Physics 2101
Section 3
March 29th

Announcements:

- Grades for Exam #3 posted
- Next quiz about Ch. 14 should be Mar. 31st

Class Website:

http://www.phys.lsu.edu/classes/spring2010/phys2101-3/

http://www.phys.lsu.edu/~jzhang/teaching.html

Pascal's Principle

Blaise Pascal (1623-1662)

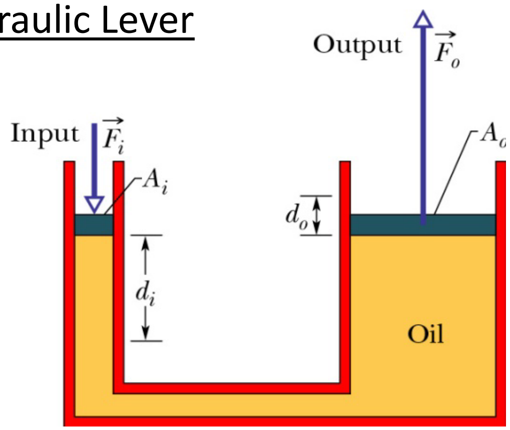
A change in the pressure applied to an enclosed incompressible fluid is transmitted throughout by the same amount.

What is the pressure 100m below sea level?

$$p_{100m} = 1 \cdot atm + 9.7 \cdot atm = 10.7 \cdot atm$$

"Transmitted" throughout the whole 100m

Hydraulic Lever



"Mechanical Advantage"

$$p_{out} = p_{in}$$

$$\frac{F_{out}}{A_{out}} = \frac{F_{in}}{A_{in}}$$

$$F_{out} = F_{in}\frac{A_{out}}{A_{in}}$$

Incompressible Fluid:

$$V = d_{in}A_{in} = d_{out}A_{out}$$

$$d_{out} = d_{in}\frac{A_{in}}{A_{out}}$$

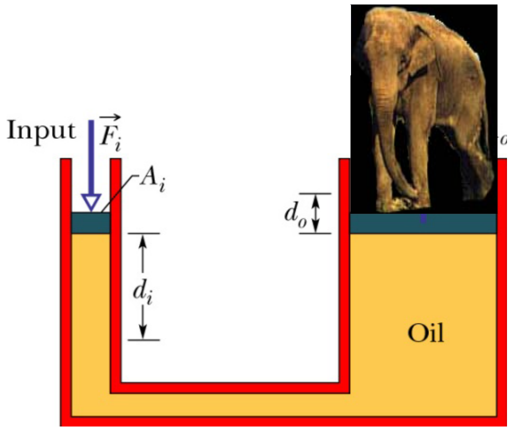
Work:

$$W_{out} = F_{out}d_{out} = \left(F_{in}\frac{A_{out}}{A_{in}}\right)\left(d_{in}\frac{A_{in}}{A_{out}}\right)$$

$$= F_{in}d_{in} = W_{in}$$

With a hydraulic lever, a given force applied over a given distance can be transformed to a greater force over a smaller distance

Examples of Pascal's Principle



A change in pressure applied to a completely enclosed fluid is transmitted undiminished to all parts of the fluid and the enclosing walls

P is the same!

A person m=75kg stands on circular piston A (diameter=0.40m) of a hydraulic pump. If you want to lift an elephant weighing 1500kg, what is the minimum diameter of circular piston B?

$$P = \frac{F_A}{A_A} = \frac{F_B}{A_B}$$

$$A_B = A_A \frac{F_B}{F_A}$$

$$\pi\left(\frac{d_B}{2}\right)^2 = \pi\left(\frac{d_A}{2}\right)^2 \frac{F_B}{F_A}$$

$$d_B = 2\left(\frac{d_A}{2}\right)\sqrt{\frac{F_B}{F_A}}$$

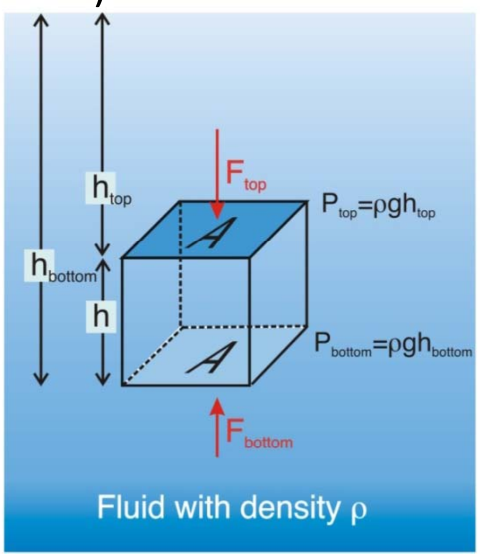
$$= 1.8m$$

Buoyancy and Archimedes' Principle

Archimedes' (287?-212 BC)

Buoyancy - lift a rock under water - its light
- take it above water - its heavy
  - many objects float - how?
  - Force of gravity points downward
  - buoyant force is exerted upward by fluid

Consider a cube in a fluid with density ρ and area A.
(forget about the pressure on top of the fluid, i.e. atmospheric pressure)



1) At top, fluid exerts a force on cube:

$$F_{top} = P_{top}A = \rho g h_{top} A$$ **DOWNWARD**

2) At bottom, fluid exerts a force on cube:

$$F_{bottom} = P_{bottom}A = \rho g h_{bottom} A$$ **UPWARD**

3) Net force due to "fluid" is **bouyant force**:

$$F_{buoyant} = F_{bottom} - F_{top} = \rho g (h_{bottom} - h_{top}) A$$

$$= \rho g h A = \rho g V$$ **UPWARD**

$$= m_{fluid} g$$ **= weight of displaced fluid**

Buoyancy and Archimedes' Principle

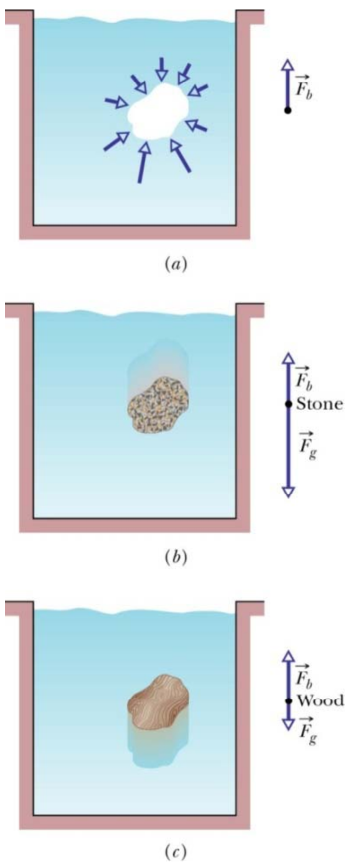
Buoyant Force - is equal to the weight of fluid displaced by the object
- is directed UPWARDs

$$F_B = m_F g$$

UPWARD

- Does not depend on the shape of the object ONLY volume.

- Applies to partially or completely immersed object

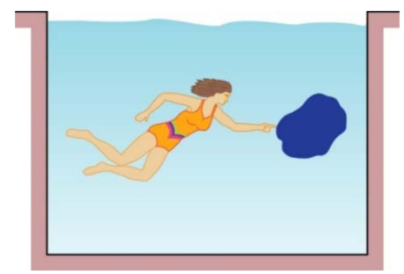


A stone drops

$(F_B - mg) < 0 \quad a \rightarrow \text{downward}$

Wood will rise

$(F_B - mg) > 0 \quad a \rightarrow \text{upward}$

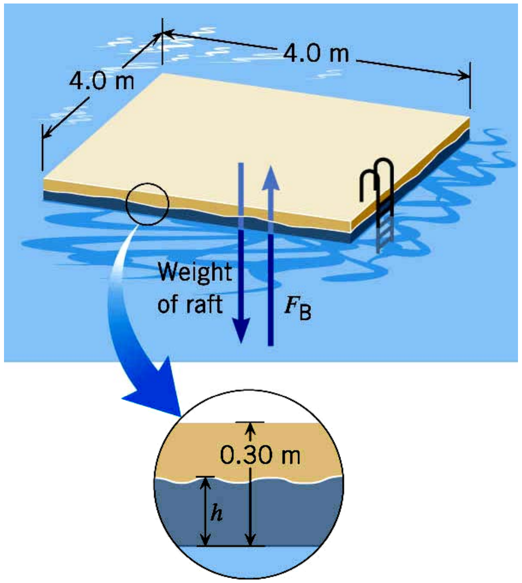


A "bag" of water stays put

$(F_B - mg) = 0 \quad a = 0$

Buoyancy

A wooden raft is 4 m on a side and 30 cm thick. How much of the raft is below the water? (ρ_{wood} = 550 kg/m^3)



$$W_{raft} = m_{raft} g = \rho_{raft} V g$$
$$= (550 kg/m^3)(4 \cdot 4 \cdot 0.3 m^3)(9.8 m/s^2)$$
$$= 25900 N$$

$$W_{raft} = W_{waterdisplaced} = \rho_{water} V_{water} g$$
$$V_{water} = \frac{25900 N}{(1000 kg/m^3)(9.8 m/s^2)}$$
$$= 2.64 m^3$$

$$V_{water} = 2.64 m^3 = (16 m^2) h$$
$$h = 0.17 m$$
$$= 17 cm$$

What happens if the density of wood is more or less?

Buoyancy and Archimedes' Principle

Two cups are filled to the same level with water. One cup has ice cubes floating in it. Which weighs more? (yes, some of the ice is sticking up out of the water)

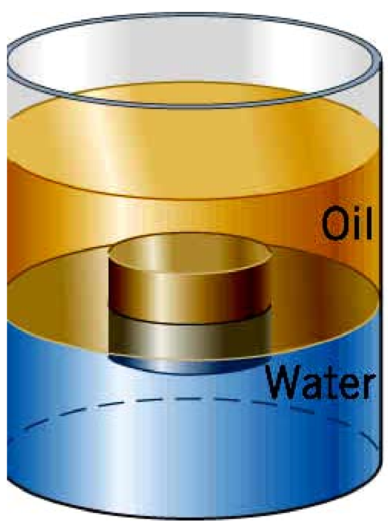
1. The cup with the ice cubes.
2. The cup without the ice cubes.
3. The two weigh the same.

Since the ice weighs exactly the same as the displaced fluid and the levels of the water are the same, the two weigh the same.

Consider an object that floats in water but sinks in oil. When the object floats in water half of it is submerged. If we slowly pour oil on the top of the water so it completely covers the object, the object

1. moves up.
2. stays in the same place.
3. moves down.

When the oil is poured over the object it displaces some oil. This means it feels a buoyant force from the oil in addition to the buoyant force from the water. Therefore it rises higher.



Question 14-1

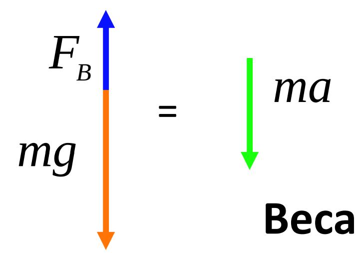
You are on a distant planet where the acceleration due to gravity is half that on Earth. Would you float more easily in water on that planet?

1. Yes, you will float higher
2. Floating would not be changed.
3. No, you will float deeper.

The ratio of your weight and the buoyant force from the water keeps the same!

Archimedes' Principle : Apparent weight in a fluid

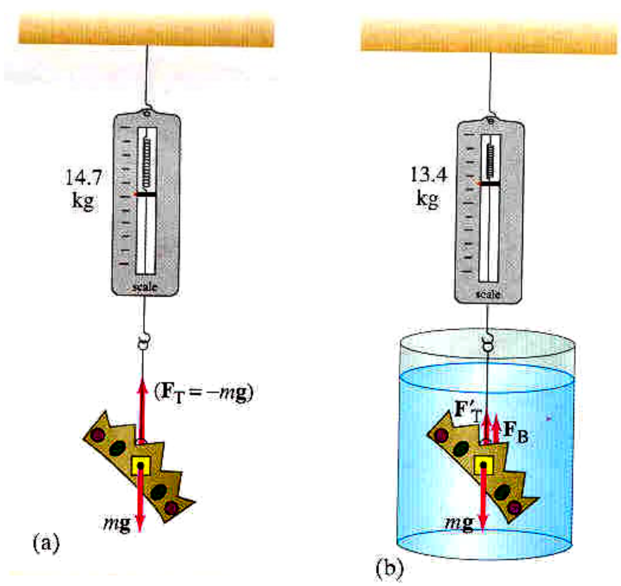
Weigh in air, then weigh in water. From this, and knowing ρ_{water} you can get object's ρ.



$$Weight_{apparent} = Weight_{actual} - F_B$$

Because of buoyant force, apparent weight in water is less than actual weight

Archemedes' : Is the King's crown gold??? (Hiero III 306-215 BC)



$$Weight_{apparent} = Weight_{actual} - F_B$$
$$= \rho_{crown} Vg - \rho_{water} Vg$$

Is it gold???

$$\frac{W_{actual}}{W_{actual} - W_{apparent}} = \frac{\rho_{crown} Vg}{\rho_{water} Vg} = \frac{\rho_{crown}}{\rho_{water}}$$

Specific gravity

$$\left(\frac{14.7 \cdot kg}{14.7 \cdot kg - 13.4 \cdot kg} \right) = 11.3 \quad ???$$

Specific gravities:	
Gold (Au)	19.3
Lead (Pb)	11.3

$$13.4 = 14.7 - F_B$$

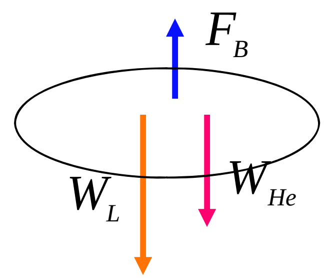
$$\rho_{water} Vg = 1.3N \qquad V = 1.3 \times 10^{-4} m^3$$

$$\rho_{crown} = \frac{14.7}{Vg} = 11300 \, {kg}/{m^3}$$

Helium Blimps

Length 192 feet Width 50 feet Height 59.5 feet
Volume 202,700 cubic feet **(5740 m^3)**
Maximum Speed 50 mph Cruise Speed 30 mph
Powerplant: Two 210 hp fuel-injected, air-cooled piston engines

What is the maximum load weight of blimp (W_L) in order to fly?



The "fluid" blimp is in is: air

$$\rho_{He} = 0.179 \cdot kg/m^3 \quad \& \quad \rho_{air} = 1.21 \cdot kg/m^3$$

At static equilibrium $\sum F = 0: \quad W_{He} + W_L = F_B$

$$W_L = F_B - W_{He}$$

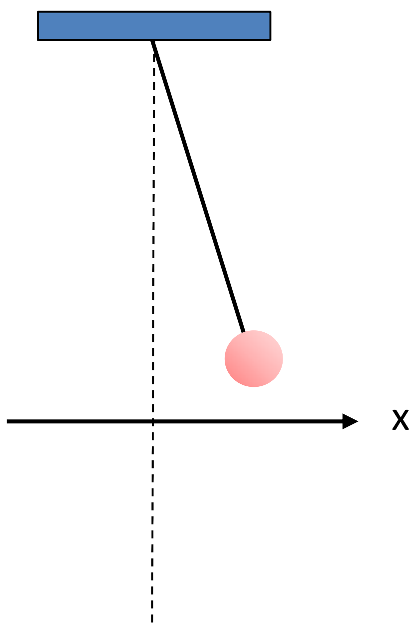
$$W_L = m_{air} g - m_{He} g$$
$$= \rho_{air} V_{ship} g - \rho_{He} V_{ship} g$$
$$= V_{ship} g (\rho_{air} - \rho_{He})$$
$$= (5740 \cdot m^3)(9.8 \cdot m/s^2)(1.21 - 0.179 \cdot kg/m^3)$$
$$= \underline{58 \cdot kN = 13{,}000 \cdot lbs}$$

"Maximum Gross Weight 12,840 pounds"

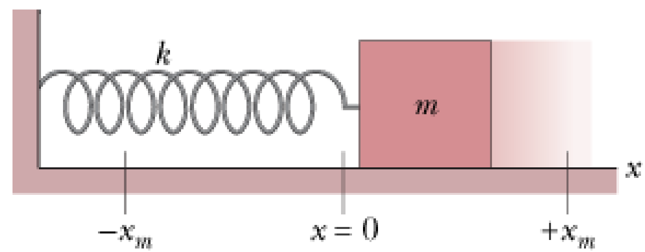
Chapter 15 : Oscillations

Motions that Repeat themselves in a well prescribed way (i.e. period)

Swing a **red ball** back and forth with certain angular frequency *f*



Moving a mass m back and forth on a frictionless with certain angular frequency ω

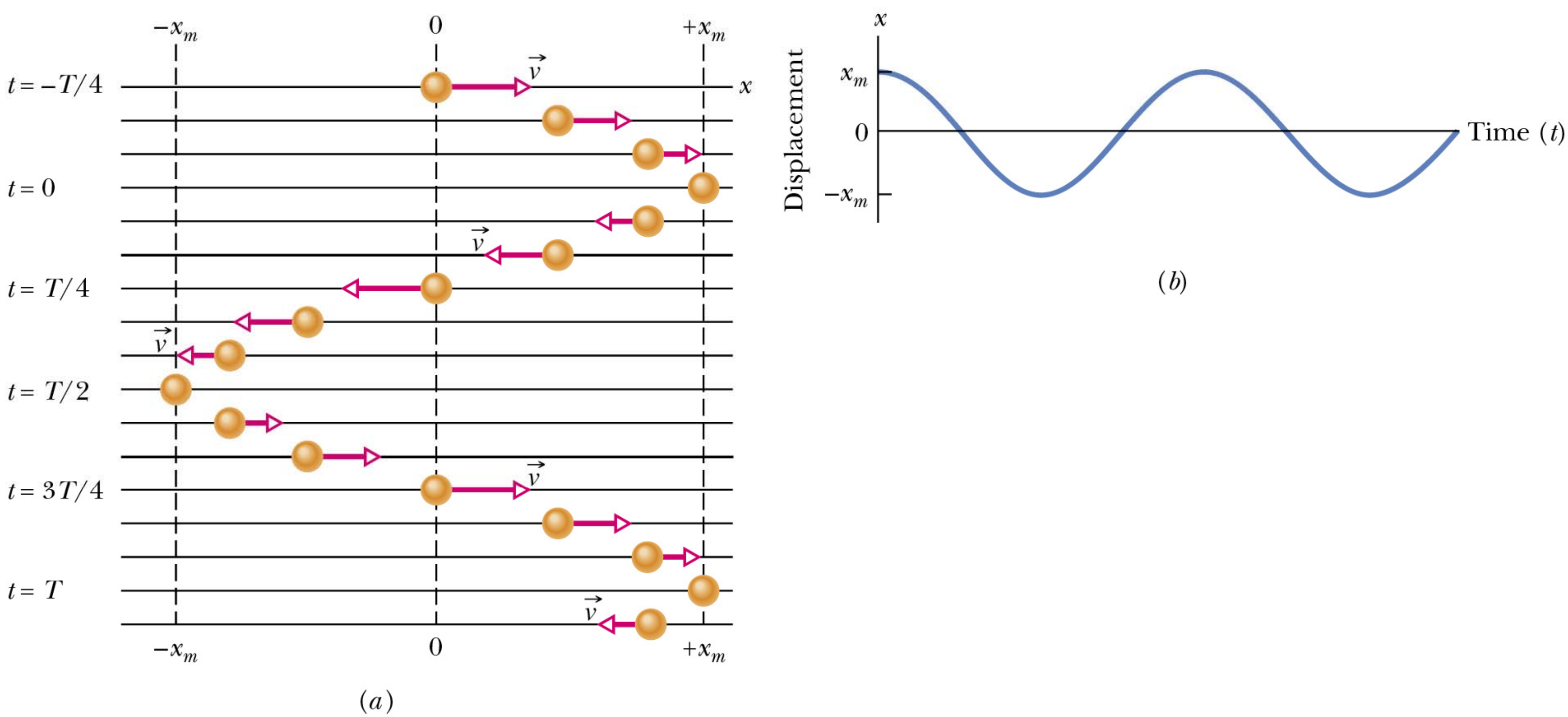


Kinematics:
position: $x(t)$
velocity: $v(t)$
acceleration: $a(t)$

Dynamics:
driving force
energy

Chapter 15 : Oscillations

Motions that Repeat themselves
in a well prescribed way (i.e. period)

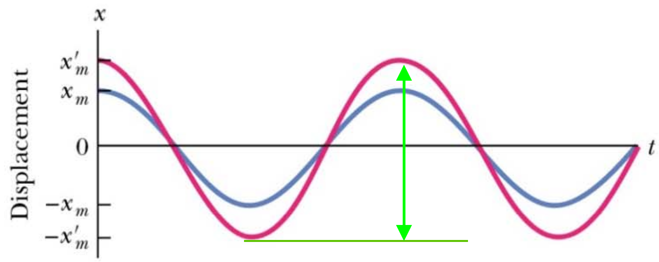


Oscillations characteristics

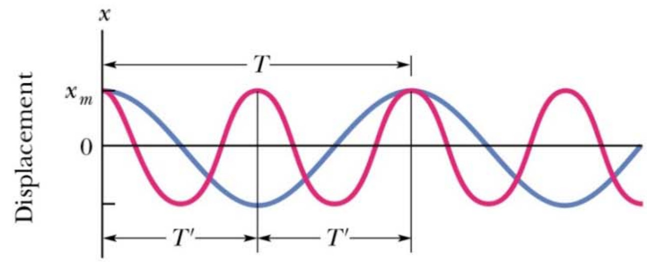
Frequency *f* (# of oscillations/second) -- Units: hertz = 1 Hz = 1 oscillation/s = 1 s^{-1}

Period *T* (time for one oscillation - cycle) = $1/f$

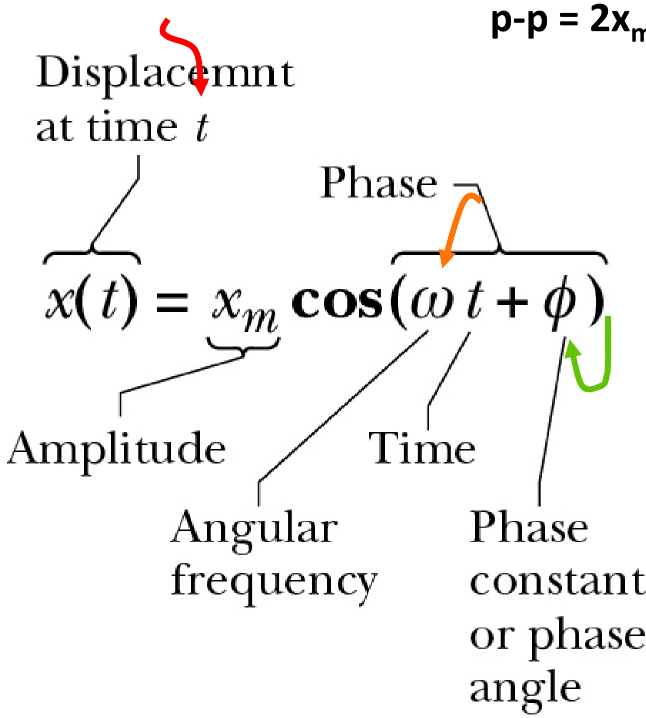
$$\omega = 2\pi f \rightarrow T = \frac{2\pi}{\omega} \rightarrow \omega T = 2\pi$$



p-p = $2x_m$

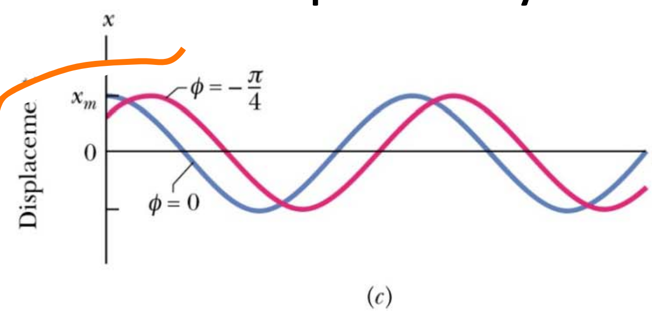


1 period = 1 cycle



$$x(t) = x_m \cos(\omega t + \phi)$$

$$\omega = \frac{2\pi}{T}$$



Don't forget to put your calculator in "RADIAN" mode