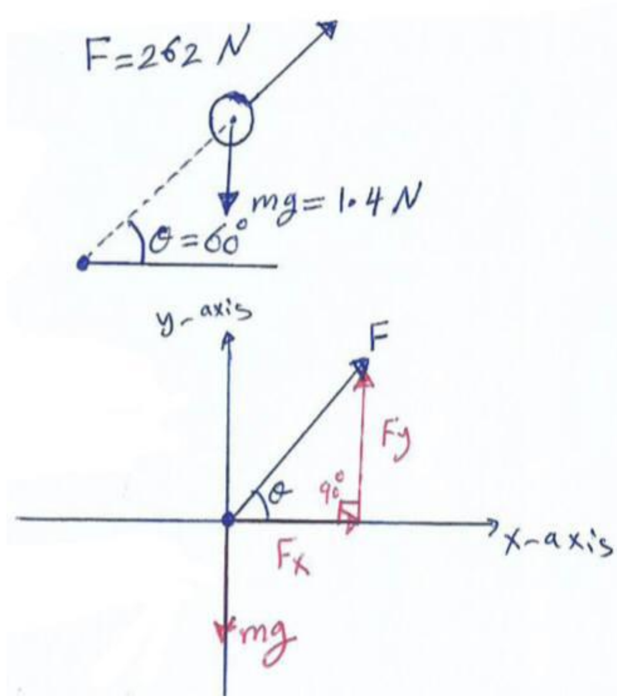
Sample problem: a force at an angle.

Example: what is the magnitude of net force on the ball along each axis, and what is the ball's acceleration along each axis? Consider the below figure.

Sol.

$F_x = F \cos\theta = 262 \cos 60 = 131$ N

$F_y = F \sin\theta = 262 \sin 60 = 227$ N



Now, we need to calculate net force along X-axis

$\Sigma F_X = 131$ N

Also, we need to calculate net force along Y-axis

$\Sigma F_y = F \sin\theta + (-mg)$

$= 227 - 1.4 = 225.6$ N

Now, calculating the acceleration along the X-axis using newton's 2nd law

$\Sigma F_x = ma_x$

$a_x = \dfrac{\Sigma Fx}{m}$

Since mg = 1.4 N, m *9.8 = 1.4

$$m = \frac{1.4}{9.8} = 0.143 \text{ Kg}$$

$$a_x = \frac{131}{0.143} = 916 \text{ m/s}^2$$

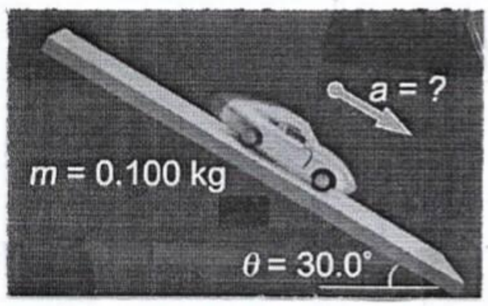
Now, calculating $\Sigma F_y = ma_y$

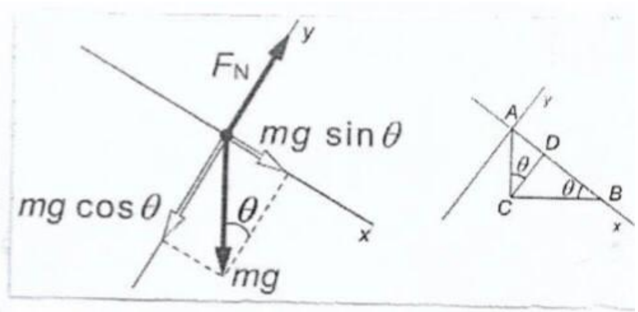
$$a_y = \frac{\Sigma Fy}{m} = \frac{225.6}{0.143} = 1577.6 \text{ m/s}^2$$

Sample problem: moving down a frictionless plane.

<u>Example:</u> what is the toy car's acceleration for the below figure?

Assumption: In this problem, ignore any friction or air resistance.





Sol.:

Components of weight w_x & w_y equals:

w_x = mg sinθ = (0.1) (9.81) sin 30 = 0.49 N

w_y = mg cosθ = (0.1) (9.81) cos 30 = 0.85 N

$\Sigma F_x = ma_x$ newton's 2nd law

Since

ΣF_x = mg sinθ = 0.49N

Hence

0.49 = ma

0.49 = (0.1) * a

a = 4.9 m/s^2 (down the plane)

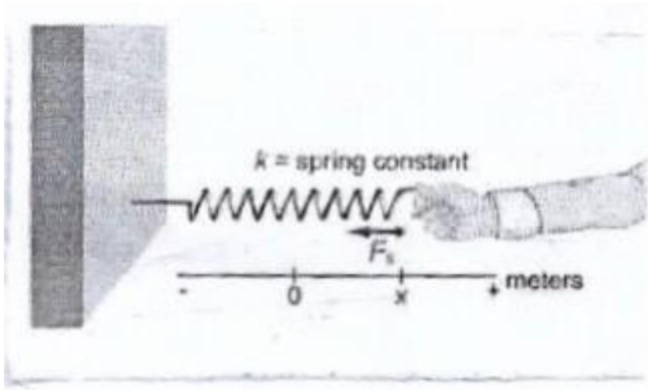
Hooke's law and spring force:

It is law of physics that states that the force (Fs) needed to extend or compress a spring by some distance (X) scales linearly with respect to that distance.

Spring force:

Force exerted by spring depends on:

- How much it is stretched or compressed.
- Spring constant.



Fs = - KX Hooke's

Where

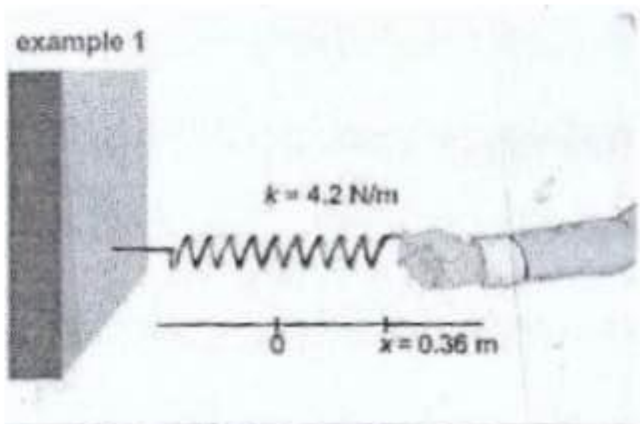
Fs: spring force. (N)

K: spring constant.

X: displacement of end from rest point. (m)

Example: what is the force exerted by the spring for the below figure?

Sol.:



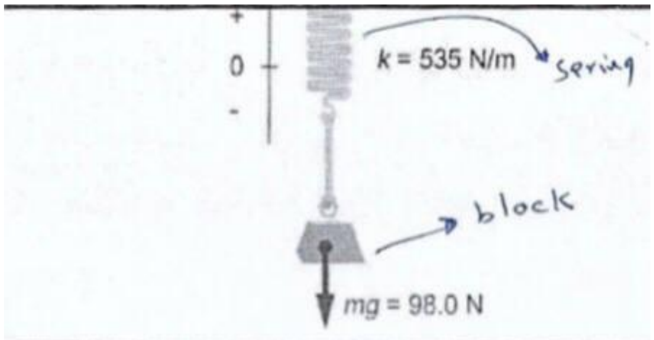
Fs = - KX

Fs = - (4.2) (0.36)

Fs = - 1.5 N (to the left)

Sample problem: spring force and tension.

Example: what is the amount of tension in rope for the below figure? What is the position of the end of the spring away from its rest position?



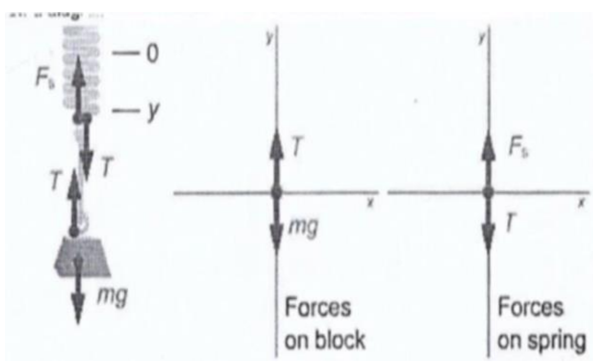
Sol.:

Notes:

- The forces sum to zero for each object (i.e spring or block) because there is no acceleration.
- The tension forces are equal in magnitude, so we use the same variable T for each of them.

Since

$\Sigma F = ma$, apply 2nd law on the block



$\Sigma F_y = ma_y$

$T - w = m(0)$

$T = w = mg = 98$ N.

$F_s = -KY$

by apply 2nd law on the spring

$\Sigma F_y = ma_y$

$F_s - T = m(0)$, $F_s = T = 98$N.

$F_s = -KY$

$98 = -535 * Y$, $Y = \frac{-98}{535} = -0.183$ m.

Air resistance: a force that opposes motion in air

- Drag force opposes motion in air.
- Drag force increases as speed increase.

The force created by air resistance is called drag force.

$$F_D = \frac{1}{2} C \rho A V^2$$

Where:

F_D: drag force

C: drag coefficient for object (based on approximation of shape)

ρ:air density

A: cross-sectional area

V: velocity

Terminal velocity: is the maximum velocity attainable by an object as it falls through a fluid, (air is the most common example)

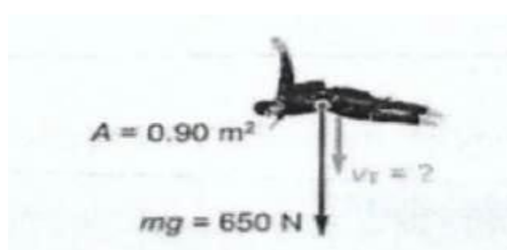
Drag force equals weight.

$$V_T = \sqrt{\frac{2mg}{c\,\rho\,A}}$$

V_T: terminal velocity

mg: weight

Example: the drag coefficient (C) is 0.49 and the air density (ρ) is 1.1 Kg/m^3. What is the skydiver's terminal velocity as shown in figure?



Sol.:

$$V_T = \sqrt{\frac{2mg}{c\,\rho\,A}}$$

$$V_T = \sqrt{\frac{2(650)}{(0.49)(1.1)(0.9)}}$$

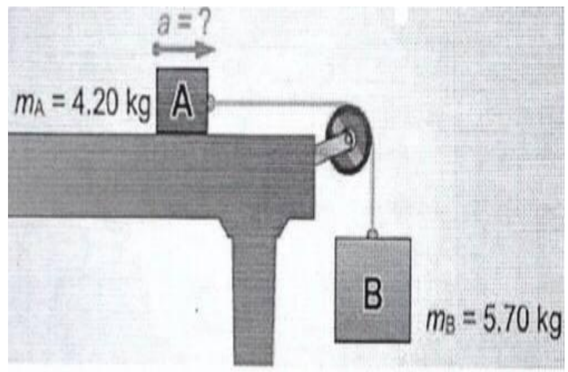
V_T = 52 m/s

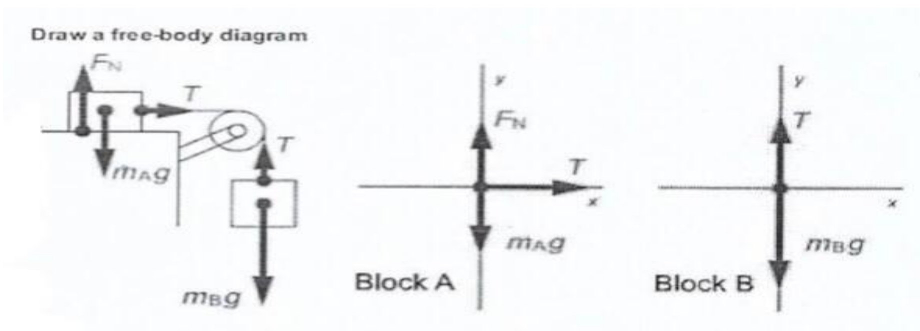
Sample problem: blocks and a pulley system.

Example: what is the acceleration of the block on the frictionless table?

Sol.:

According to the free body diagram, we noticed that the magnitudes of the tension forces exerted on each block by the rope are the same; the amount of tension does not vary within a rope. Because the rope connects the blocks, they accelerate at the same rate (but in different direction).





Block A on table

	X- Component	Y- component
Tension	T	0
Weight	0N	-mg
Normal force	0N	FN
Acceleration	a	0 m/s^2

Falling block B

	X- Component	Y- component
Tension	0N	T
Weight	0N	-mg
Acceleration	0 m/s^2	-a

Apply 2nd law of newton on block A

$\Sigma F_x = m_A a_x$

$T = m_A a_x$

$a_x = \frac{T}{mA}$ … (1)

Apply 2nd law of newton on block B

$\Sigma F_y = m_B a_y$

$T - w_B = m_B a_y$

$T = w_B + m_B a_Y$

Since $a_y = - a_x$

$T = m_B g + m_B (-a_x)$

$T = m_B g - m_B a_x$ sub. Into equ. 1

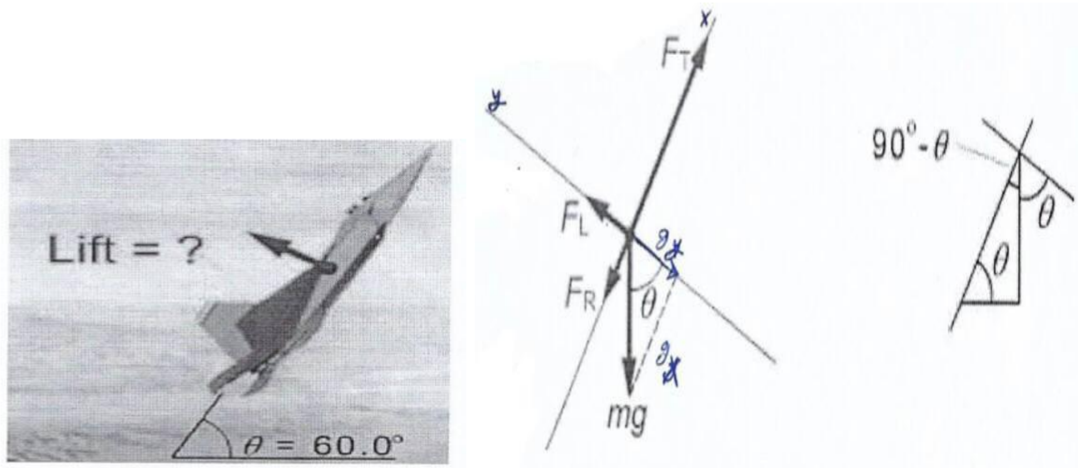
$a_x = \frac{mB\ g - mB\ ax}{mA}$

$m_A * a_x = m_B g - m_B a_x$

$a_x (m_A + m_B) = m_B g$ $a_x = m_B g / (m_A + m_B) = \frac{5.7*9.8}{(4.2+5.7)} = 5.64\ m/s^2$

Sample problem: airplane at constant velocity.

<u>Example:</u> The plane flies at an angle of 60° and it does not accelerating. Its weight is $2.6 * 10^5$ N and its engine thrust is $3 * 10^5$N. What is the amount of lift force on its wings?



Sol.:

According to the figure on right side, one can see that the jet airplane flying through the air at an angle. It travels at a constant velocity; this means that it does not accelerating and no net force is acting on the plane along any dimension.

The forces acting on the plane are its weight, the force provided by its engine, called thrust, the drag force from air resistance, and the lift force from the wings.

The lift force acts perpendicular to the surface of wings.

	X- Component	Y- component
Weight	-mg sinθ	-mg cosθ
Thrust	F_T	0N
Lift	0	F_L
Drag Force	F_R	0

$\Sigma F = m\,a$ 2nd law of newton

$\Sigma F_y = 0$

$F_L - mg\cos\theta = 0$

$F_L - 2.6*10^5 \cos 60 = 0$

$F_L = 1.3 * 10^5$ N