Chap 4–5: Newton's Third Law of Motion

Action and reaction. Cause and effect.

A force is applied by one object on another.

Whenever one object exerts a force on the second object, the second exerts an equal and opposite force on the first.

To every action there is a reaction that is equal and opposite.

Chap 4–5: Newton's Third Law of Motion

Examples: Hammer, ice-skater, Boat, rocket.

A force is acting ON one object, BY another object.

The force you exert on a wall does not influence you.
The reaction force the wall exerts on you affects you.

$$\mathbf{F}_{pg} = -\mathbf{F}_{gp}$$

Force on person by the ground = opposite of force on ground by person.

$$\mathbf{F}_{12} = -\mathbf{F}_{21}$$

Force on object 1 by object 2 = opposite of force on object 2 by object 1.

Chap 4–6: Weight – the Force of Gravity

Newton's Second Law:

$$\mathbf{F} = m\mathbf{a}$$

Near the surface of the earth the acceleration is downward with magnitude g.

The force of gravity on an object (weight) has a magnitude:

$$\mathbf{F_G} = m\mathbf{g}$$

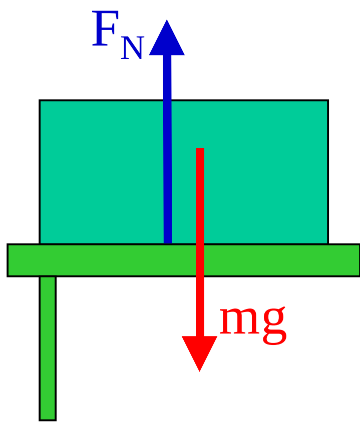
The direction is downwards towards the center of the Earth.

SI Units of g = 9.80 m/s^2 = 9.80 N/kg.

Remember: weight depends on the gravitational acceleration which depends on the location. Weight is different on the moon since g is different.

Chap 4–6: Weight – the Force of Gravity

Example: A box of mass 15.0 kg.



a) Determine the weight and Normal force.

Weight: mg = **(15.0 kg)(9.80 N/Kg) =147 N.**

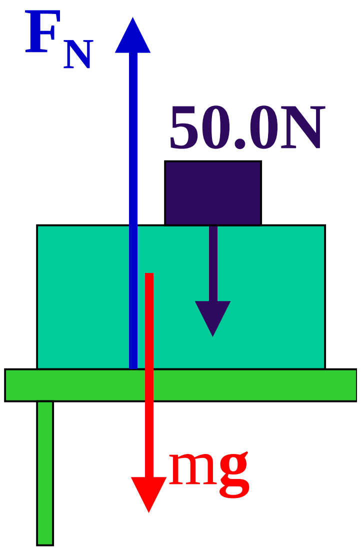
Normal Force: Since the box is at rest, then

$$\Sigma F_y = F_N - mg = \mathbf{0}$$

$$\Rightarrow F_N = mg = \mathbf{147\ N\ upwards}$$

Chap 4–6: Weight – the Force of Gravity

Example: A box of mass 15.0 kg.



b) Put an extra weight of 50.0 N.

Determine the Normal force.

Normal Force: Since the box is at rest, then

$$\Sigma F_y = F_N - mg - 50.0\ \mathrm{N} = 0$$

$\Rightarrow F_N = 147\ \mathrm{N} + 50.0\ \mathrm{N} = 197\ \mathrm{N}$ **upwards.**

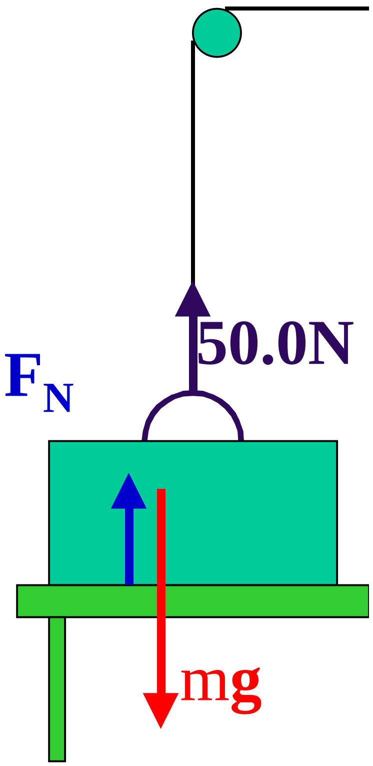
The normal force is larger.

Chap 4–6: Weight – the Force of Gravity

Example: A box of mass 15 .0 kg.

Pull the box upwards with a force of 50.0 N.

c) Determine the Normal force.



Normal Force: Since the box is at rest, then

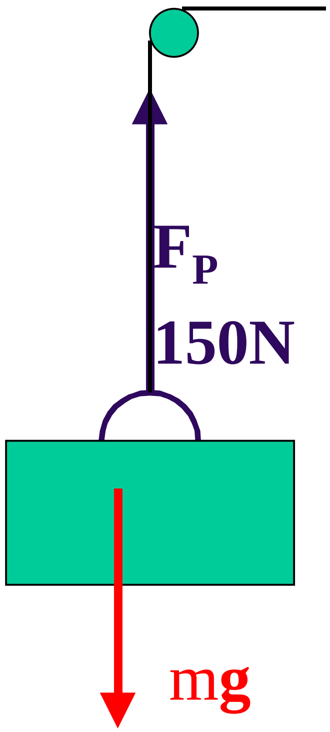
$$\Sigma F_y = F_N - mg + 50.0\ \text{N} = 0$$

$\Rightarrow F_N = 147\ \text{N} - 50.0\ \text{N} = 97.0\ \text{N}$ **upwards.**

The normal force is smaller.

Chap 4–6: Weight – the Force of Gravity

Example: Accelerating a box of mass 15.0 kg.



Pull the box upwards with a force of 150 N.

Determine the Net force.

$$\Sigma F_y = F_P - mg = 150\text{ N} - 147\text{ N} = 3.00\text{ N upwards.}$$

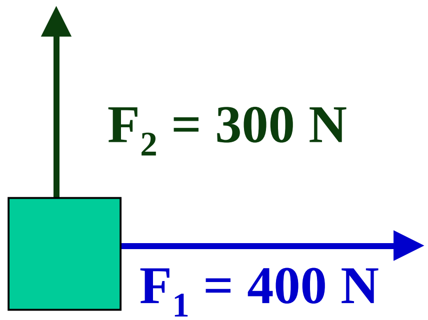
Determine the acceleration.

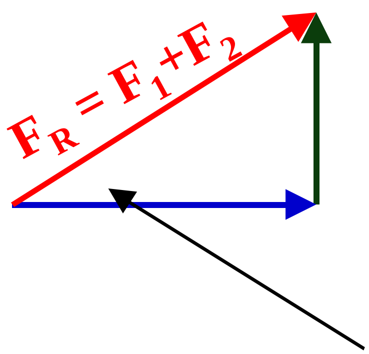
$$a_y = \Sigma F_y / m = 3.00\text{ N} / 15.0\text{ kg} = 0.2\text{ m/s}^2$$

Chap 4–7: Problem Solving Strategies

Newton's 2nd: acceleration ∝ net force.

Net force is the vector sum of all forces.





$$F_R = \sqrt{F_1^{\,2} + F_2^{\,2}} = \sqrt{(300\mathrm{N})^2 + (400\mathrm{N})^2}$$

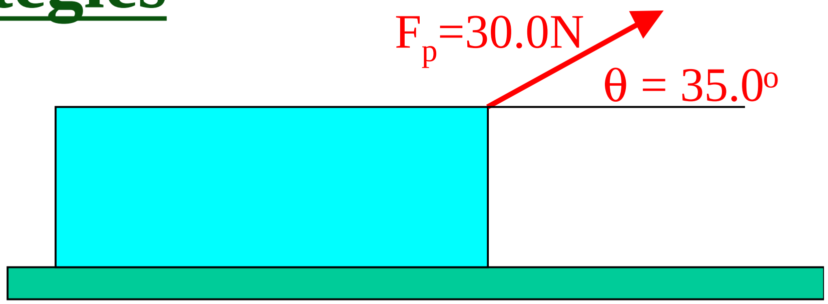
$$\theta = \arctan\left(\frac{F_y}{F_x}\right) = \arctan\left(\frac{300\,N}{400\,N}\right)$$

F_R = 500 N

θ = 36.9°

Chap 4–7: Problem Solving Strategies

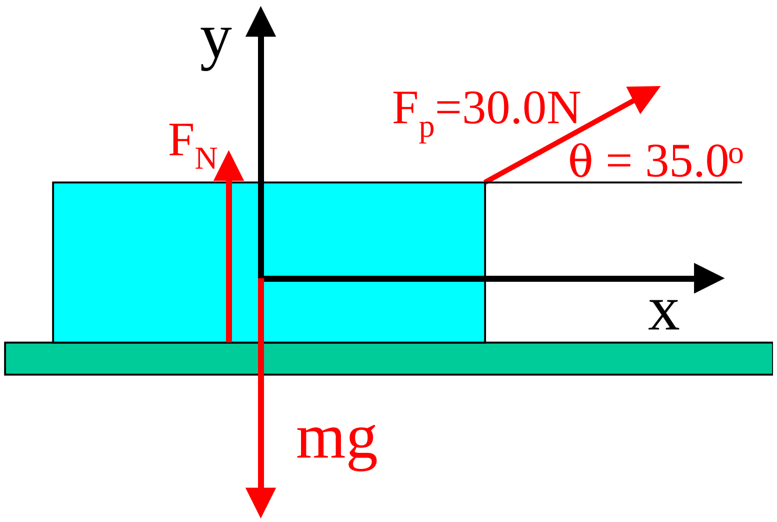
Example: Pulling a 10.0 kg box



Forces:

F_{px} **= (30.0 N)(cos 35.0°) = 24.6 N**

F_{py} **= (30.0 N)(sin 35.0°) = 17.2 N**



a) Find the acceleration of the box:

x–direction:

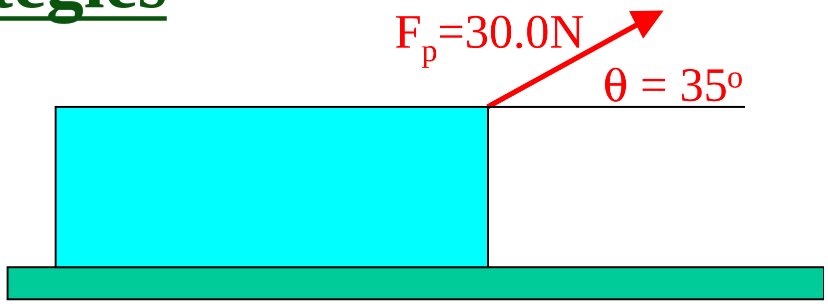
$\Sigma F_x = F_{px} = ma_x$

$a_x = F_{px}/m = 24.6\ N / 10.0\ kg = 2.46\ N/kg$

$a_x = 2.46\ m/s^2$

Chap 4–7: Problem Solving Strategies

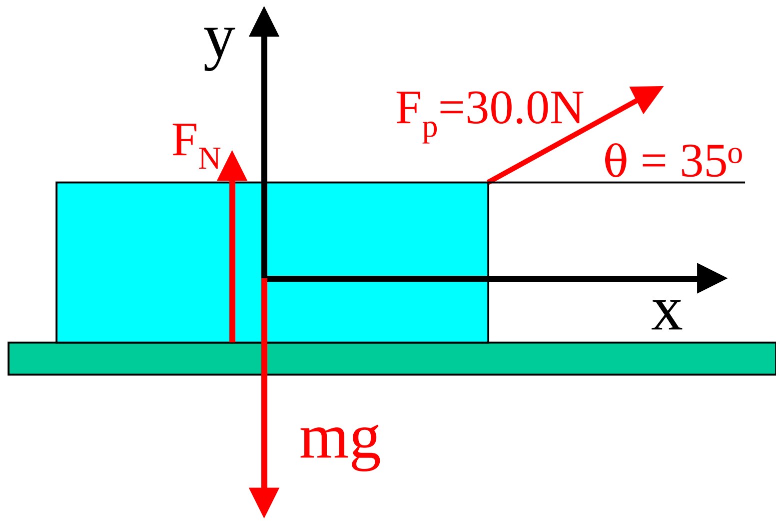
Example: Pulling a 10.0 kg box



Forces:

F_{py} = **(30.0 N)(sin 35.0º) = 17.2 N**

mg = **(10.0kg)(9.80m/s²) = 98.0 N**



a) Find F_N:

y–direction: a_y = 0 **(the box is on the table)**

$\Sigma F_y = F_{py} + F_N - mg = ma_y$

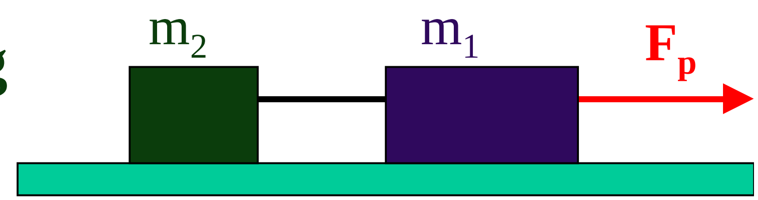
$F_{py} + F_N - mg = \mathbf{0}$

F_N = **98.0N – 17.2 N= 80.8 N**

Chap 4–7: Problem Solving Strategies

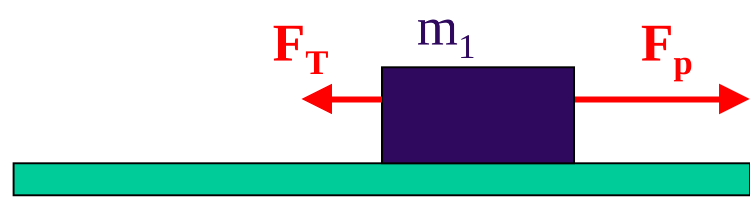
Example: Pulling two boxes. $F_{p} = 50$ N

$m_1 = 15.0$ kg **$m_2 = 8.00$ kg**



a) Find a_x:

Box 1: $\Sigma F_{1x} = F_p - F_T = m_1 a_{1x}$



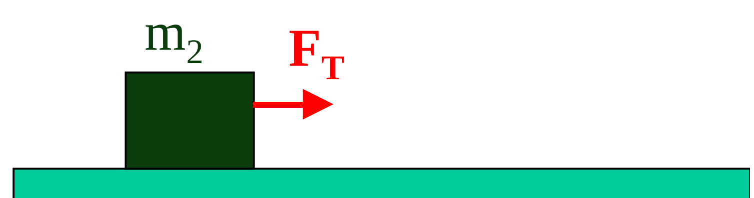
Box 2: $\Sigma F_{2x} = F_T = m_2 a_{2x}$

Since $a_{1x} = a_{2x} = a$

Then add boxes 1 & 2

$$(m_1 + m_2)\, a = F_P$$

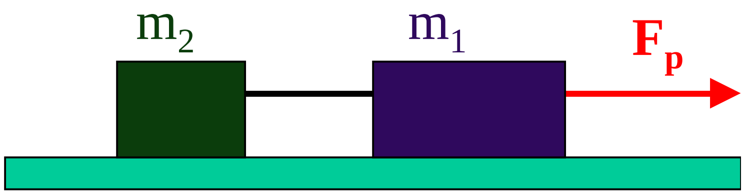
$$a = F_p / (m_1 + m_2) = \mathbf{50\ N / 23.0\ kg}$$



$$a = \mathbf{2.17\ m/s^2}$$

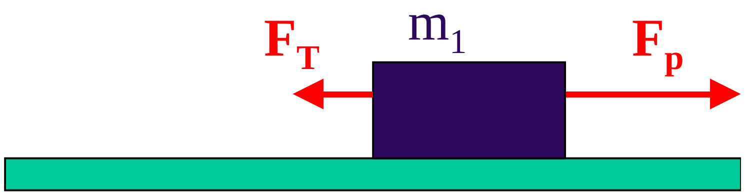
Chap 4–7: Problem Solving Strategies

Example: Pulling two boxes.



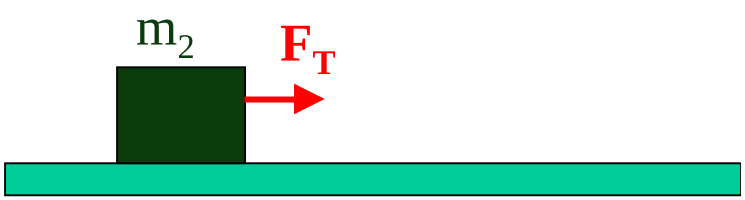
$F_p = 50$ N

$m_1 = 15.0$ kg $m_2 = 8.00$ kg



a) Find F_T:

$a = 2.17\ \mathrm{m/s^2}$



$F_T = m_2 a = (8.00\ \mathrm{kg})(2.17\ \mathrm{m/s^2})$

$F_T = 17.4$ N

Chap 4–7: Problem Solving Strategies

Example:

m_1 = 1300.0 kg **m_2 = 1000.0 kg**

Find the acceleration: **$a = -a_1 = a_2$**

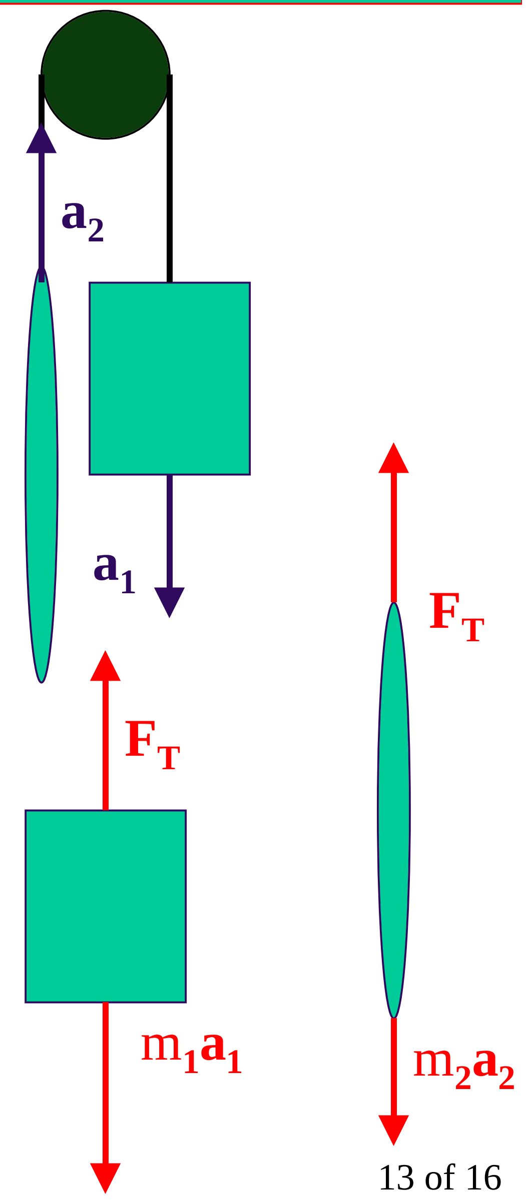
Box 1: $F_T - m_1 g = m_1 a_1 = -m_1 a$

Box 2: $F_T - m_2 g = m_2 a_2 = +m_2 a$

Subtract 1 from 2

$$(m_1 - m_2)g = (m_1 + m_2)a$$

$$a = \frac{m_1 - m_2}{m_1 + m_2} g = \frac{300kg}{2300kg} 9.80 \frac{m}{s^2} = 1.28 \frac{m}{s^2}$$



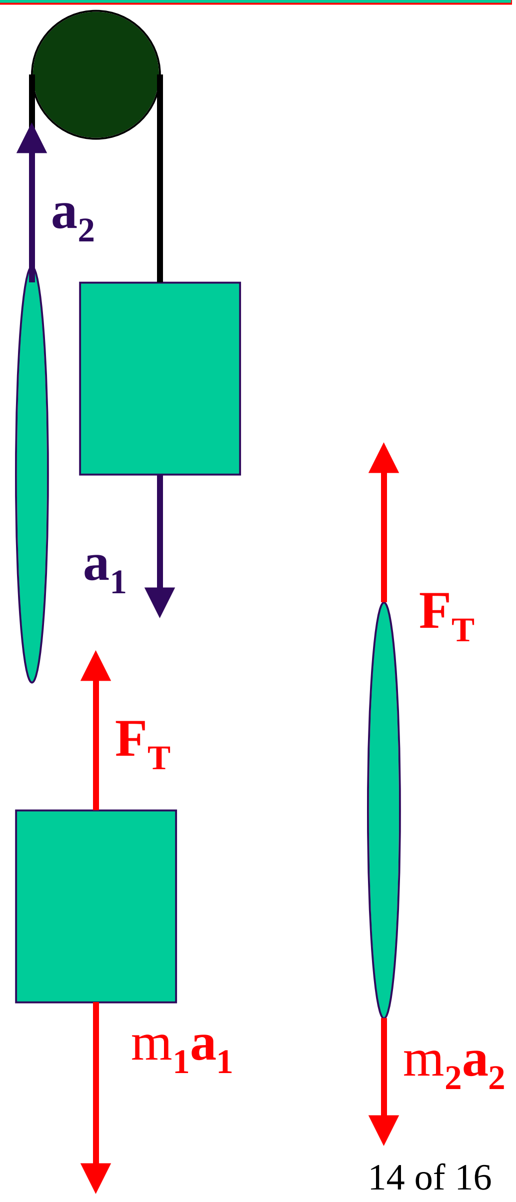
Chap 4–7: Problem Solving Strategies

Example:

$m_1 = 1300.0$ kg **$m_2 = 1000.0$ kg**

Find the tension:

$$a = -a_1 = a_2 = 1.28\ \text{m/s}^2$$



Box 2: $F_T - m_2 g = +m_2 a$

$$F_T = m_2(g + a)$$

$$F_T = (1000.0\ \text{kg})(9.80\ \text{m/s}^2 + 1.28\ \text{m/s}^2)$$

$$F_T = 1.11\times10^4\ \text{N}$$

Chap 4–7: Problem Solving Strategies

Example:

m_1 = 1300.0 kg **m_2 = 1000.0 kg**

Find the tension:

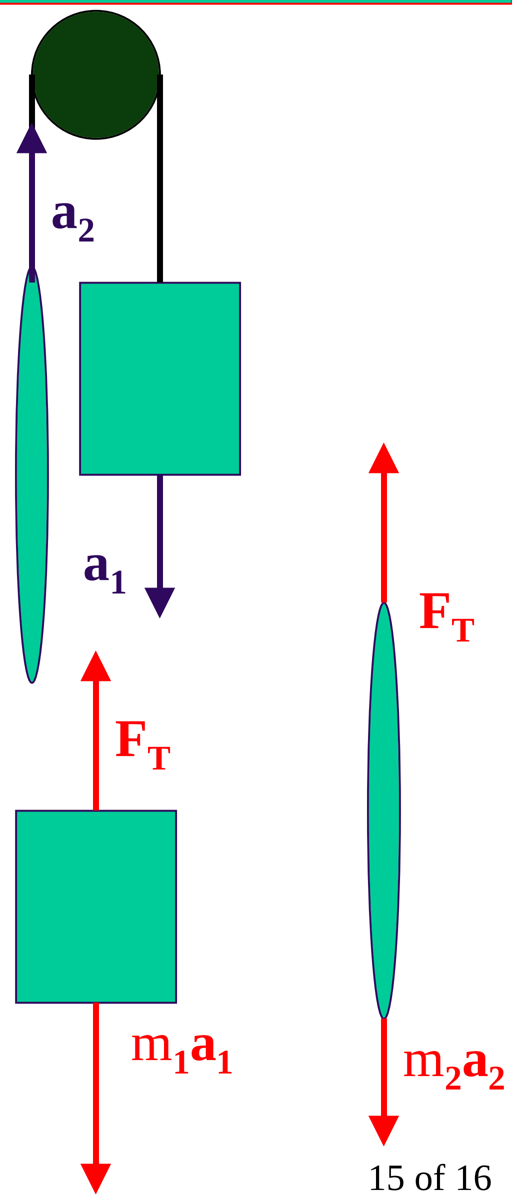
$$\mathbf{a = -a_1 = a_2 = 1.28\ m/s^2}$$

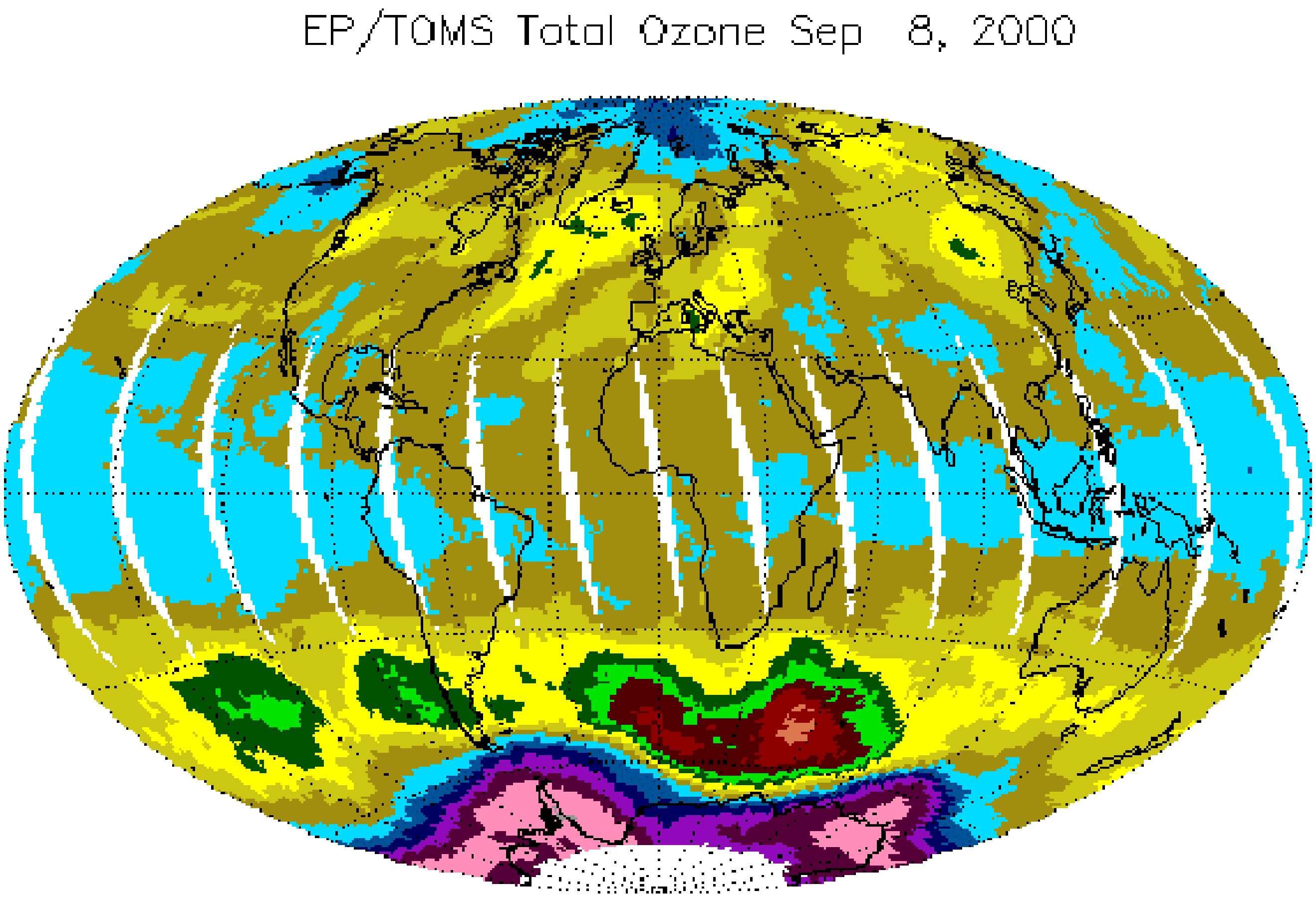
Box 1: $F_T - m_1 g = -m_1 a$

$$F_T = m_1(g - a)$$

$$F_T = (1300.0\ \text{kg})(9.80\ \text{m/s}^2 - 1.28\ \text{m/s}^2)$$

$$\mathbf{F_T = 1.11 \times 10^4\ N}$$





It's back, and it's bigger than ever. The ozone hole that has been a cause of concern in recent years has again reformed over Earth's South Pole. The seasonal recurrence of the ozone hole was expected, although the size of the hole has never been so large this early in the season.
Ozone is important because it shields us from damaging ultraviolet sunlight. Ozone is vulnerable, though, to CFCs and halons being released into the atmosphere. The ozone hole's large size is probably related to unusually low temperatures, allowing CFC byproducts like chlorine to react with atmospheric ozone molecules with greater efficiency. In the above false-color picture taken earlier this month, low ozone levels are shown in red and grey.