Mastering Physics Assignment 1

Deadline is October 1 at 5 pm
Flash problem believed to be fixed as of Friday
Try Firefox if still a problem!

Mastering Physics Assignment 2

Is available on Mastering Physics website
Seven practice problems + six for credit
Due Wednesday, October 10 at 11 pm

GENERAL PHYSICS I: PHYS 1020

Schedule - Fall 2007
(lecture schedule is approximate)

5	M	Oct 1	11			Tutorial and Test 1 (chapters 1, 2, 3)
	W	3	12	Chapter 5	Uniform circular motion	
	F	5	13			
6	M	8	Thanksgiving Day			Experiment 2: Measurement of g by free fall
	W	10	14	Chapter 5	Uniform circular motion	
	F	12	15	Chapter 6	Work and energy	
7	M	15	16			Tutorial and Test 2 (chapters 4, 5)
	W	17	17			
	F	19	18	Chapter 7	Impulse and momentum	
8	M	22	19			No lab or tutorial
	Tue	23	MID-TERM TEST, Ch 1-5, Tuesday, October 23, 7-9 pm			
	W	24	20	Chapter 7	Impulse and momentum	
	F	26	21	Chapter 8,	Rotational kinematics	

Week of October 1
Tutorial and test 1, ch. 1, 2, 3

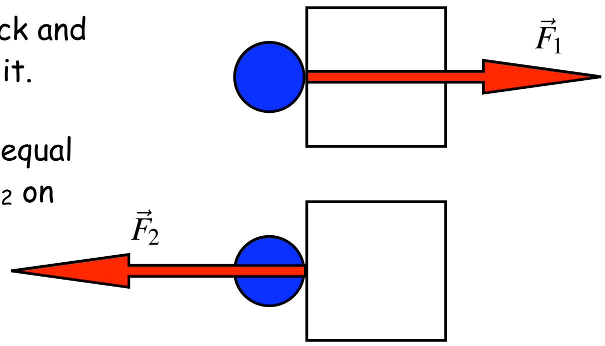
Week of October 8
Experiment 2: Measurement of g by free fall

Newton's Third Law of Motion

When you exert a force on an object, it exerts a force back on you.

The ball hits the block and exerts a force F_1 on it.

The block exerts an equal and opposite force F_2 on the ball.



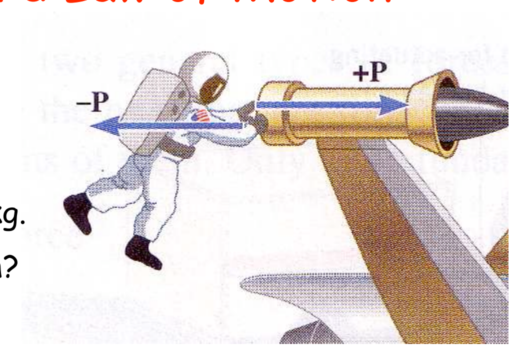
$\boxed{\vec{F}_2 = -\vec{F}_1}$

Action and reaction forces are equal and opposite, and **they act on different objects**

Newton's Third Law of Motion

An astronaut of mass m_a = 92 kg exerts a force P = 36 N on a spacecraft of mass m_s = 11,000 kg.

What is the acceleration of each?



Force on the spacecraft, P = 36 N to the right.

Second Law:

Acceleration of craft, $a_s = P/m_s$ = (36 N)/(11,000 kg) = 0.0033 m/s^2

Reaction force of spacecraft on the astronaut is –P (Newton's 3rd law).

Second Law:

Acceleration of astronaut, $a_a = -P/m_a$ = (–36 N)/(92 kg) = –0.39 m/s^2

The Fundamental Forces of Nature

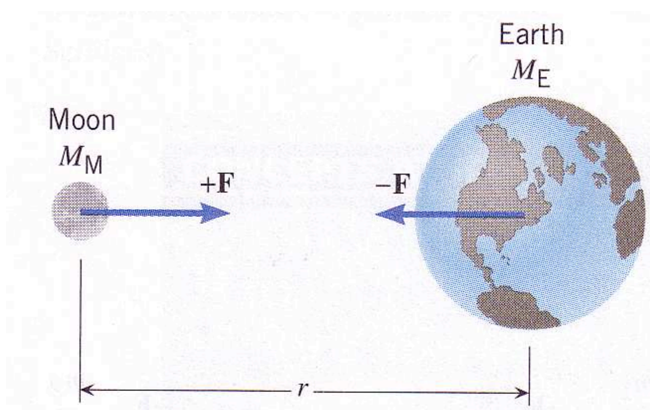
- **Strong Nuclear Force**: the strongest of all. Responsible for holding neutrons and protons captive in the nuclei of atoms. Acts over only very short distances of about 10^{-15} m.

- **Electroweak Force**: a combination of:

  - **electromagnetic force**: binds electrons to nuclei to form atoms and molecules.
  - **weak nuclear force**: responsible for nuclear beta-decay.

- **Gravity**: the weakest force of all. A significant force because all matter (we believe) is attracted by gravity.

- **Perhaps**, a repulsive gravitational force acting at long distances (distant galaxies appear to be moving away faster than they should if only normal gravity acts).



The earth exerts a gravitational force on the moon that is proportional to M_M.

The moon exerts a gravitational force on the earth that is proportional to M_E.

→ As the forces are equal in magnitude (3rd law), the gravitational force must depend on both M_M and M_E.

Newton's Law of Gravitation

(deduced from observations of the motion of the planets)

The gravitational force between two masses, m_1 and m_2, is proportional to the product of the masses and inversely proportional to the square of the distance between their centres.

$$F_{grav} = \frac{Gm_1m_2}{r^2}$$

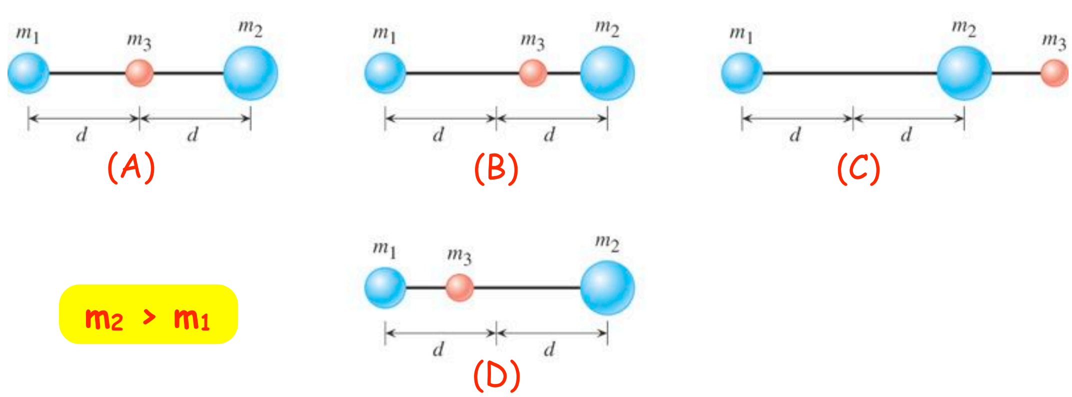
Distance between centres of gravity

G is the universal gravitational constant:

$$G = 6.673 \times 10^{-11}\ \mathrm{N.m^2/kg^2}$$

m_1, m_2 are "gravitational masses". In all cases seen, they are equal to the inertial masses (the mass in F = ma).

Clickers!

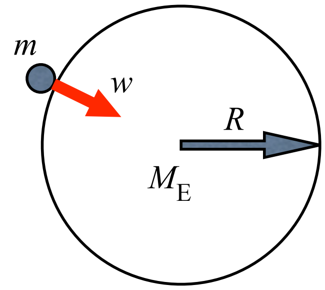


Three objects of mass m_1, m_2, m_3 are located along a straight line. m_2 is greater then m_1. The net gravitational force acting on mass m_3 is zero.

Which drawing correctly represents the locations of the objects?

Gravity attracts m_3 toward both m_1 and m_2, and $F \sim 1/r^2$

Newton's Law of Gravitation



Earth:
$M_E = 5.98 \times 10^{24}$ kg
$R = 6.38 \times 10^6$ m

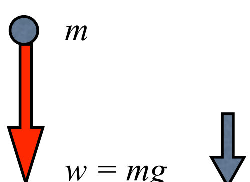
What is the gravitational force (weight, w) of a mass m on the earth's surface?

$$w = \frac{GmM_E}{R^2} = (6.673 \times 10^{-11}\ \mathrm{N.m^2/kg^2}) \times \frac{m \times (5.98 \times 10^{24}\ \mathrm{kg})}{(6.38 \times 10^6\ \mathrm{m})^2}$$

$$\boxed{w = 9.80 \times m = mg} \qquad g = \frac{GM_E}{R^2} \text{ at earth's surface}$$

Above earth's surface, weight decreases with distance r from the centre of the earth as $1/r^2$.

Weight and Gravitational Acceleration



Due to gravity –
Acceleration = a, downwards

$w = mg$
gravitational mass

Newton's second law: $w = ma$ (w accelerates the mass)

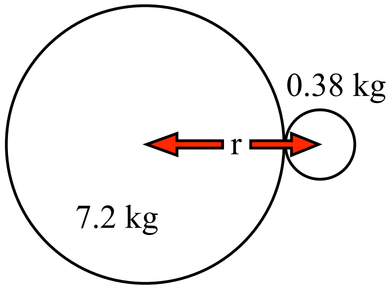
So weight, $w = mg = ma$
inertial mass

and $a = g$ independent of mass.

All objects fall equally fast in the absence of air resistance

If gravitational and inertial masses were not equal, this would not be the case!

4.19/18: A bowling ball (mass m_1 = 7.2 kg, radius r_1 = 0.11 m) and a billiard ball (mass m_2 = 0.38 kg, radius r_2 = 0.028 m) may be treated as uniform spheres. What is the magnitude of the maximum gravitational force between them?



Gravitational force between them:

$$F = G\frac{m_1 m_2}{r^2}$$

Distance between centres:

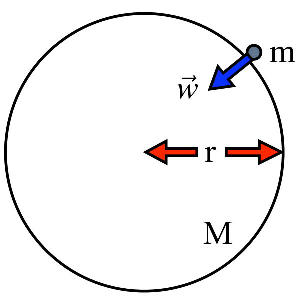
$$r = r_1 + r_2 = 0.11 + 0.028 = 0.138 \text{ m}$$

$$F = (6.673 \times 10^{-11} \text{ N.m}^2/\text{kg}^2) \times \frac{(7.2 \text{ kg}) \times (0.38 \text{ kg})}{(0.138 \text{ m})^2}$$

$$= 9.6 \times 10^{-9} \text{ N}$$

Newton's Law of Gravitation

4.-/26: The weight of an object is the same on planets A and B. The mass of planet A is 60% that of planet B. Find the ratio of the radii of the planets.



Weight of mass m on the surface of a planet of radius r and mass M:

$$w = G\frac{mM}{r^2}$$

On planet A: $w_A = G\frac{mM_A}{r_A^2}$

On planet B: $w_B = G\frac{mM_B}{r_B^2}$

The weights are the same, so: $\cancel{G}\frac{\cancel{m}M_A}{r_A^2} = \cancel{G}\frac{\cancel{m}M_B}{r_B^2}$

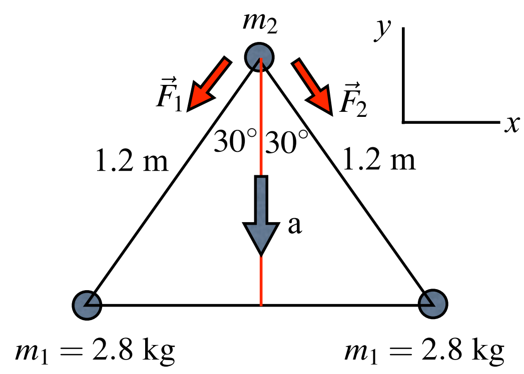
So $\frac{r_A}{r_B} = \sqrt{\frac{M_A}{M_B}} = \sqrt{0.6} = 0.775$

Newton's Law of Gravitation

4.28: Three uniform spheres are located at the corners of an equilateral triangle with sides of 1.2 m.

Two of the spheres have a mass of 2.8 kg. The third sphere is released from rest.

What is the magnitude of its initial acceleration?

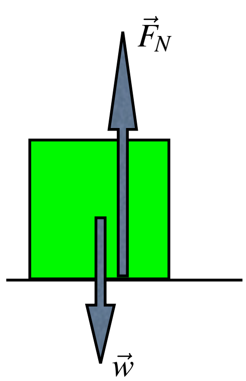


$$F_1 = F_2 = G\,\frac{m_2 \times (2.8\ \text{kg})}{(1.2\ \text{m})^2} \qquad F_{1x} + F_{2x} = 0\ \text{(symmetry)}$$

$$F_{1y} + F_{2y} = -2F_1 \cos 30^\circ = -2.247 \times 10^{-10} \times m_2$$

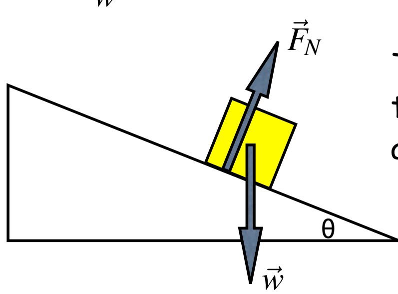
$$\text{Acceleration } = \frac{-2.247 \times 10^{-10} \times m_2}{m_2} = -2.247 \times 10^{-10}\ \text{m/s}^2$$

The Normal Force



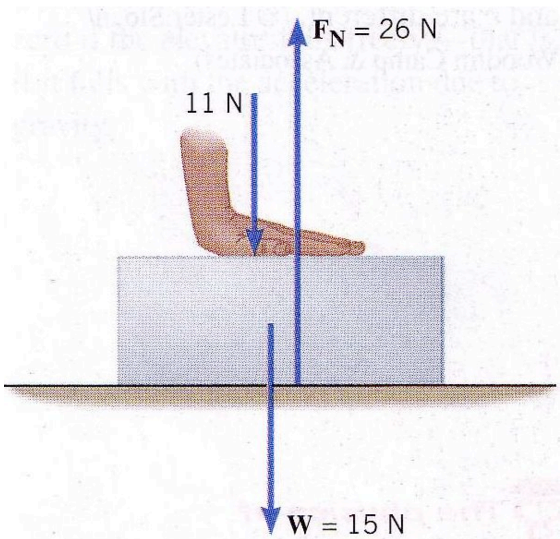
The normal force acts when an object is in contact with a surface and exerts a force on it.

The normal force is perpendicular (normal) to the surface.



The normal force acts no matter what the angle of the surface is and is always perpendicular to the surface.

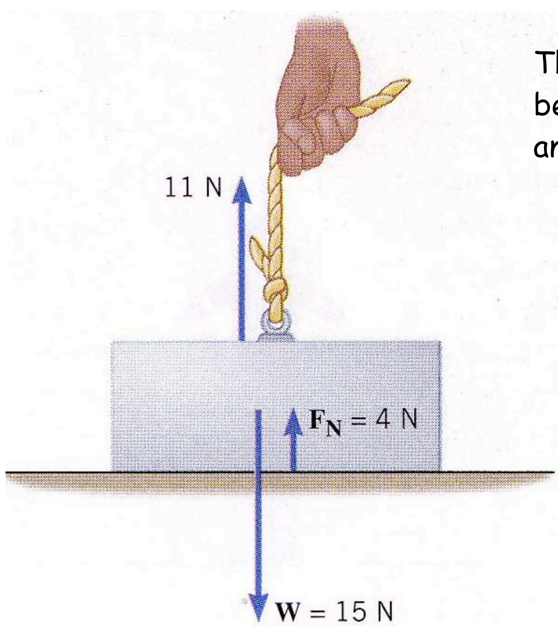
The Normal Force



The normal force F_N of the ground on the block supports all of the forces pushing down on the ground:

$$F_N = 15 + 11 = 26 \text{ N}$$

The Normal Force

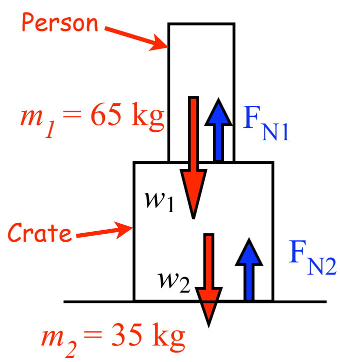


The normal force is reduced because the rope is exerting an upward force on the block:

$$F_N = 15 - 11 = 4 \text{ N}$$

The normal force also changes if there is acceleration upward or downward.

The Normal Force



4.34: A 65 kg person stands on a 35 kg crate.

Normal force F_{N2} supports both masses:

$$F_{N2} = (65 + 35)g = 980 \text{ N}$$

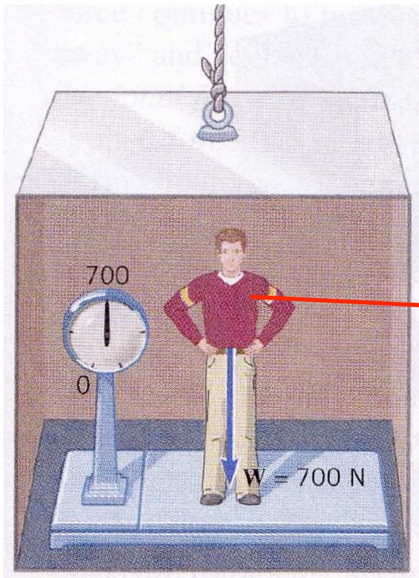
Normal force F_{N1} supports only the person:

$$F_{N1} = 65g = 637 \text{ N}$$

To do -

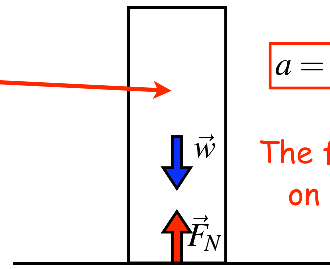
- The bathroom scales in the elevator problem - how did they get there?
- Apparent weight
- Free fall
- Friction, static and kinetic
- Equilibrium
- Non-equilibrium

Apparent Weight



$w = mg = 700\ \text{N}$

The scale shows the force needed to support the person – it is the normal force, F_N of the scale on the feet of the person.



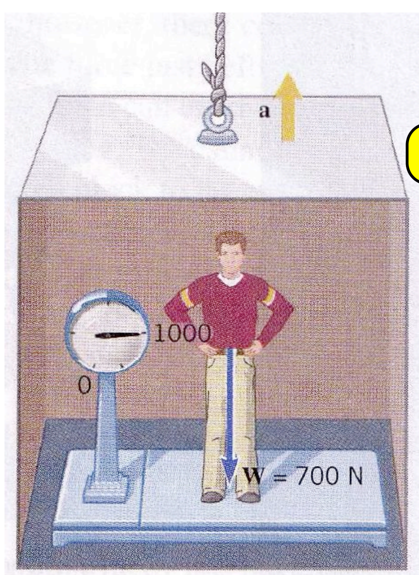
$\boxed{a = 0,\ \vec{v}\ \text{constant}}$

The forces acting on the person

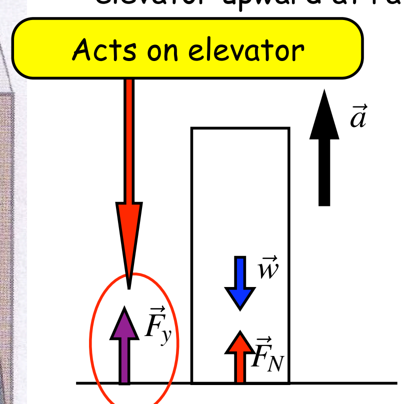
$$\vec{F}_N + \vec{w} = 0$$

$$F_N = 700\ \text{N} = \text{weight of person, } mg$$

Apparent Weight



A force is accelerating the elevator upward at rate a.

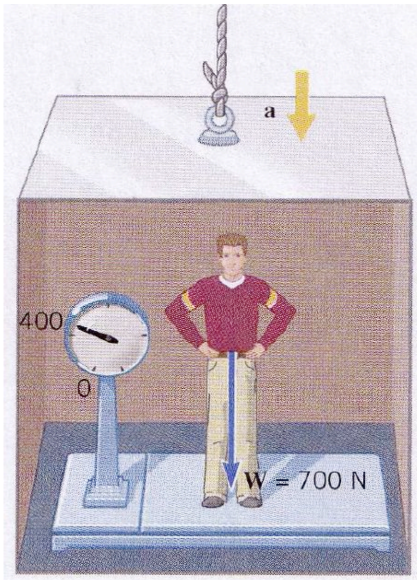


Magnitudes of forces acting on person:

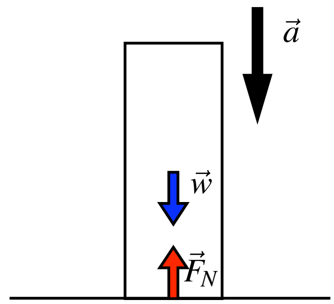
$$F_{net} = F_N - w = ma \quad \text{(2nd law)}$$

Or, apparent weight, $F_N = w + ma \quad = 1000\ \text{N}$

Apparent Weight



The elevator is accelerated downward.



Net **downward** force acting on the person:

$$F_{net} = w - F_N = ma$$

So apparent weight is: $F_N = w - ma \ = 400 \text{ N}$