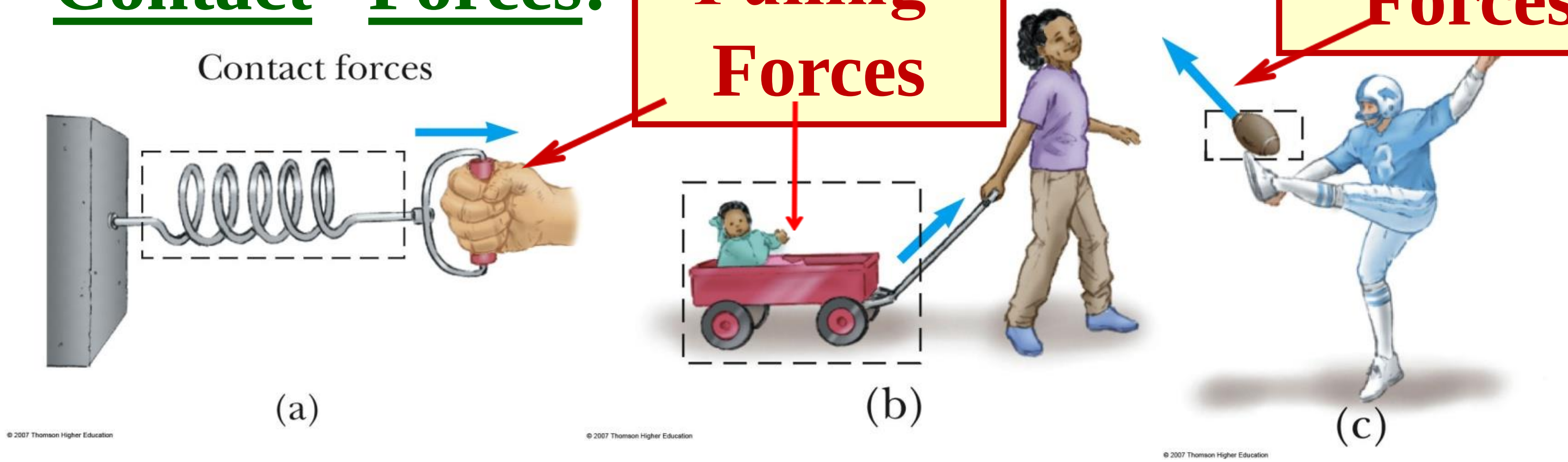
# Classes of Forces

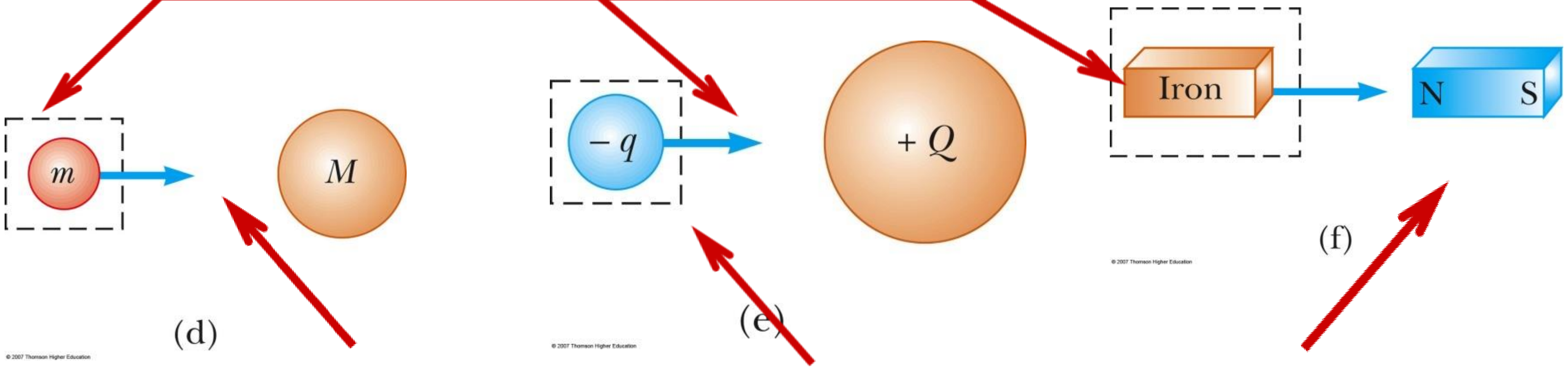
## 1. "Contact" Forces:

"Pulling" Forces

"Pushing" Forces




## 2. "Field" Forces:

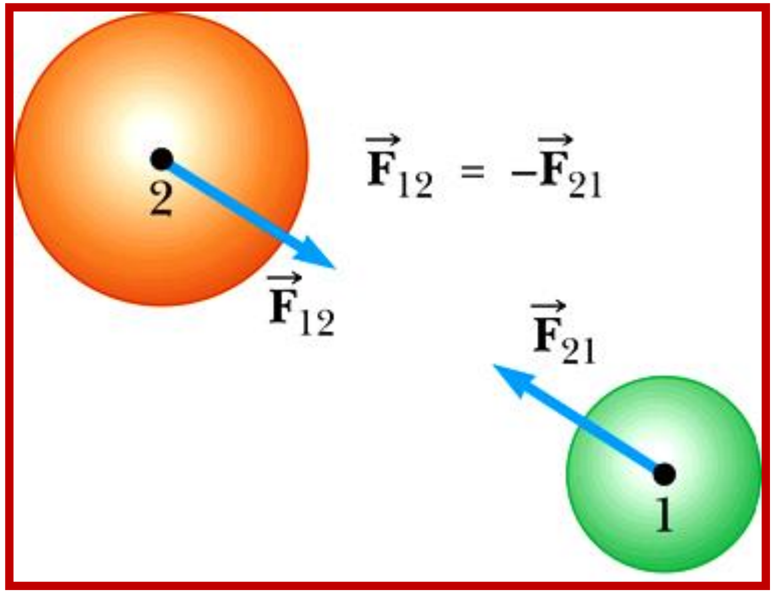



*Gravity*

*Electricity & Magnetism*

# Newton's 3rd Law

***"If two objects interact, the force $F_{12}$ exerted by object 1 on object 2 is equal in magnitude & opposite in direction to the force $F_{21}$ exerted by object 2 on object 1."***




As in the figure

# Newton's 3rd Law:

**1.** Forces always occur in pairs

**2.** The "action force" is equal in magnitude & opposite in direction to the "reaction force".

**3.** One of the forces is the "action force", the other is the "reaction force". It doesn't matter which is considered the "action" & which the "reaction"

**4.** The action & reaction forces **MUST ACT ON DIFFERENT OBJECTS.**

# "Normal" Force

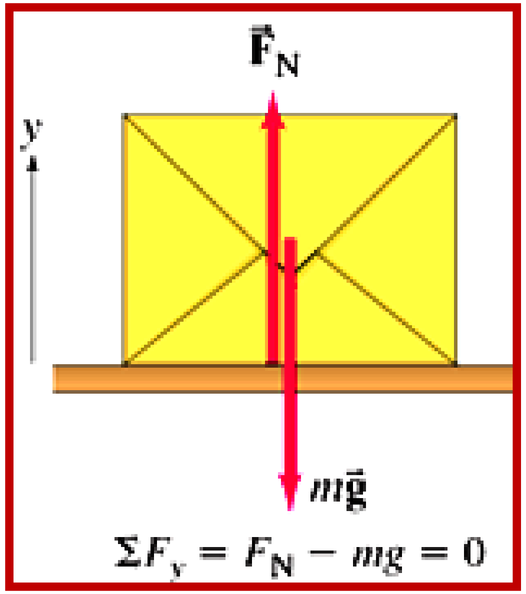
**Newton's 2nd Law** in vertical direction!

$$\sum F = ma = 0$$

$$\sum F = F_N - mg = 0$$

**or**

$$F_N = mg$$




## *A Very Important Conceptual Question!*

$$F_N = mg$$

***Which Newton's Law of Motion tells us this?***

**Newton's 2nd Law!**

***NOT*** **Newton's 3rd Law!!**

# Kinetic Friction Compared to Static Friction

- Consider both the kinetic and static friction cases
  - Use the different coefficients of friction
- **The force of *Kinetic Friction* has a single value** $F_{friction} = \mu_k N$
- **The force of *Static Friction* varies:**

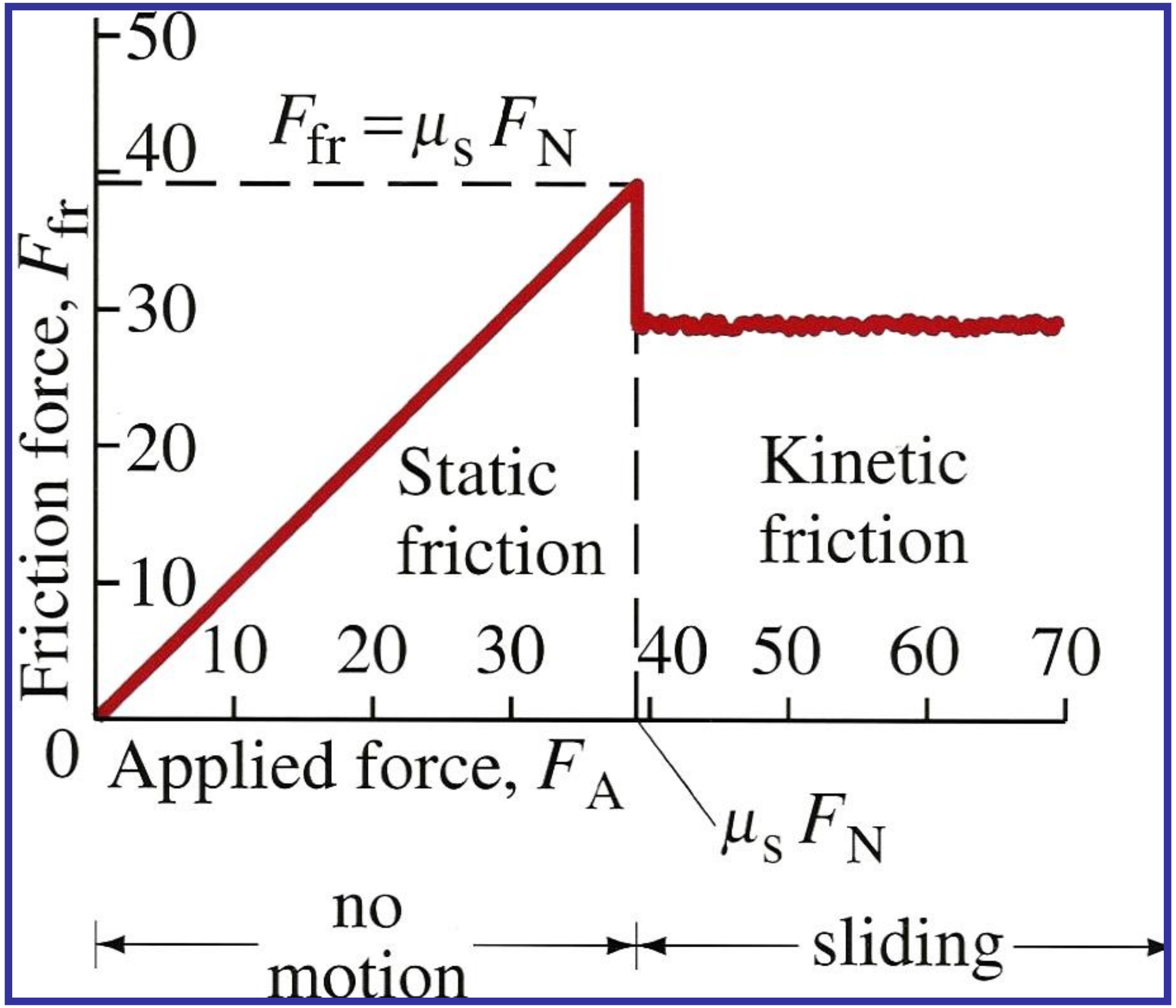
$$F_{friction} \le \mu_s N$$

- For a given combination of surfaces, generally

$$\mu_s > \mu_k$$

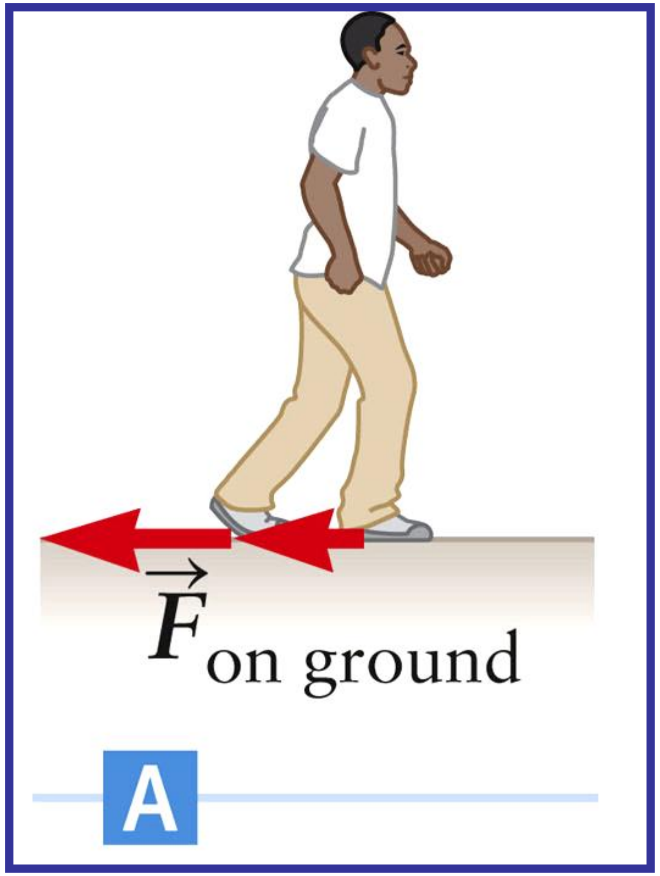
- It is more difficult to start something moving than it is to keep it moving once started

# Static & Kinetic Friction



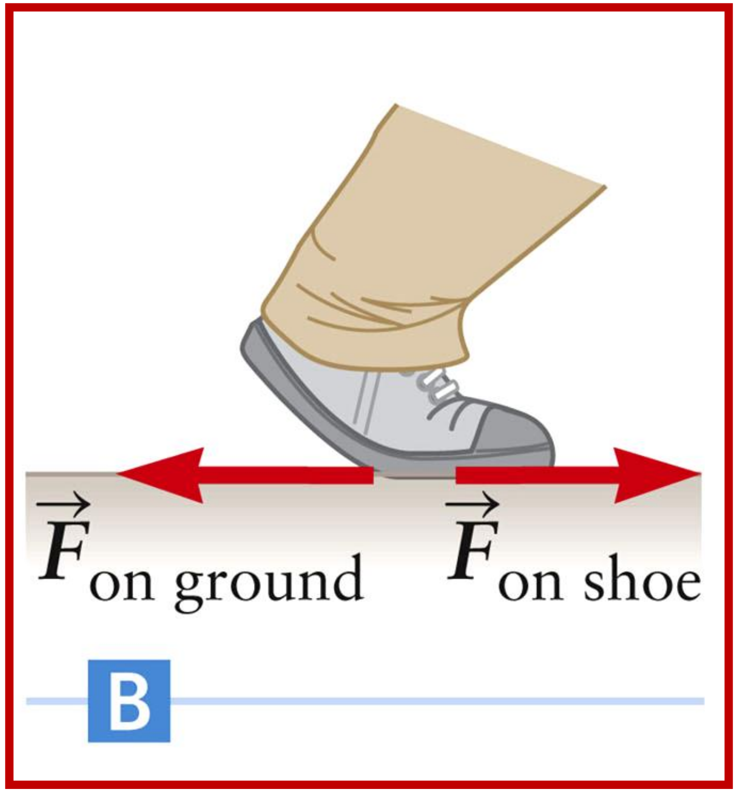
# Friction & Walking

- The person "pushes" off during each step.
- The bottoms of his shoes exert a force on the ground. This is $\mathbf{F}_{\text{on ground}}$.
- If the shoes do not slip, the force is due to static friction
  - The shoes do not move relative to the ground



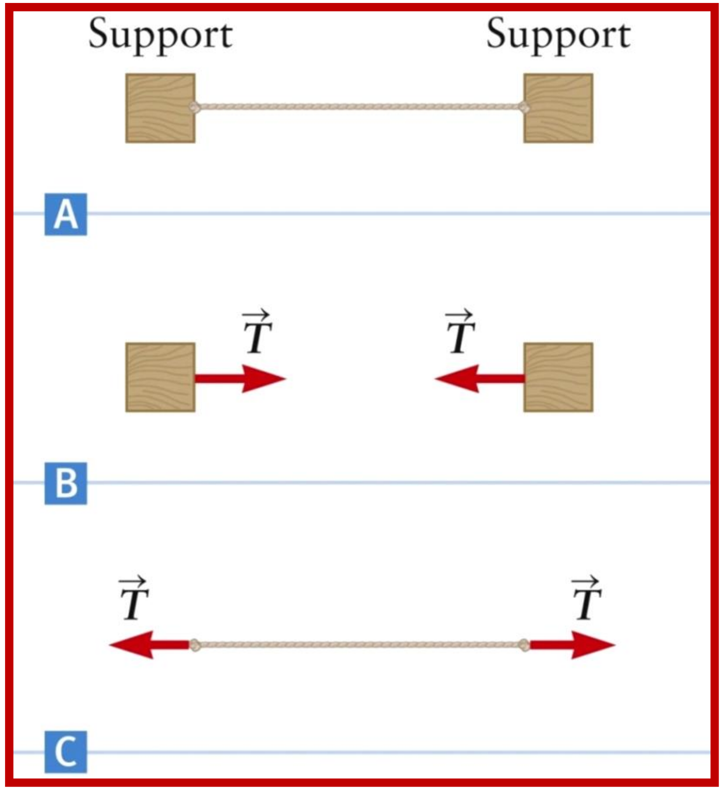
# Newton's Third Law

- This tells us that there is a reaction force **$F_{\text{on shoe}}$**
- This force propels the person as he moves
- If the surface was so slippery that there was no frictional force, the person would slip



# Tension

- Strings exert a **Force** on the objects they are connected to
  – Cables & ropes act similarly
- Strings exert a force due to their ***Tension***
- For ***massless strings***, the ends both exert the same force of magnitude **T** on the supports where they are connected.

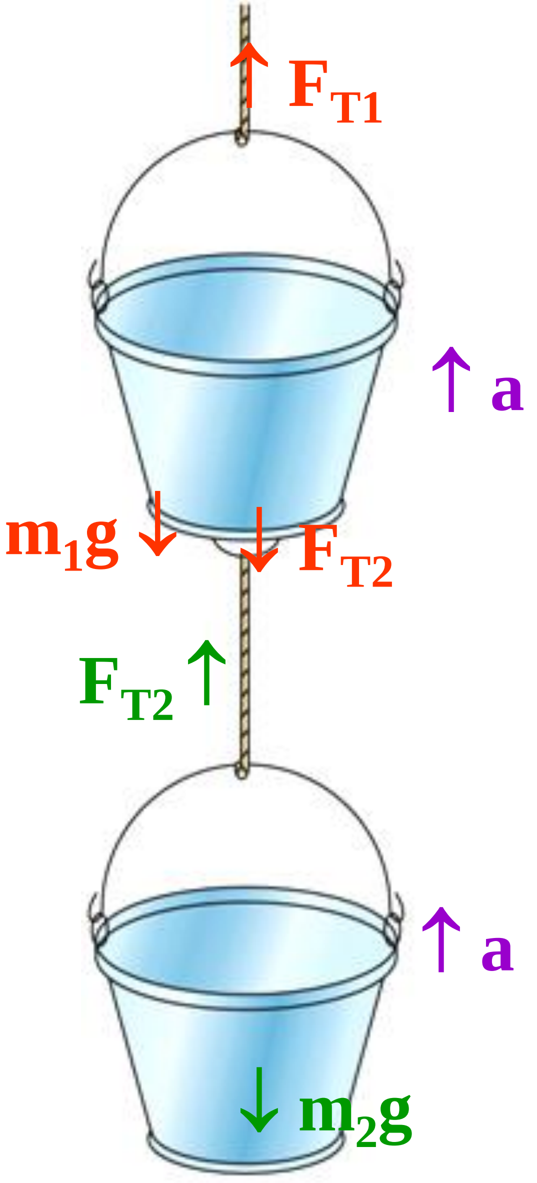



**T** is the ***Tension Force*** in the string.

# General Approach to Problem Solving

1. **Read** the problem carefully; then read it again.
2. **Draw** a sketch, then a free-body diagram.
3. **Choose** a convenient coordinate system.
4. **List** the known & unknown quantities; **find** relationships between the knowns & the unknowns.
5. **Estimate** the answer.
6. **Solve the problem without putting in any numbers (algebraically); once you are satisfied, put the numbers in.**
7. **Keep track of dimensions.**

# Problem 4.25




$m_1 = m_2 = 3.2$ kg, $m_1g = m_2g = 31.4$ N

Acceleration $a = 2.0\ m/s^2$

**Calculate $F_{T1}$ & $F_{T2}$**

**Use Newton's 2nd Law: $\sum F_y = ma$**

for ***EACH*** bucket separately!!!

Take up as positive.

**Bucket 1:** $F_{T1} - F_{T2} - m_1g = m_1a$ **(1)**

**Bucket 2:** $F_{T2} - m_2g = m_2a$ **(2)**

From (2), $F_{T2} = m_2(g + a) = (3.2)(9.8 + 2.0)$

or $F_{T2} = 37.76$ N

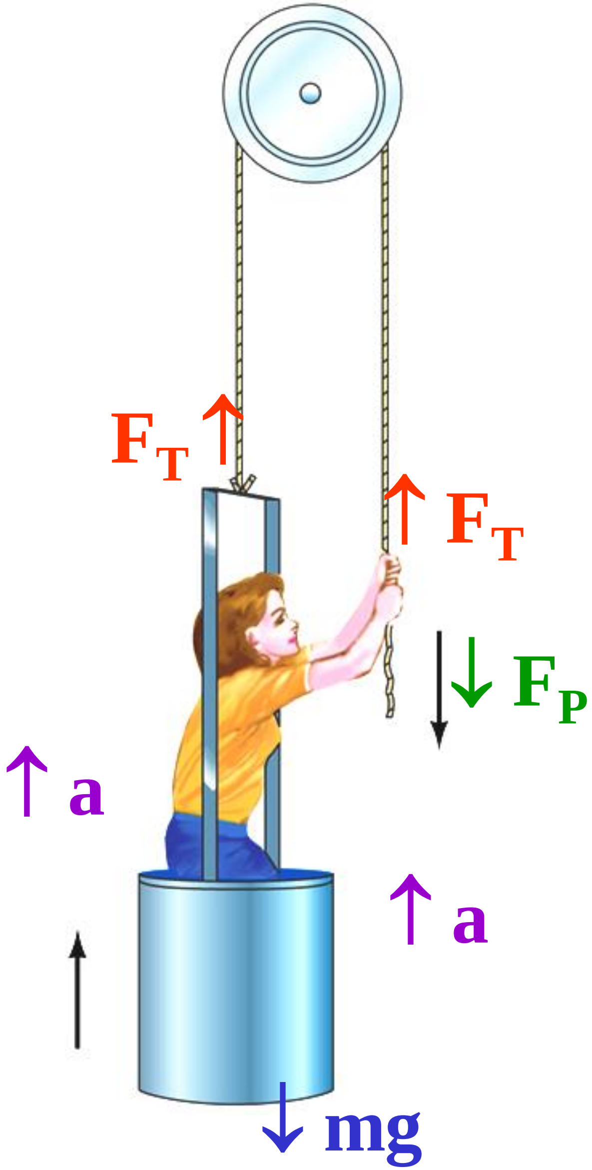
Put this into (1)

$F_{T1} - m_2(g + a) - m_1g = m_1a$

Gives: $F_{T1} = m_2(g + a) + m_1(g+a)$

or $F_{T1} = (m_2+m_1)(g + a) = 75.5$ N

# Problem 4.24




Acceleration $a = 2.0\ m/s^2$

$m = 65\ kg$, $mg = 637\ N$

Calculate $F_T$ & $F_P$

Take up as positive.

Newton's 2nd Law: $\sum F = ma$

($y$ direction) on woman + bucket!

$$F_T + F_T - mg = ma$$

$$2F_T - mg = ma$$

$$F_T = (½)m(g + a) = 383.5\ N$$

Also, Newton's 3rd Law says that

$$\Rightarrow \quad F_P = - F_T = -383.5\ N$$