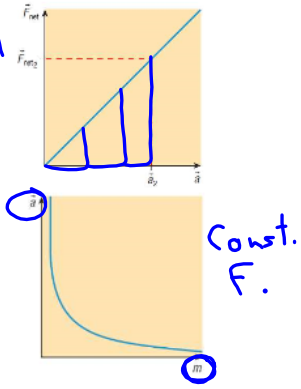
# SPH3U: 3.3 Newton's Second Law of Motion

## 1. Newton's second law

| | |
|---|---|
| Newton's second law: | $F = ma$. If there is an external force on an object, it causes an acceleration inversely proportional to the mass. |
| force vs. accel. | linear graph (straight line) increasing, starts at 0. |
| accel. vs. mass | inverse graph - as mass goes up, accel goes down. |




A net force of 36 N [forward] is applied to a volleyball of mass 0.25 kg. Determine the acceleration of the volleyball.

$\vec{F}_{Net} = m\vec{a}$ $\quad \vec{a} = \frac{\vec{F}_{net}}{m} = \frac{36\text{ N [F]}}{0.25\text{ kg}}$ $\quad 1\text{N} = 1\text{ kg}\cdot\text{m/s}^2$

$= 144\text{ m/s}^2$

$= 140\text{ m/s}^2$

A 64 kg runner starts walking at 3.0 m/s [E] and begins to speed up for 6.0 s, reaching a final velocity of 12.0 m/s [E]. Calculate the net force acting on the runner.

$\vec{F}_{net} = m\vec{a}$ $\quad \vec{a} = \frac{\vec{v}_f - \vec{v}_i}{\Delta t} = \frac{12 - 3}{6}$

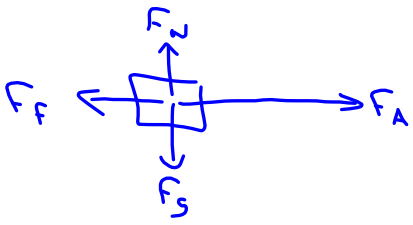
$= \frac{9}{6} = 1.5\text{ m/s}^2\text{ [E]}.$

$\vec{F}_{net} = (64\text{ kg})(1.5\text{ m/s}^2)$

$= 96\text{ N [E]}$

A 9100 kg jet moving slowly on the ground fires its engines, resulting in a force of 22 000 N [E] on the jet. The force of friction on the jet is 3800 N [W].

a. Draw the FBD for the jet.




b. Calculate the net force acting on the jet.

$\vec{F}_{Net} = F_A - F_f$
$= 22\,000 - 3800$
$= 18\,200\ N\ [E]$.

c. Calculate the acceleration of the jet.

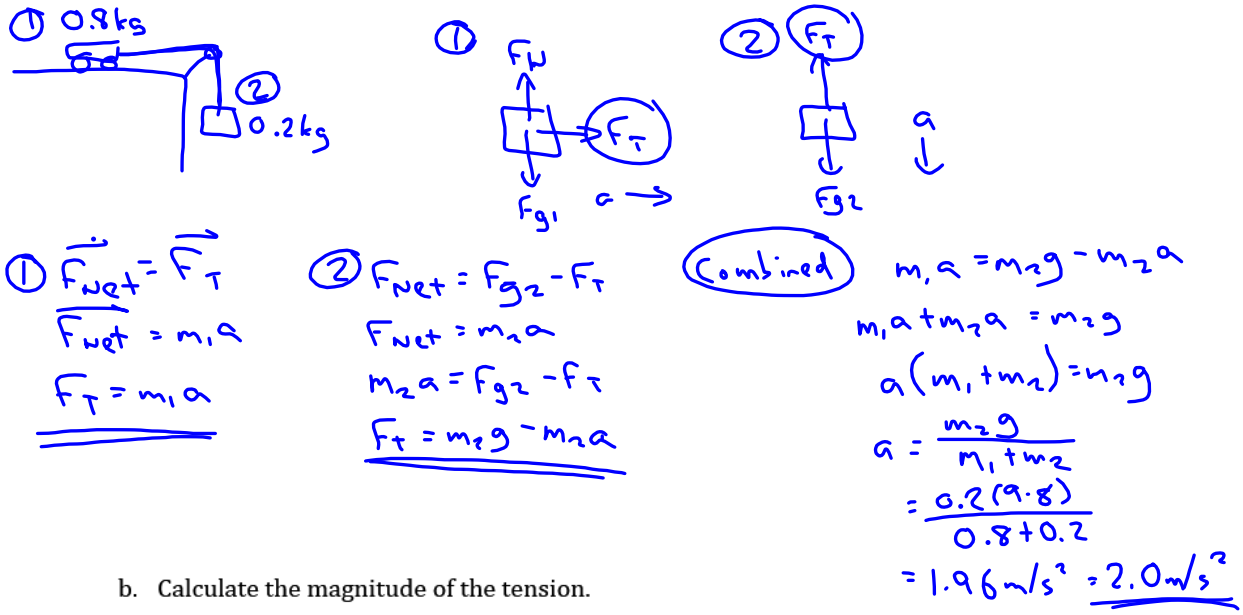
$\vec{a} = \frac{\vec{F}_{Net}}{m} = \frac{18\,200}{9100}$
$= 2.0\ m/s^2\ [E]$.

**2. Newton's second law and gravity**

| | |
|---|---|
| Force due to gravity: | $\vec{F}_g = m\vec{g}$ ($\vec{F} = m\vec{a}$, where $\vec{g}$ is the accel) |

In an investigation, students place a 0.80 kg cart on a table. They tie one end of a light string to the front of the cart, run the string over a pulley, and then tie the other end to a 0.20 kg hanging object. Assume that no friction acts on either object.

a. Determine the magnitude of the acceleration of the cart and the hanging object.




① $\vec{F}_{net} = \vec{F}_T$

$F_{net} = m_1 a$

$F_T = m_1 a$

② $F_{net} = F_{g2} - F_T$

$F_{net} = m_2 a$

$m_2 a = F_{g2} - F_T$

$F_T = m_2 g - m_2 a$

Combined

$m_1 a = m_2 g - m_2 a$

$m_1 a + m_2 a = m_2 g$

$a(m_1 + m_2) = m_2 g$

$a = \frac{m_2 g}{m_1 + m_2}$

$= \frac{0.2(9.8)}{0.8 + 0.2}$

$= 1.96 \text{ m/s}^2 = 2.0 \text{ m/s}^2$

b. Calculate the magnitude of the tension.

$F_T = m_1 a$

$= (0.8)(1.96)$

$= 1.568 \text{ N}$

$= 1.6 \text{ N}$

**3. Summary**

**Homework:** page 136: #1-4, 6, 10-11