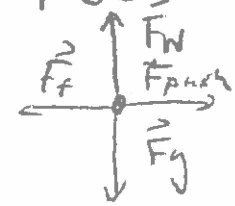
Answers

APPLICATION OF NEWTON'S LAWS

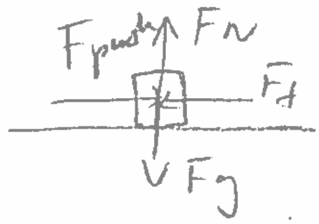
1. a)A robot pushes a crate across a smooth floor. There is a rough patch in the floor and the robot must push with 12.5 N to overcome the patch. If it is able to maintain a constant velocity while pushing with 12.5 N, what is the force of friction between the rough floor and the crate? Draw a free-body diagram of the crate.

motion →

FBD



$a = 0\ m/s^2 \Rightarrow F_{net} = 0N$



$F_f = F_{push}$

$\therefore \vec{F_f} = 12.5N$ [against motion]

b) If the crate has a mass of 3.0 kg, what is the coefficient of friction?

$F_{fk} = F_N \cdot \mu_k$

$\therefore \mu_k \doteq 0.43$

$\mu_k = \frac{F_{fk}}{F_N}$

$= \frac{12.5}{(3.0)(9.8)}$

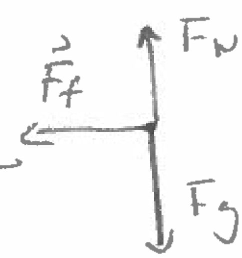
$\doteq 0.43$

2. a) A car coasts on a horizontal surface. It comes to a stop after 3 seconds. If the deceleration of the 1500 kg car was $1.5 m/s^2$, what was the force of friction between the surface and the wheels? Include a free-body diagram.

motion →

$\vec{F_{net}} = \vec{F_f}$

$\therefore F_f = 2.3 \times 10^3 N$ [against motion]



$F_{net} = ma$

$= (1500)(1.5)$

$= 2250\ N$

b) What is the coefficient of friction between the wheels and the surface?

$\mu_k = \frac{\vec{F_f}}{F_N} = \frac{2250}{(1500)(9.8)} \doteq 0.15$

$\therefore \mu_k = 0.15$

3.a) A 0.25kg bucket is attached by a rope to a pulley. What is the magnitude of the tension force in the rope if the bucket is at rest? Include a free-body diagram.

$F_{net} = 0N$

$\vec{F}_{net} = \vec{T} + \vec{F}_g$

$0 = T - mg$

$T = mg$

$= (0.25)(9.8)$

$= 2.45\ N$

$\therefore T = ||\vec{T}|| = 2.5N$

b) How will the tension force in the rope change if you fill the 10.0L bucket with water but the bucket remains in equilibrium?

$1L_{H_2O} = 1kg_{H_2O}$

$F_{net} = 0N$

$\vec{F}_{net} = \vec{T} + \vec{F}_g$

$T = mg$

$= (0.25 + 10.0)(9.8)$

$T = 100.45N$

$\therefore T$ increases by $98N$

OR

$\therefore T$ becomes $\frac{T_b}{T_a} = \frac{100.45}{2.45} = 41$ times greater.

c) Provided that the bucket is large enough, how many liters of water can you put in it if the rope cannot handle more than 250N?

max $T = 250N$

$T = mg$

$250 = (0.025 + m_{H_2O})(9.8)$

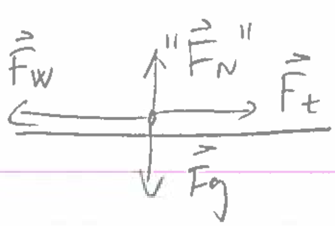
$250 = 2.45 + 9.8 m_{H_2O}$

$m_{H_2O} = \frac{247.45}{9.8}$

$m_{H_2O} = 25\ kg$

$\therefore$ I can put 25L of water into the bucket

4.A 2000 kg sailboat experiences an eastward force of 3000 N from the ocean's tide and a westward force of 4620N from the wind. Find the acceleration of the boat.



$\vec{F}_{net} = \vec{F}_g + \vec{F}_N + \vec{F}_w + \vec{F}_t$

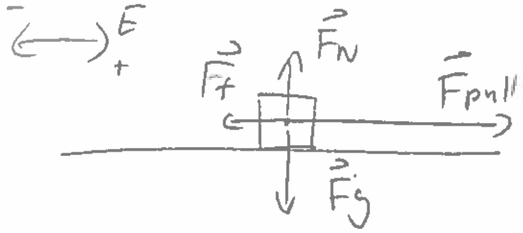
$= 0 - 4620 + 3000$

$= -1620\ N$

$\vec{a} = \frac{\vec{F}_{net}}{m} = \frac{-1620}{2000} = -0.81\ m/s^2$

$\therefore \vec{a} = 0.81\ m/s^2\ [W]$

5. A 10.0-kg box is pulled horizontally along a horizontal surface with coefficient of kinetic friction of 0.30. If the pulling force is 35N east, what is the acceleration of the box? (magnitude and direction)



$\vec{a} = \frac{\vec{F}_{net}}{m}$

$= \frac{5.6}{10}$

$= 0.56 \ m/s^2 \ [E]$

$\vec{F}_{net} = \vec{F}_g + \vec{F}_N + \vec{F}_f + \vec{F}_{pull}$

$= 0 - 29.4 + 35$

$= 5.6 N \ [E]$

$\vec{F}_{f_k} = F_N \cdot \mu_k$

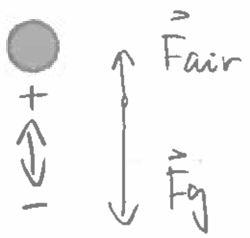
$= mg \mu_k$

$= (10.0)(9.8)(0.30)$

$= 29.4 N \ [W]$

$\therefore \vec{a} = 5.6 \times 10^{-1} \ \frac{m}{s^2} \ [E]$

6. a) An 80.0-kg person jumps from a burning building into a net. Assume air resistance is 100 N. Find the acceleration of the person as they fall if the net is 30 m below.



$\vec{F}_{net} = \vec{F}_g + \vec{F}_{air}$

$= -mg + 100$

$= -(80.0)(9.8) + 100$

$= -684 N$

$= 684 N \ [D]$

$\vec{a} = \frac{\vec{F}_{net}}{m}$

$= \frac{-684}{80.0}$

$= -8.6 \ m/s^2$

$\therefore \vec{a} = 8.6 \ m/s^2 \ [D]$

b) Would this acceleration change if the net was 60m below? If yes how? If not, why?

→ the acceleration will not change with the length (= magnitude) of the displacement. As long as $F_{air} = 100N$, F_{net} will remain 684N.

c) Would the velocity of the person just before they hit the net change with the different height they jump from?

$\|\vec{v}_{fy}\|$ will increase with increased height as

$v_{fy}^2 = v_{iy}^2 + 2ad \rightarrow v_{fy} = \sqrt{0^2 - 2(-9.8)(-height)}$

7. Identify the reaction force – magnitude and direction in each of the following examples:

a) A football is kicked with 500 N[N]

A football pushes onto the foot 500N [S].

b) A book pushes down on the table with 2.5 N

A table pushes onto a book with 2.5N [U].

c) A crane lifts a steel pipe with force of 600 N [up]

A steel pipe pulls onto the crane with 600N [D].

d) A gun forces a bullet with force of 1000N [left]

A bullet pushes onto the gun with 1000N [R].

e)Earth pulls down on an apple with 10 N

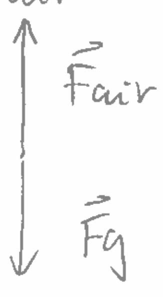
An apple pulls onto the Earth with 10N [U].

8. a)What is the acceleration of a person with a parachute that together weight of 915N if their parachute experiences a force of air resistance 1027N [up]?

↑+ ↓−

$mg = F_g = 915\ N$

$F_{air} = 1027\ N$



$\vec{F}_{net} = \vec{F}_g + \vec{F}_{air}$

$= -915 + 1027$

$= 112\ N\ [U]$

$m = \frac{weight}{g}$

$m = \frac{915}{9.8}$

$m = 93.3673\ kg$

$\vec{a} = \frac{\vec{F}_{net}}{m}$

$= \frac{112}{93.3673}$

$\doteq 1.2\ m/s^2\ [U]$

∴ the acceleration is 1.2 m/s^2 [U].

b) What is the person's mass if the parachute has mass of 9.4 kg?

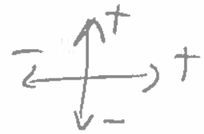
$m_{p+p} = \frac{915}{9.8}$

$= 93.3673$

$m_{person} = 93.3673 - 9.4$

$= 83.9676\ kg$

∴ the mass of the person is 84 kg.

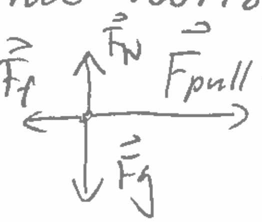


$m = 68.0\,kg$

9. What is the acceleration of a 10.0kg sled loaded with a 58.0-kg of supplies provided that the coefficient of friction between the rough snow and the sled is 0.25 and the dogs pulling the sled are exerting force of 228 N [East]?

"Maybe I had better look at the map again..."

• Assume horizontal surface



$$\vec{F}_{net} = \underbrace{\vec{F}_g + \vec{F}_N}_{} + \vec{F}_f + \vec{F}_{pull}$$
$$= 0 - 166.6 + 288$$
$$= 61.4\,N\,[E]$$

$$\vec{a} = \frac{\vec{F}_{net}}{m} = \frac{61.4}{68.0} \doteq 0.90\,m/s^2$$

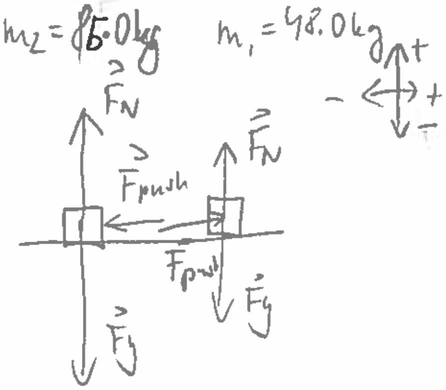
$\therefore \vec{a} = 9.0 \times 10^{-1}\,m/s^2$ [E]

$$\vec{F}_f = \vec{F}_N \cdot \mu_k = mg\mu_k$$

$$\vec{F}_f = (68.0)(9.8)(0.25) = 166.6\,N\,[W]$$

10. A 48.0-kg figure skater pushes her partner whose mass is 85.0 kg with force of 45 N [left]. Provided that both figure skaters were at rest before the force was applied, calculate the acceleration of each of the skaters.

$m_2 = 85.0\,kg$ $m_1 = 48.0\,kg$



$F_{push_{12}} = F_{push_{21}} = 45N$ • Assume no $\vec{F}_f$

$$\vec{a}_1 = \frac{\vec{F}_{net_1}}{m_1} = \frac{45}{48.0} \doteq 0.94\,m/s^2\,[R]$$

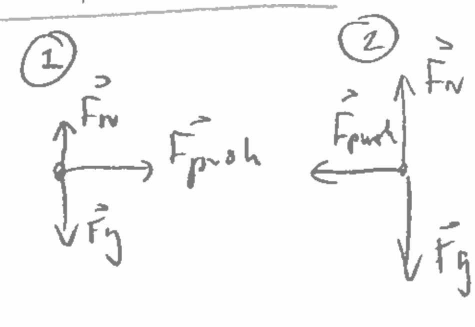
$$\vec{a}_2 = \frac{\vec{F}_{net_2}}{m_2} = \frac{-45}{85.0} \doteq 0.53\,m/s^2$$

$$\vec{F}_{net} = \vec{F}_g + \vec{F}_N + \vec{F}_{push} = 0 + 45$$

$\vec{F}_{net\,①} = 45N$

$\vec{F}_{net\,②} = -45N$

FBD



∴ The female skater accelerates $0.94\frac{m}{s^2}$ [R] and the male skater accelerates $0.53\frac{m}{s^2}$ [L].

m v_i v_f t

11. How much force was needed to accelerate a 1400.0-kg object from rest to 27m/s in 5.8 seconds?

$$a = \frac{v_f - v_i}{t}$$

$$a = \frac{27 - 0}{5.8}$$

$$a \doteq 4.655 \ m/s^2$$

$$\vec{F}_{net} = m \cdot \vec{a}$$

$$= (1400)(4.655)$$

$$= 6517 \ N$$

$$= 6.5 \times 10^3 \ N$$ [direction of motion]

∴ 6.5×10^3 N in the direction of motion was needed to accelerate the object.

~~12~~. In your words or using a formula state five laws concerning forces: