Statics & Dynamics

- **Statics**

$$\sum F = 0$$

The sum of the forces acting on an object is equal to o

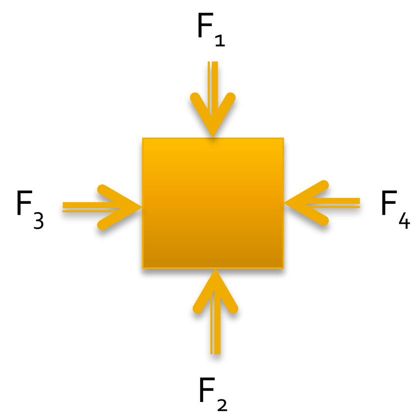
$$F_1 = F_2$$
$$F_3 = F_4$$

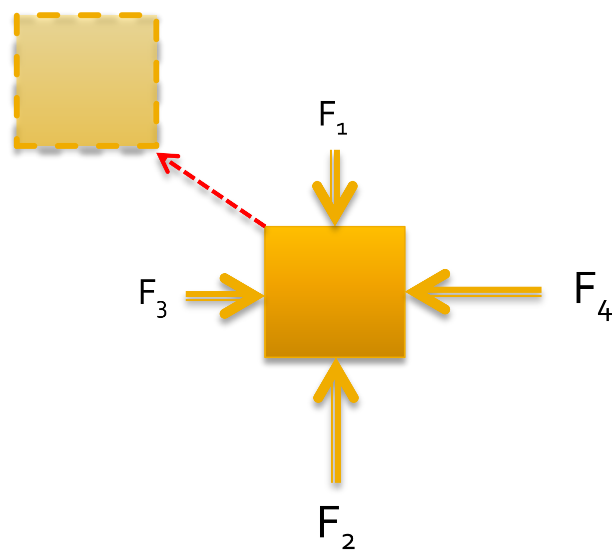
- **Dynamics**

$$\sum F \neq 0$$

$$F_2 > F_1$$
$$F_4 > F_3$$

free body diagrams:





Rocket!

- **Newton's second law of motion:**

$$F = ma$$

force mass acceleration

  - We know that the forces acting on our rockets are:

$$W = mg$$

weight

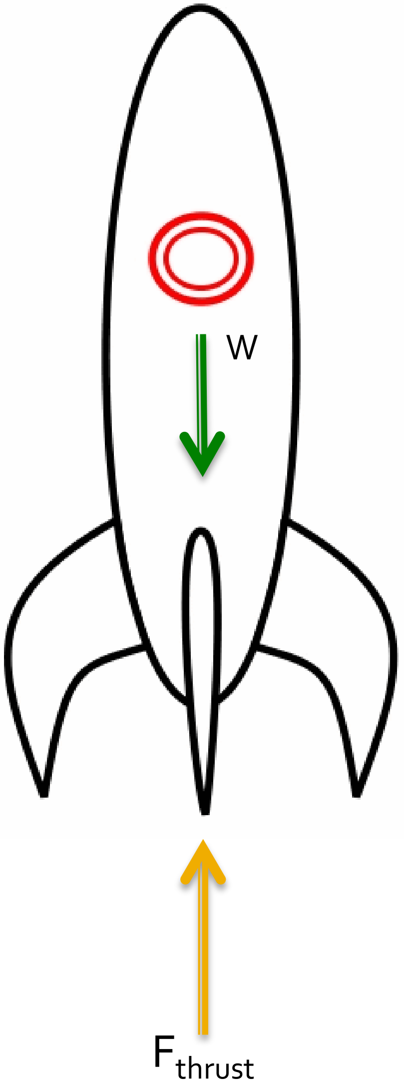
gravity
(a =9 .8 m/s²)

$$F_{thrust} = uR$$

exhaust velocity

rate of mass ejection
(Δ fuel mass/Δ time)

  - Another force to take into account is the force due to air friction; we will assume it is negligible



Energy

- **First law of thermodynamics:**
  Energy is conserved; it can neither be created nor destroyed

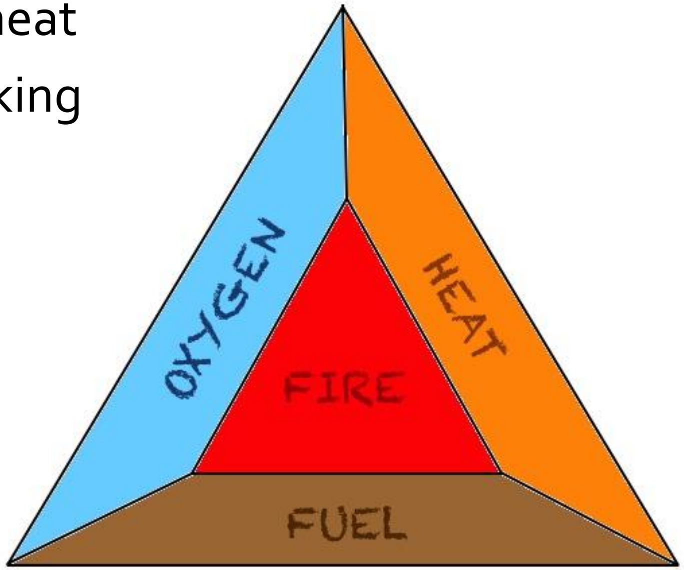
$$\mathrm{D}E = \mathrm{D}Q + \mathrm{D}W$$

energy heat work

  - Any energy that you put into a system must come out of the system as work or heat
  - The energy that we put into the rocket (fuel) is equal to the work (how far it travels) and heat (from combustion and air friction) that come out of the rocket

Fuel

- The energy in the fuel that is not lost to the heat of combustion is converted into work energy to propel the rocket into the air
  - Combustion reactions require fuel, oxygen and heat
  - The energy of combustion comes from the breaking of molecular bonds of the reactants
  - Fuel for our rockets is a mixture of KNO_3 (in the stump remover) and $C_{12}H_{22}O_{11}$ (table sugar)
- *Think about it*: How does changing the size of the fuel particles affect the combustion reaction?



$$O_2 + KNO_3 + C_{12}H_{22}O_{11} \rightarrow CO_2 + H_2O + N_2 + K_2CO_3 + KOH$$

In Conclusion

- Recall:

$$E = Q + W$$

- We know:

E → chemical energy from our fuel

Q → heat energy from combustion

W → (F_{thrust} x distance traveled)-W_{rocket}

- You are now a rocket scientist!

Stoichiometry Review

- **Using stoichiometry, we can calculate the relative quantities (grams, moles, atoms, etc.) of reactants and products in chemical reactions**
  - *Example 1*: 85.0 g of propane (C_3H_8) is burned in excess oxygen. *How many grams of water are formed?*

Mouse click to reveal example 1 answer

  - *Example 2*: Iron reacts with superheated steam to form hydrogen gas and iron (II, III) oxide. *Calculate the number of moles of hydrogen produced by 20.0 g of iron in excess steam.*

Another mouse click to reveal example 2 answer

Molecule	Molecular Weight (g/mol)
C_3H_8	44.1
O_2	32
CO_2	44.01
H_2O	18
Fe	55.85
Fe_3O_4	231.533
H_2	2.016

Stoichiometry Review

- **Using stoichiometry, we can calculate the relative quantities (grams, moles, atoms, etc.) of reactants and products in chemical reactions**
  - *Example 1*: 85.0 g of propane (C_3H_8) is burned in excess oxygen. *How many grams of water are formed?*

$\underline{1}\,C_3H_8 + \underline{5}\,O_2 \rightarrow \underline{3}\,CO_2 + \underline{4}\,H_2O$

$85.0\text{ g } C_3H_8 \;\frac{(1\text{ mol } C_3H_8)}{(44.1\text{ g } C_3H_8)}\;\frac{(4\text{ mol } H_2O)}{(1\text{ mol } C_3H_8)}\;\frac{(18\text{ g } H_2O)}{(1\text{ mol } H_2O)} = \mathbf{138.8\text{ g } H_2O}$

  - *Example 2*: Iron reacts with superheated steam to form hydrogen gas and iron (II, III) oxide. *Calculate the number of moles of hydrogen produced by 20.0 g of iron in excess steam.*

$\underline{3}\,Fe + \underline{4}\,H_2O \rightarrow \underline{1}\,Fe_3O_4 + \underline{4}\,H_2$

$20.0\text{ g Fe}\;\frac{(1\text{ mol Fe})}{(55.85\text{ g Fe})}\;\frac{(4\text{ mol } H_2)}{(3\text{ mol Fe})} = \mathbf{0.478\text{ g } H_2}$

Molecule	Molecular Weight (g/mol)
C_3H_8	44.1
O_2	32
CO_2	44.01
H_2O	18
Fe	55.85
Fe_3O_4	231.533
H_2	2.016