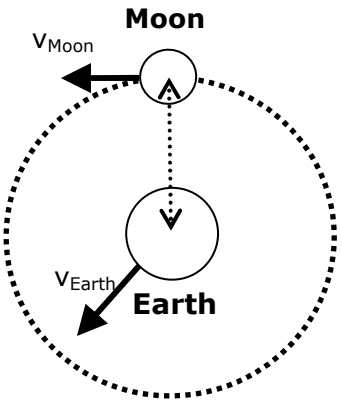
Center of Mass:

1. Consider the Earth (m_{earth}= 5.98x10^{24} kg) and the Moon (m_{moon}= 7.36x10^{22} kg) as an isolated system (i.e. ignore external forces). The mean distance between them is 3.82x10^{8} m.

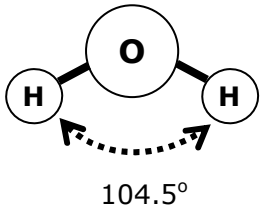


a) Determine the center of mass for the Earth-Moon system.

b) At a particular moment, the moon is moving with a linear speed (v_{moon}) of 992 m/s (while in a "circular" orbit around the Earth) while the Earth is moving at 2.99x10^{4} m/s (v_{earth}) at a 45^{o} counter-clockwise angle to v_{moon}. Determine the velocity of the center-of-mass for the Earth-Moon system.

2. A water molecule consists of a central oxygen atom attached to 2 hydrogen atoms, one on each side. The angle between the hydrogen atoms is 104.5^{o}.

The Water Molecule



104.5^{o}

a) The average mass of an oxygen and hydrogen, respectively, is 15.999 amu and 1.0079 amu (1 amu = 1.661x10^{-27} kg). Calculate the mass of the oxygen and hydrogen atom, respectively, in SI units.

b) The center-to-center distance between the oxygen and either hydrogen atom is 0.957854 Å (1 Å = 10^{-10} m). Calculate the distance between an oxygen atom and a hydrogen atom, respectively, in SI units.

c) Determine the center of mass for a water molecule.

Impulse and Momentum:

1. A 50 kg object with an initial velocity, $\vec{v}_o = \left(30\frac{m}{s}\right)\hat{i}$, is decelerated by a varying net force, $\vec{F} = \left[-\left(4000\frac{N}{s}\right)t - 1000N\right]\hat{i}$, to $\vec{v} = \left(10\frac{m}{s}\right)\hat{i}$ over a time interval of 0.5 seconds.

a) What is the change in momentum for this object?

b) Calculate the impulse received by the object using the force equation above.

c) What is the average force exerted on the object?

d) Calculate the impulse received by the object using the average force calculated in (c).

e) If the deceleration from 30 m/s to 10 m/s had occurred over a time interval of 5 sec (obviously subject to a different force equation), what is the impulse received by the object?

f) Calculate the average force exerted on the object in (e).

2. A 2005 Corvette convertible coupe automobile was tested by Road & Track magazine. The following performance data were collected:

Tested Weight (lb)	Mass (kg)	¼ mile time (s)	Final speed (mph)	Final speed (m/s)
3480	1581.8	12.8	114.5	51.2

a) What is the initial and final linear momentum of the vehicle for this road test (in SI units)?

b) What is the change in momentum for the Corvette during this trial?

c) What is the rate of momentum change for the Corvette during this test? How does this value compare the average force vector exerted by the road on the Corvette during this trial?

d) How much impulse (change in momentum) does the earth receive during this trial?

e) Estimate the change in velocity ($\Delta\vec{v}_{earth}$) for the earth during this same road test. The mass of the earth is 5.98×10^{24} kg.

Conservation of Linear Momentum:

1. An 100 kg object traveling at 50 m/s collides (perfectly inelastic) with a 50 kg object initially at rest.

a. Determine the linear momentum vector for each object prior to the collision?

b. If the collision is perfectly inelastic, what is the total momentum vector for the 2-object system following the collision?

c. What is the center-of-mass velocity vector for the two combined objects following the collision?

d. Calculate the impulse vector exerted on each object.

e. What is the kinetic energy of each object following the collision?

f. Calculate the non-conservative work (W_{nc}) performed on the 2 object system.

2. A 100 kg object traveling at 50 m/s collides head-on (perfectly elastic) with a 50 kg object initially at rest.

a. What is the kinetic energy of each object prior to the collision?

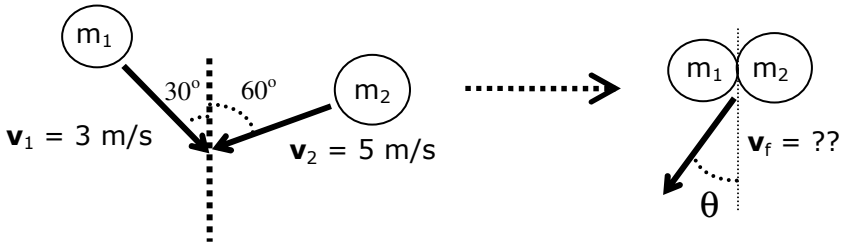
b. What is the kinetic energy of the two object system immediately following the collision?

c. Using the laws for conservation of linear momentum and conservation of mechanical energy, determine the velocity vectors for each object following the collision?

d. What is the impulse received by each object during the collision?

2-D Collisions:

Two objects (m_1=100 kg and m_2 = 150 kg) collide as shown in the diagram (there are no external forces acting on either object):



a) What is the magnitude and direction of the linear momentum vector (prior to the collision) for each object, respectively?

b) Express the linear momentum vector (prior to the collision) for each object in component form.

c) Determine the linear momentum vector for the 2 object system (prior to the collision), magnitude and direction.

d) Considering the collision to be perfectly inelastic, what is the linear momentum vector (in component form) for the 2 object system following the collision?

e) Determine the velocity vector, in component form, for the 2 object system following the collision?

f) What is the magnitude and direction for the velocity for the 2 object system following the collision?