma = C_p / C_V$$

Specific heat Ratio
1.67 for monotomic gas
1.40 for diatomic gas



Specific Heat **Units:** J/(kg K)

Amount of energy needed to change the temperature of 1 kg of substance by 1 ºC or K.

Substance dependent, equal amounts of energy transferred to different substances will generally not have the same change in temperature.

$$Q = Mc\Delta T$$

1st Law, W=0

Q – energy added by heating **Units:** Joules
ΔT – temperature change of substance **Units:** ºC or K
M – total mass of substance **Units:** kg
c – specific heat of substance **Units:** J/(kg ºC)

See table 19.2 for list of specific heats.

Heat Exchange: Mix substances at different temps – watch the results

Calorimetry – quantitatively measure heat exchange

Heat energy is transferred from system 1 to system 2 (or 3 or 4...)
For a closed/isolated system
Energy is conserved (W=0)

$$Q_{net} = \sum Q = Q_1 + Q_2 + \ldots = ZERO$$

Phase Changes and Latent Heat

Heat that goes into breaking attractive bonds and separating their molecules, rather than increasing the temperature.

$$L = \frac{|Q|}{m}$$

L, Latent Heat: **Units:** J/kg or kcal/kg

"magnitude of heat needed per unit mass to induce a phase change"

See table 19.3 for a table of latent heats + freezing/boiling points

Setup the following problems

14.5

A 1.0 m diameter vat of liquid is 2.0 m deep. The pressure at the bottom of the vat is 1.3 atm. What is the mass of the liquid in the vat?

Ans: 2.4×10^3 kg

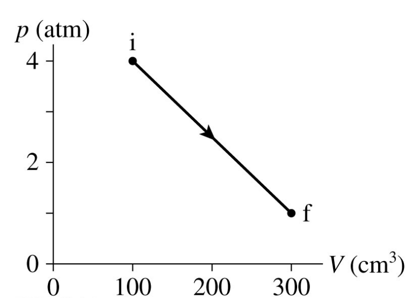
19.47

Your 300 mL cup of coffee is too hot to drink when served at 90ºC. What is the mass of an ice cube taken from a -20ºC freezer that will cool your coffee to a pleasant 60ºC?

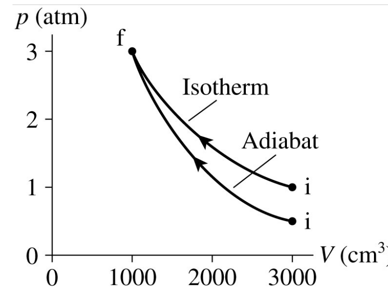
Ans: 61 g

19.79

The figure shows a thermodynamic process followed by 0.015 mol of hydrogen. How much heat is transferred to the gas? Ans: 36J (Ti=325 K, Tf=244K, ΔEth=-15.2J)



Conceptual/MC Questions



For the following process shown, what is true?
(a) The heat energy transferred the adiabatic process is greater than the isothermal process.
(b) The work done by the gas in the isothermal process is less than the work done in the adiabatic process.
(c) The temperature final is the same for each process
(d) The ΔEth is the same for each process.

Ans: c. By the ideal gas law, PV/T = constant. The final P and V are the same, thus they must have the same temperature. The other answers require understanding the first law of thermodynamics and work.

You have two containers of equal volumes. One is full of helium gas, the other holds an equal mass of argon gas. Both gasses have the same pressure. How does the temperature of the helium compare to the temperature of the argon?

(a) $T_{He} > T_{Ar}$
(b) $T_{He} < T_{Ar}$
(c) $T_{He} = T_{Ar}$
(d) Dunno

Ans: b. Via the ideal gas law PV=nRT. With volume and pressure the same, the temperature depends on the number of mols (n). With equal masses, the more massive particle has less mols. From the periodic table, the molar mass of Ar is greater than He, thus the number of mols of argon is less than helium. Thus the temperature of Argon is greater than that of Helium.

Chapter 12: Rotation of a Rigid Body

Center of Mass - "balancing point"

"point at which all of the mass of an object or a system may be considered to be concentrated" "mass-weighted center of the object"

Describe the motion of a many particle system w.r.t. the C of M.

Why? Because it is easier, and the same physics apply.

A "free" object will rotate around its center of mass.
Model object/system as if it were concentrated at multiple points

$$x_{cm} = \frac{1}{M}\sum_i m_i x_i = \frac{m_1x_1 + m_2x_2 + m_3x_3 + ...}{m_1 + m_2 + m_3} \qquad y_{cm} = \frac{1}{M}\sum_i m_i y_i = \frac{m_1y_1 + m_2y_2 + m_3y_3 + ...}{m_1 + m_2 + m_3}$$

The center of mass of an object may not necessarily lie
- at the center of the object
- at the location of the most massive particle in the object
- within the object

Rotational Kinetic Energy: **Units:** Nm or J

$K_{rot} = \frac{1}{2} I\omega^2$ Check the units

What's the sign of rotational KE?

Moment of Inertia, I Rot. equiv. of mass **Units:** kg m^2

$$I = \sum_i m_i r_i^2$$

Moment of inertia depends on the axis of rotation, and the distance of the masses from the axis.

Moment of inertia for combined/unknown system

If you know both objects moment of inertia, then just add them up.

$$I_{sys} = I_1 + I_2 + I_3 + \ldots$$

Parallel axis-theorem. Moment of inertia about an axis that is parallel to one through its center of mass a distance, d, from c. of m.

$$I = I_{\text{CM}} + Md^2$$

Moment of inertia…

Notice they all have the same form.
times mass times length squared

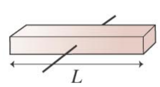
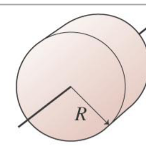
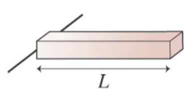
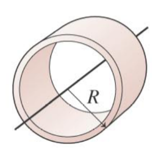
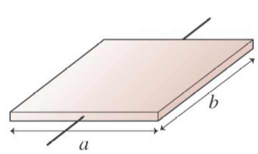
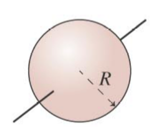
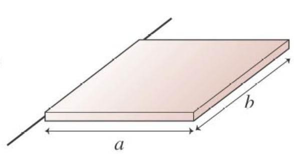
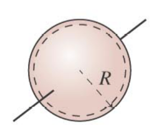
Point Particle

$I = mr^2$

Multiple Point Particles

$$I = \sum_i m_i r_i^2$$

TABLE 12.2 Moments of inertia of objects with uniform density

Object and axis	Picture	I	Object and axis	Picture	I
Thin rod, about center		$\frac{1}{12}ML^2$	Cylinder or disk, about center		$\frac{1}{2}MR^2$
Thin rod, about end		$\frac{1}{3}ML^2$	Cylindrical hoop, about center		MR^2
Plane or slab, about center		$\frac{1}{12}Ma^2$	Solid sphere, about diameter		$\frac{2}{5}MR^2$
Plane or slab, about edge		$\frac{1}{3}Ma^2$	Spherical shell, about diameter		$\frac{2}{3}MR^2$

You will have this for the final

How does a seesaw work?
What's a lever good for anyway?

Vector

Torque (τ) – can cause rotations   Units: Nm (not J)

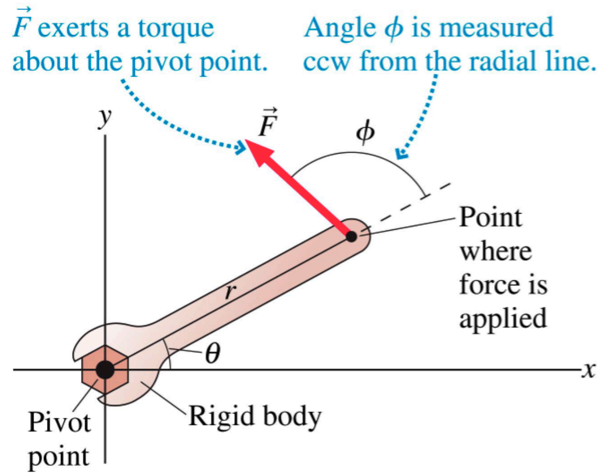
Rotational equivalent of force. "effectiveness of force in causing rot."

$$\tau \equiv rF\sin\phi$$

magnitude

Depends on the magnitude of the applied force F
The distance, r, from the point of application to the pivot
The angle ϕ between the force and radius vector

CCW Torques are positve
CW Torques are negative



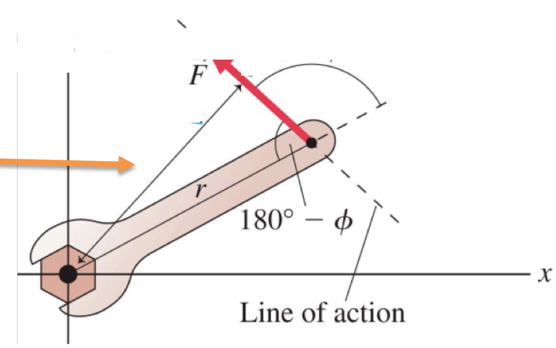
Torques and moment arms

Alternatively the distance (d=r sin ϕ) from the pivot point to the line of action (the line along which the force acts)

$$|\tau| = dF = (r\sin\phi)F$$

d is called the moment/lever arm

Angle between d and F is 90º



Newton's II law for rotations

"An object's angular acceleration is equal to the torque exerted on it divided by its moment of inertia (rotational mass). The angular acceleration is in the same direction as the torque."

$$\vec{\tau}_{net} = \sum \vec{\tau}_i = I\vec{\alpha}$$

I, moment of inertia (rotational mass)

"If the net torque on an object is not zero, the object will undergo an angular acceleration."

Static Equilibrium (balanced and/or stable)

Net force and Net torque equal zero

$$\vec{F}_{net} = \sum \vec{F}_i = 0 \qquad \vec{\tau}_{net} = \sum \vec{\tau}_i = 0$$

translational and rotational equilibrium condition

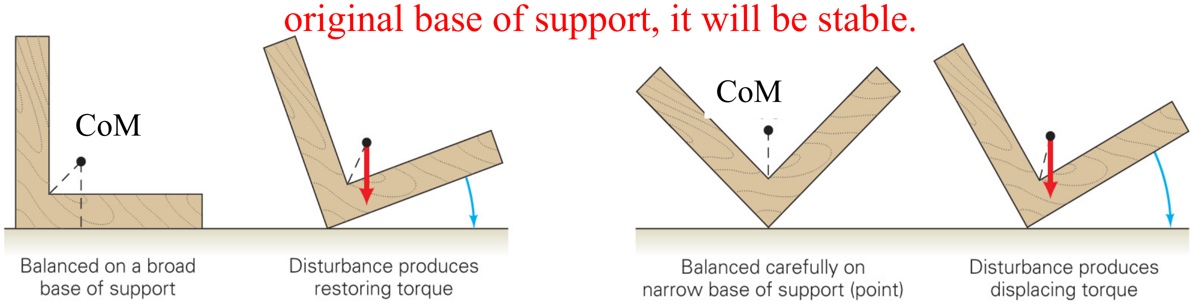
Unbalanced forces produce translational acceleration

Unbalanced torques produce rotational acceleration

Stable Equilibrium – Any small displacement results in restoring force or torque, which tends to return the object to its original equilibrium position.

Unstable Equilibrium – Any small displacement results in a torque, which tends to rotate the object farther from its equilibrium position.

As long as the center of mass (CoM) still lies inside and above the objects original base of support, it will be stable.



Translation and Rotation Motion (how we move)

Rigid Body – object where distance between particles are fixed

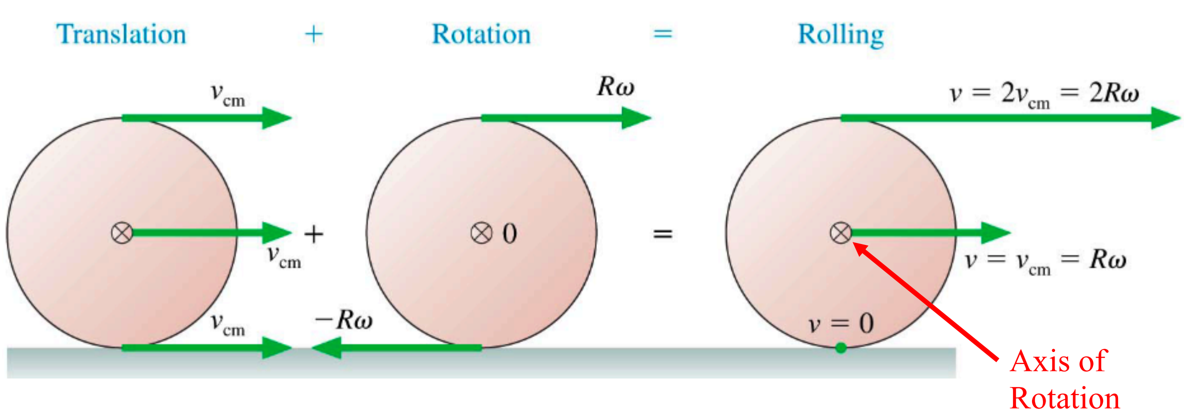
Translational motion – Linear motion

Pure Translation- particles have same instantaneous velocity

Rotational Motion – Rotational motion about a fixed axis

Pure Rotation- particles have same instantaneous angular velocity

Rolling – Combination of both (Curve Ball, Slice, Fade, “English”)



Rolling without slipping (we want static friction)

Can relate Translation and Rotation motion

For a ball/cylinder - Center of mass over point of contact

Arc Length	Velocity	Acceleration
$s = r\theta$	$v_{cm} = r\omega$	$a_{cm} = r\alpha$

Kinetic Energy of a rolling body

A rolling body has both translational and rotational kinetic energy

$$K_{rolling} = \tfrac{1}{2} I_{cm}\omega^2 + \tfrac{1}{2} M v_{cm}^2$$

Total KE = Rotational KE + Translational KE of CoM

Using the no slipping condition $v_{cm} = r\omega$ you can write this as

$$K_{rolling} = \tfrac{1}{2} I_{cm}\left(\frac{v_{cm}}{r}\right)^2 + \tfrac{1}{2} M v_{cm}^2 = \tfrac{1}{2} I_{cm}\omega^2 + \tfrac{1}{2} M (r\omega)^2$$

Total Mechanical Energy

Same as b4, except we have rotational KE

$$E_{mech} = K + U$$

Conservation of total ME – for no slip rolling systems

$$K_f + U_f = K_i + U_i = E_{Tot} \ (CONSTANT)$$

Vector

Angular Momentum, L

Units: kg m^2/s

$$\vec{\mathbf{L}} = I\vec{\omega}$$

For a point particle

$$L = mr^2\left(\frac{v_t}{r}\right) = mrv_t$$

Points in the same direction as ω (RHR)

Can rewrite Newton's II law for rotations in terms of L.

$$\vec{\tau}_{net} = I\vec{\alpha} = I\frac{\Delta\vec{\omega}}{\Delta t} = \frac{\Delta(I\vec{\omega})}{\Delta t} = \frac{\Delta\vec{L}}{\Delta t} = \frac{d\vec{L}}{dt}$$

"The angular momentum of an isolated system (net torque = 0) is conserved. The total initial and final angular momentum are equal"

$$\vec{\tau}_{net} = \frac{\Delta\vec{L}}{\Delta t} = ZERO$$

$$\Delta\vec{L} = \vec{L}_f - \vec{L}_i = 0$$

$$\vec{L}_f = \vec{L}_i$$

Ang mom con

Keep track of total "L" before and after

$$\sum \vec{L}_f = \sum \vec{L}_i \qquad recall \quad L = I\omega$$

Notice to change L either change the angular velocity or the moment of inertia

Recall ice-skater.

Setup the following problems

12.22

A 4.0-m-long 500 kg steel beam extends horizontally from the point where it has been bolted to the framework of a new building. A 70 kg construction worker stands at the far end of the beam. What is the magnitude of the torque about the point where the beam is bolted into place?

Ans: 12.5 kNm

12.26

A 1.0 kg ball and a 2.0 kg ball are connected by a 1.0 m long rigid, massless rod. The rod is rotating cw about its center of mass at 20 rpm. What torque will bring the balls to a halt in 5.0 s?

Ans: 0.28 Nm ccw

12.79

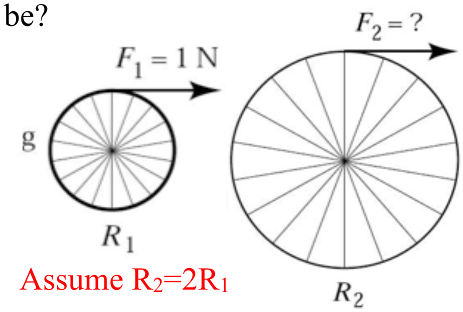
A 200g , 40 cm diameter turntable rotates on a frictionless bearing at 60 rpm. A 20 g block sits at the center of the turntable. A compressed spring shoots the block radially outward along a frictionless groove in the surface of the turntable. What is the turntable's angular velocity when the block reaches the outer edge?

Ans: 50 rpm

Conceptual/MC Questions

Two wheels with fixed hubs, each having a mass of 1.0 kg, start from rest, and have the forces shown below applied to them. Assume the hubs and spokes are massless, so that the rotational inertia is $I=mR^2$. In order to impart identical angular accelerations, how large must F_2 be?

(a) 0.25 N
(b) 0.50 N
(c) 2.0 N
(d) 4.0 N



Assume $R_2=2R_1$

Answer: (c) The radius doubles, which quadruples the moment of inertia. The torque is doubled by the increase in radius. As the angular acceleration is the torque over the moment of inertia the result is to halve the angular acceleration unless the force is also doubled.

Two wheels initially at rest roll the same distance without slipping down identical inclined planes starting from rest. Wheel B has twice the radius but the same mass as wheel A. All the mass is concentrated in their rims, so that the rotational inertias are $I=mR^2$. Which has more translational kinetic energy when it gets to the bottom?

(a) Wheel A
(b) Wheel B
(c) The kinetic energies are equal
(d) need more information

Answer: (c) For each wheel, the gain in total kinetic energy (translational plus rotational) equals the loss in gravitational potential energy. Because the two wheels have identical mass and roll down the same distance they both lose the same amount of potential energy. Both wheels also have the same ratio of translational to rotational kinetic energy, so their translational kinetic energies are the same.

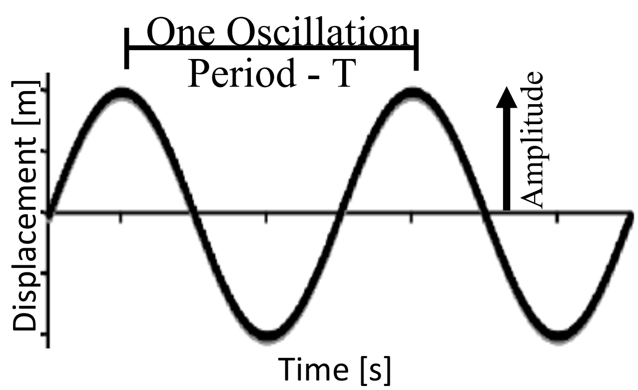
Chapter 15: Oscillations

Simple Harmonic Motion (SHM) $\quad X(t) = A\sin(\omega t)$

Harmonic Motion – anything that repeats itself at regular intervals

Simple – special case for sinusoidal oscillations

Things that undergo SHM are SH Oscillators (SHO)



Period, T – time it takes for one oscillation **Units**: s $\quad T = \dfrac{1}{f}$

Frequency, f – # of oscillations in one second **Units**: Hz

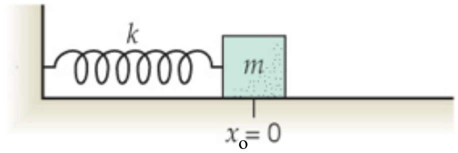
Angular Frequency, $\omega = 2\pi f = \dfrac{2\pi}{T}$ **Units**: rad/sec

Displacement – displacement from equilibrium (±x) **Units**: m

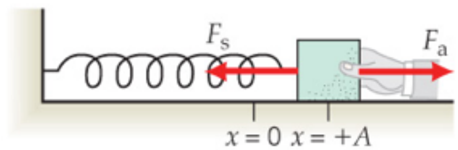
Amplitude, A – max displacement from equilibrium **Units**: m

Horizontal Mass/Spring system

Friction Free



Equilibrium



Stretched from Equilibrium

$\longrightarrow$ +x

Hooke's Law:

$$F_s = -kx \quad if \quad x_o = 0$$

Direction of force opposite of displacement

k- spring constant

"restoring force"

If you apply a Force of 10 N to stretch the system 10 cm from equilibrium, what is the spring constant of the spring?

$$F_{net} = -F_s + F_a = 0$$

$$F_a = kx$$

After you let go what is the net force on the mass? Does it accelerate?

$$F_{net} = F_s$$

$$ma_{net} = -kx$$

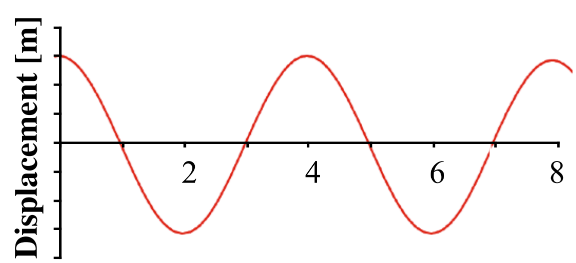
Acceleration proportional to the negative of displacement

$$a(t) = -\frac{k}{m}x(t)$$

Sketch the motion

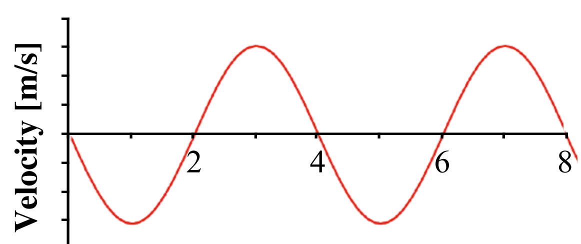
Use previous page. Slopes?

Note: + to the right, - to the left

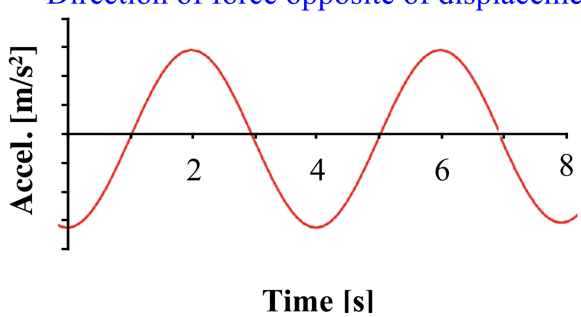


What's the period? ω?

$$T = 4.0 \ s \qquad \omega = \frac{2\pi}{T} = \frac{\pi}{s} rad/s$$



Direction of force opposite of displacement



Equations of motion.
For an initial displacement A in the +x direction.

$$x(t) = A\cos\omega t = x_{\max}\cos\omega t$$

$$v(t) = \tfrac{d}{dt}x(t) = -\omega A\sin\omega t = -v_{\max}\sin\omega t$$

$$a(t) = \tfrac{d}{dt}v(t) = -\omega^2 A\cos\omega t = -a_{\max}\cos\omega t$$

Amplitudes for equations of motion

$$x_{\max} = A$$

$$v_{\max} = \omega A$$

$$a_{\max} = \omega^2 A$$

Does period depend on amplitude or gravity?

Mass/Spring System: ω, f, and T relations

Angular Frequency, ω — Frequency, f — Period, T

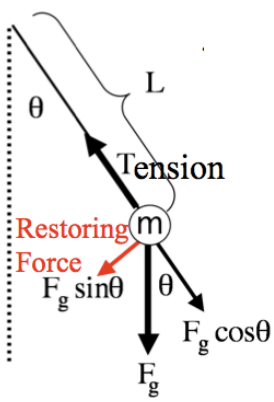
$$\omega = \sqrt{\frac{k}{m}} \quad \text{(rad/s)} \qquad f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \quad \text{(1/s or Hz)} \qquad T = 2\pi\sqrt{\frac{m}{k}} \quad \text{(s)}$$

Equations valid for small angles θ<10º

Pendulum: ω, f, and T relations (small angles ~ 10º)

Angular Frequency, ω — Frequency, f — Period, T

$$\omega = \sqrt{\frac{g}{L}} \quad \text{(rad/s)} \qquad f = \frac{1}{2\pi}\sqrt{\frac{g}{L}} \quad \text{(1/s or Hz)} \qquad T = 2\pi\sqrt{\frac{L}{g}} \quad \text{(s)}$$



Can define equations of motion for angular displacement

$$\theta(t) = \theta_o \cos\omega t$$

But we'll only deal with mass/spring system equations of motion

Do you need the mass of the pendulum bob?

Total Energy (ch10 review?)

Constant for conservative system

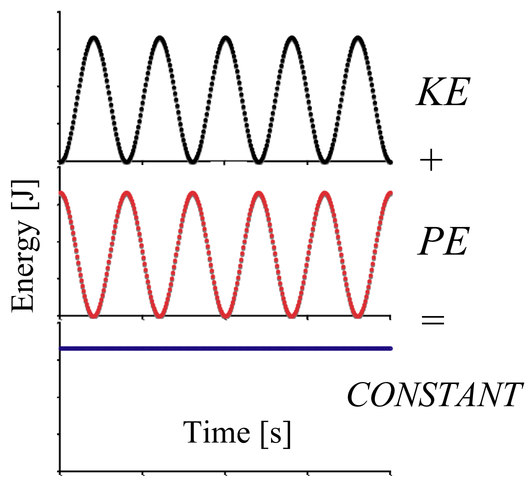
Friction Free

$$E = K + U = \tfrac{1}{2}mv^2 + \tfrac{1}{2}kx^2$$

Total Energy in system

$$E = \tfrac{1}{2}mv_{max}^2 = \tfrac{1}{2}kA^2$$

Note: $v_{max} = \sqrt{\frac{k}{m}}A = \omega A$



Useful Algebra (you are welcome)

Mass/Spring velocity: $v = \pm\sqrt{\tfrac{k}{m}(A^2 - x^2)}$

Mass/spring position: $x = \pm\sqrt{A^2 - \tfrac{m}{k}v^2)}$

Mass/spring amplitude: $A = \sqrt{x^2 + \tfrac{m}{k}v^2}$

At what point in the motion is KE max? is this v_{max} or a_{max}?

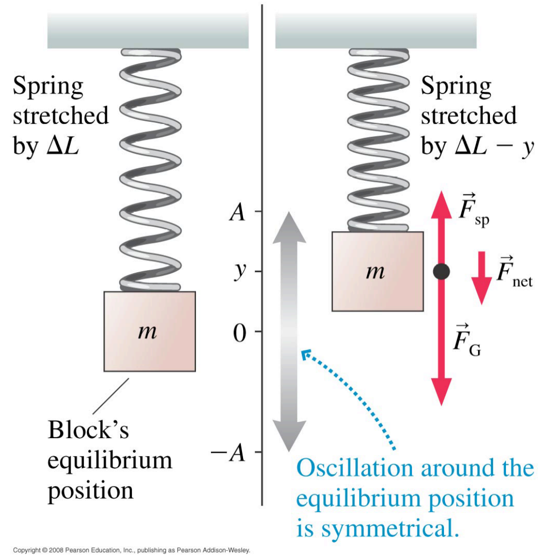
At what point in the motion is PE a max? is this v_{max} or a_{max}?

Vertical Mass/Spring

Static Equilibrium
(ΔL stretch of spring)

$$F_{net} = F_{sp} - F_g \quad = 0$$
$$F_{net} = k\Delta L - mg = 0$$

$$\boxed{\Delta L = \frac{mg}{k}}$$



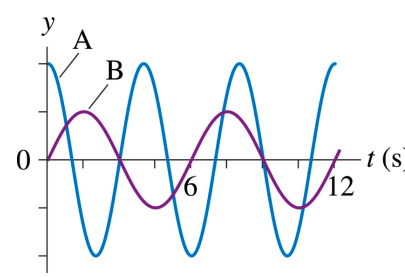
Let the block oscillate around this equilibrium position

$$\left(F_{net}\right)_y = \left(F_{sp}\right)_y + \left(F_g\right)_y = k(\Delta L - y) - mg$$
$$= \left(k\Delta L - mg\right) - ky = -ky$$

Equations same as before… which is nice.

Be careful, value given may be from unstretched length,
Not equilibrium.

15.32 Setup the following problems



The two graphs shown are for two different vertical mass-spring systems. (a)What is the frequency of system A? When is the first time at which the mass has a max speed while traveling in the upward direction? (b)What is the period of system B? What is the first time at which the energy is all potential? (c)If both systems have the same mass, what is the ratio of k_A/k_B? Ans: (a) f=0.25 Hz, 3.0 s (b) T=6.0s, 1.5s (c) 9/4

15.46
A 200 g block hangs from a spring with spring constant 10 N/m. At t=0 s the block is 20cm below the equilibrium position moving upward with a speed of 100 cm/s. What are the block's (a)Oscillation frequency (b) Distance from equilibrium when the speed is 50 cm/s. (c) Amplitude of oscillation? Ans: (a) 1.1 Hz (b) 0.23 m (c) 0.245 m

Conceptual/MC Questions

You and your trusty vertical mass-spring system are on the moon. Which statement about the system is false? Recall that the acceleration due to gravity on the moon is 1/6 of the value found on earth.

(a) The oscillation period on the moon is the same as when you are on earth.
(b) At equilibrium, the net force on the mass is zero.
(c) At equilibrium on the moon the spring is stretched further than when on the earth.
(d) The period is the same regardless of the amplitude of oscillation.

Answer: (c) At equilibrium, the net force on the mass would be zero and the spring force would equal the gravitational force. The force due to gravity on the mass would be 1/6 less than if you were on earth. So, the spring would be stretched 1/6 as much as if it were on the earth.

You also took a pendulum with you to the moon, by what would the period of the oscillation on the moon change by in comparison to the period on earth?

(a) 1/6
(b) $\sqrt{6}$
(c) 6
(d) $1/\sqrt{6}$

Ans: (b). Set up the ratio of the period on the moon and on earth. All but the acceleration due to graving cancel. Plug in the gravity on the moon in terms of the gravity on earth… solve.

$$\frac{T_{moon}}{T_{earth}} = \frac{2\pi\sqrt{L/g_{moon}}}{2\pi\sqrt{L/g_{earth}}} = \sqrt{\frac{g_{earth}}{g_{moon}}} = \sqrt{\frac{g_{earth}}{\frac{1}{6}g_{earth}}} = \sqrt{6}$$