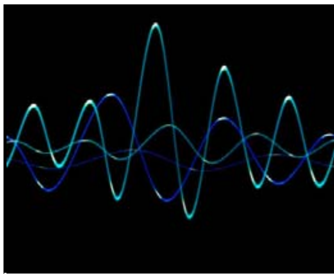


Unit 4: Oscillatory Motion and Mechanical Waves

4.1 Simple Harmonic Motion

Oscillatory Motion - repetitive back and forth motion (ie. wings, strings vibrating, electrical current)

Cycle - one complete oscillation

Period - the amount of time it takes to complete one revolution

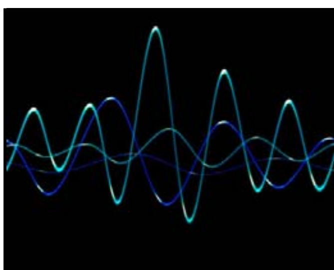
Frequency - oscillations/cycles per second

$$\boxed{f = 1/T}$$

$T = \frac{1}{f}$

f = frequency in hertz (Hz) or cycles/second

T = period (seconds)



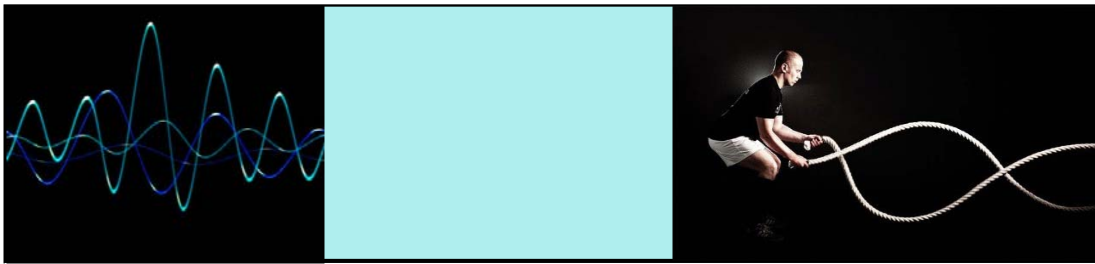
Ex.) The wings of a Canadian Goose flap 200 times per minute.

a) What is the frequency of the flap?

b) What is the period of the flap?

a) $\frac{200 \text{ times}}{60 s} = \frac{f}{1 s}$ $\boxed{f = 3.\bar{3} Hz}$

b) $T = \frac{1}{f} = \boxed{0.3 s \text{ to flap once}}$

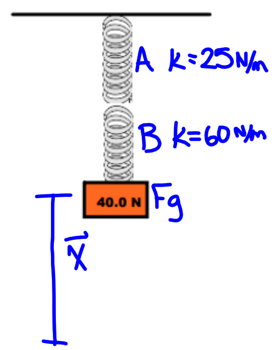


An oscillating object needs a force to keep it going. When the force comes from inside the system it is called a **restoring force**. Any oscillating system which has a restoring force acting against the displacement to keep an object in motion is a simple harmonic oscillator and exhibits simple harmonic motion.

One example is this mass sliding along a frictionless surface attached to a spring. The spring is providing the restoring force to this system:

Analyze this motion in further detail on page 355. Then look at a vertical set up on page 356.

Ex.) Two springs are hooked together and one end is attached to a ceiling. Spring A has a k = 25 N/m and spring B has a k = 60 N/m. A mass weighing 40.0 N is attached to the free end of the spring system. What is the total displacement of the mass?



$F_g = F_{rA}$

$-40.0 = k\vec{x}_A$

$-40.0 = 25\vec{x}_A$

$x_A = -1.6\text{ m}$

$F_g = F_{rB}$

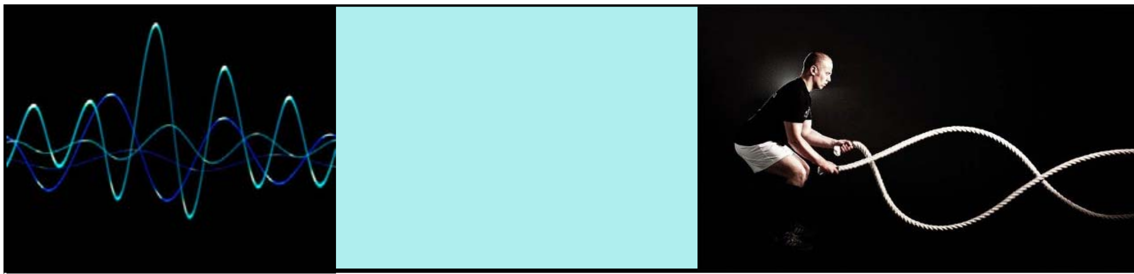
$-40.0 = 60\vec{x}_B$

$\vec{x}_B = -0.\overline{6}\text{ m}$

$\vec{x}_{total} = \vec{x}_A + \vec{x}_B$

$= -1.6 + -0.\overline{6}$

$= -2.3\text{ m} = \boxed{2.3\text{m [down]}}$



The following rules apply for objects undergoing Simple Harmonic Motion:

- there is a restoring force acting in the opposite direction of the displacement (a force acting opposite of the movement to pull the object back and keep it oscillating)

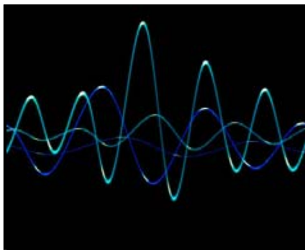
- at the maximum displacements, the restoring force is at its maximum. This displacement is called the oscillators amplitude. The velocity at this point is zero.

- at equilibrium, the restoring force is zero and the velocity is at its maximum.

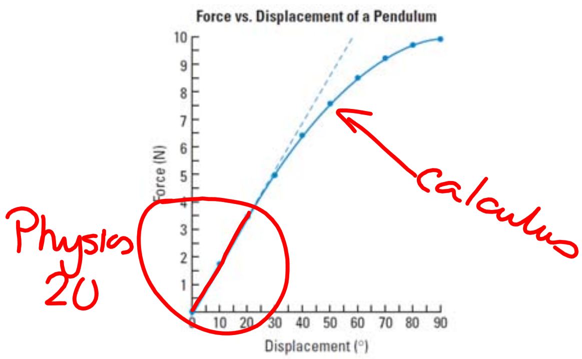
Ideal Pendulum - swings through a small angle, has no friction, and has all mass concentrated at the bob

The restoring force in a pendulum is a component of the force of gravity acting opposite the displacement of the bob. Analyze on page 360.

$$\boxed{F_r = F_g \sin\theta}$$



Note: For the pendulum to be a true simple harmonic oscillator, its graph of restoring force versus displacement should be linear, as the dotted line suggests. After 15^{o} , its line departs from the straight line, and its motion can no longer be considered SHM.



Questions: Pg. 365 # 1-6.