Chapter 5

Newton's Laws of Motion:

Newton's First Law:

If No Net Force acts on a body ($\vec{F}_{net} = 0$) the body's velocity cannot change; that is, the body cannot accelerate.

We understand the following:

1) If $\vec{F}_{net} = 0 \Longrightarrow \vec{a} = 0$
   - → the body at rest
   - → $\vec{V}$ = Constant

2) Force is must to change the state.

3) Forces
   - → $\vec{F}_g = m\vec{g} = -mg\hat{j}$
   - → Normal Force from the surface
   - → Tension Force
   - → friction Force
   - → ....

Newton's second Law:

The net force on a body is equal to the Product of the body's $\boxed{\text{mass}}$ and its $\boxed{\text{Acceleration}}$
$\quad m \quad \vec{a}$

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

$F_{net,x} = ma_x$

$F_{net,y} = ma_y$

We Understand the following.

1) The Unit of force is $N = kg\,m/s^2$

2) mass is Called inertial mass: the mass try to resist the force action.

Newton's Third Law:

When two bodies interact, the forces on the bodies from each other are always equal in magnitude and opposit in direction

We understand the following:-

1) The Action force acts on body(1)
The Reaction force acts on body(2)

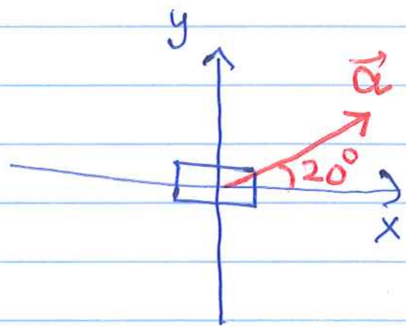
2) The Action & Reaction Forces act at the same time

$$F_{AB} \longleftarrow (A)\ (B) \longrightarrow F_{BA}$$

Chapter 5 - Lecture Problems:

(5-3) $m = 1kg$ moves at
$\vec{a} = 2\,m/s^2$; at $20°$ to $+X$

Find 1) F_{nx} ? 2) F_{ny} ? 3) F_{net}



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

$F_{net\,X} = m a_x = (1)(2)\cos 20$
$= 2\cos 20$
$= 1.88\,N$

$F_{net\,y} = m a_y = m a \sin 20 = (1)(2)(\sin 20)$
$= 0.684\,N$

$\vec{F}_{net} = 1.88\hat{i} + 0.684\hat{j}\ N$

(5-9) $m = 0.340\,kg$ $\to x(t) = -15 + 2t - 4t^3$ meter
$\to y(t) = 25 + 7t - 9t^2$ meter

At $t = 0.700s$

a) F ? b) θ ?

$V_x(t) = \frac{dx}{dt} = 2 - 12t^2$ m/s

$a_x(t) = \frac{dV_x}{dt} = -24t$ m/s2

$F_{net\,X} = m a_x = (0.34)(-24t)$

$F_{net\,x}(t) = -8.16t\ N$

$V_y(t) = \frac{dy}{dt} = 7 - 18t$ m/s

$a_y(t) = \frac{dV_y}{dt} = -18$ m/s² constant

$F_{net\,y}(t) = m a_y = (0.34)(-18)$ constant

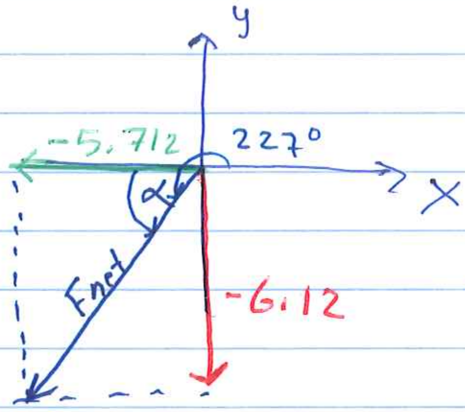
$F_{net\,y} = -6.12\,N$

At $t = 0.700\,s$

$F_{net\,x} = -5.712\ N$

$F_{net\,y} = -6.12\ N$

$\vec{F}_{net} = -5.712\hat{i} - 6.12\hat{j}\ N$



$F_{net} = \sqrt{(-5.712)^2 + (-6.12)^2}$

$= 8.37\ N$

$\tan\alpha = \dfrac{6.12}{5.712}$, $\alpha = \tan^{-1}\left(\dfrac{6.12}{5.712}\right) = 47°$

$\vec{F}_{net} = 8.37\ N$, At $47°$ with $-x$ counter clockwise

or

$\vec{F}_{net} = 8.37\ N$, At $227°$ with $+x$ counter clockwise.

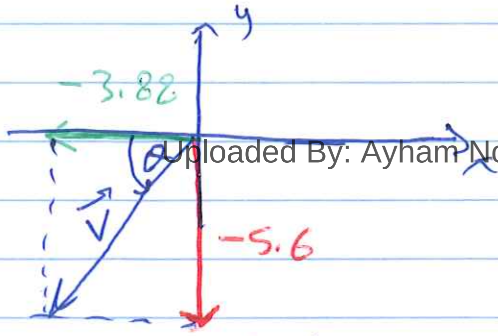
c) What is the angle of the Particle's direction of travel at $t = 0.700\,s$?

this means the direction of Velocity ?

$V_x(t) = 2 - 12t^2$, At $t = 0.7\,s$ $V_x = -3.88\ m/s$

$V_y(t) = 7 - 18t$, At $t = 0.7\,s$ $V_y = -5.6\ m/s$

$\vec{V} = -3.88\hat{i} - 5.6\hat{j}\ m/s$



$V = \sqrt{(-3.88)^2 + (-5.6)^2}$

$V = 6.8\ m/s$

$\theta = \tan^{-1}\left(\dfrac{5.6}{3.88}\right) = 55.3°$

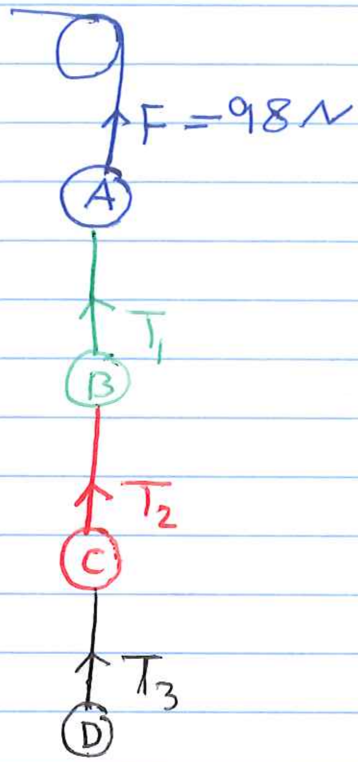
$\vec{V} = 6.8\ m/s$; At $55.3°$ with $-x$ Counter clockwise

or

$\vec{V} = 6.8\ m/s$; At $235.3°$ with $+x$ Counter clockwise

(9-13) $T_3 = 9.8N$, $T_2 = 49N$

$T_1 = 58.8N$



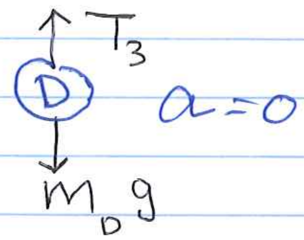
Find m_A ? m_B ? m_C ? m_D ?

Write the equation of motion For each mass

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

No motion $\Rightarrow$

$\vec{F}_{net} = 0 \Rightarrow a = 0$

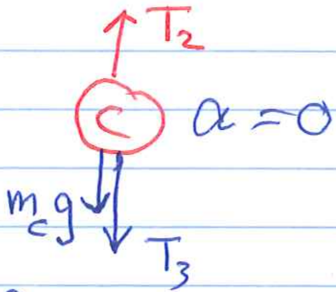


$m_D(a) = T_3 + {}^{-}m_D g$

$0 = T_3 - m_D g$

$m_D = \frac{T_3}{g} = \frac{9.8}{9.8} = 1\ kg$

$m_D = 1kg$

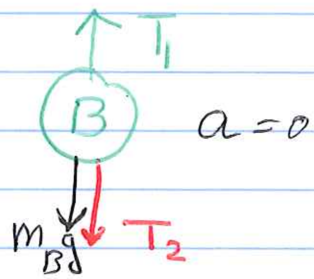


$m_c a = T_2 + {}^{-}m_c g + {}^{-}T_3$, $a = 0$

$m_c g = T_2 - T_3$

$m_c = \frac{T_2 - T_3}{g} = \frac{49 - 9.8}{9.8} = 4kg$

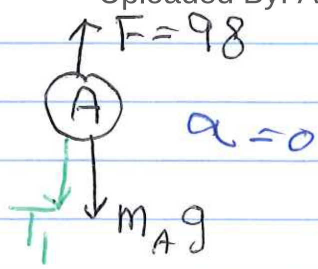
$m_c = 4kg$



$T_1 + {}^{-}m_B g + {}^{-}T_2 = 0$

$m_B = \frac{T_1 - T_2}{g} = \frac{58.8 - 49}{9.8}$

$m_B = 1kg$



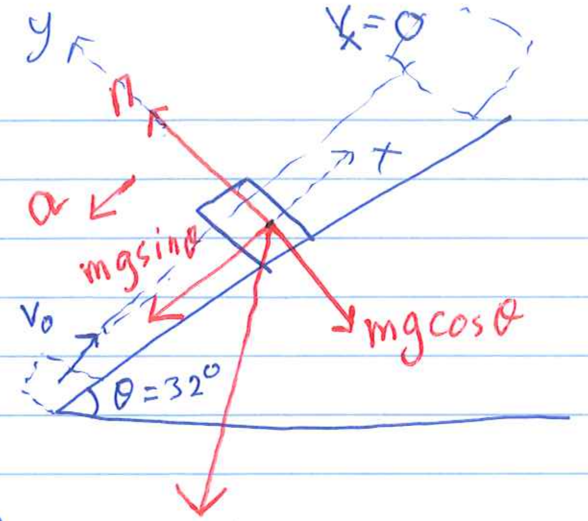
$F + {}^{-}T_1 + {}^{-}m_A g = 0$

$m_A = \frac{F - T_1}{g} = \frac{98 - 58.8}{9.8}$

$m_A = 4kg$

(5 - 31) $V_0 = +3.5\ m/s$

$\theta = 32$

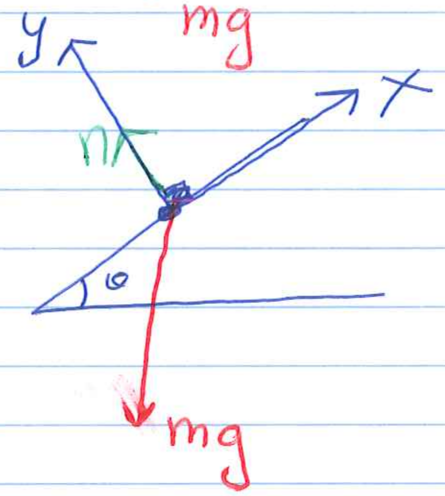


a) Find d?:

2 Forces are acting on the block mg + normal Force

$\sum F_y = 0 \Rightarrow n - mg\cos\theta = 0$

$n = mg\cos\theta$



$\sum F_x = m a_x = -mg\sin\theta$

$a_x = -g\sin\theta$

$= -9.8 \sin(32)$

$a_x = -5.2\ m/s^2$

$V_{0x} = +3.5\ m/s$

$V_x = 0$

$\Delta X = V_{0x} t + \frac{1}{2} a_x t^2$ No time, then

$V_x^2 = V_{0x}^2 + 2 a_x \Delta X$

$0 = (3.5)^2 + 2(-5.2)\Delta X$

$\Delta X = \frac{(3.5)^2}{2(5.2)} = 1.18\ m$

b) t? $V_x = V_{0x} + a_x t$,

$0 = +3.5 + (-5.2)t$ $t = 0.67\ s$

c) At the bottom when it gets back

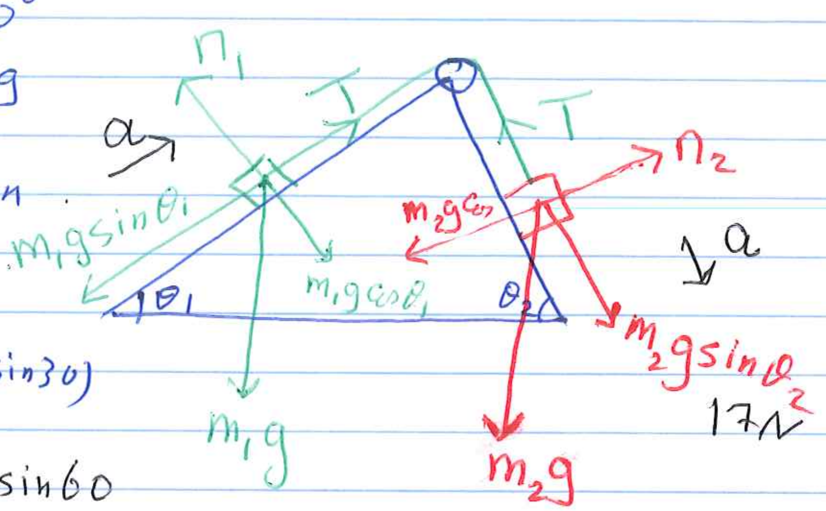
$V_x = -3.5\ m/s$ Velocity

Speed $= 3.5\ m/s$

(5-71) $\theta_1 = 30^\circ$, $\theta_2 = 60^\circ$

$m_1 = 3\,kg$, $m_2 = 2\,kg$

To find the direction of motion



$m_1 g \sin\theta_1 = (3)(9.8)(\sin 30)$
$= 14.7N$

$m_2 g \sin\theta_2 = (2)(9.8)\sin 60$
$= 17N$

take the direction of a to be positive

for $m_1 \Longrightarrow m_1 a = T - m_1 g \sin\theta_1$ ①

for $m_2 \Longrightarrow m_2 a = m_2 g \sin\theta_2 - T$ ②

Add $\longrightarrow$

$(m_1 + m_2) a = m_2 g \sin\theta_2 - m_1 g \sin\theta_1$

$$a = \frac{m_2 g \sin\theta_2 - m_1 g \sin\theta_1}{m_1 + m_2}$$

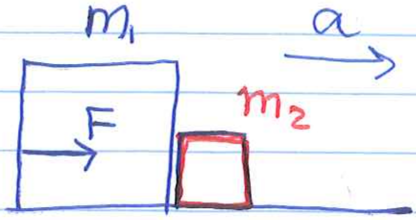
$$a = \frac{17 - 14.7}{5} = \frac{2.3}{5}\, m/s^2 = 0.46\, m/s^2$$

from ① $T = m_1 a + m_1 g \sin\theta_1$

$= (3)\left(\frac{2.3}{5}\right) + 14.7 = 1.38 + 14.7$

$T = \boxed{16N}$

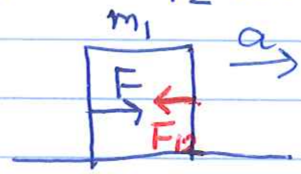
(5 − 55) $m_1 = 2.3\,kg$
$m_2 = 1.2\,kg$
$\vec{F} = 3.2\,\hat{i}\ N$



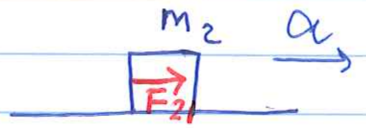
a) Find the force between the 2 blocks?

Note the following

m_2 acts a force on m_1 equal to F_{12} toward −x
As a reaction force



m_1 acts on m_2 a force F_{21}.
toward +x.



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

Newton's third Law

$m_1 a = F - F_{12}$ ①

$m_2 a = F_{21}$ ②

Note $F_{12} = F_{21}$

by Adding

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

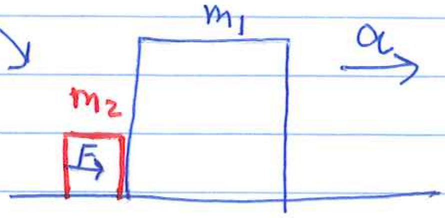
$a = \dfrac{F}{m_1 + m_2} = \dfrac{3.2}{2.3 + 1.2} = 0.91\ m/s^2$

in ② $F_{21} = m_2 a = (1.2)(0.91) = 1.1\,N$

$\vec{F}_{21} = 1.1\,\hat{i}\ N$ $\vec{F}_{12} = -1.1\,\hat{i}\ N$

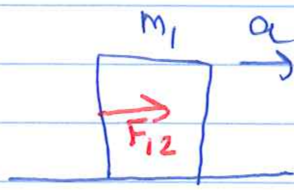
b) $F = 3.2\,\hat{i}\ N$ acting on m_2

Find the force between the ~~(m_1~~ blocks



$(m_1 + m_2)\,\vec{a} = \vec{F}_{net}$

$a = \dfrac{3.2}{1.2 + 2.3} = 0.91\ m/s^2$



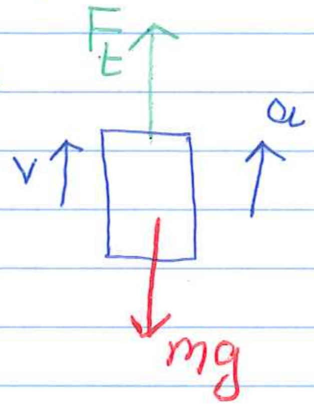
$m_1 a = F_{12}$, $F_{12} = (2.3)(0.91) = 2.1\,N$

differ from Part ⓐ

Solve Sample Problem 5.07
it is the same as Problem (5-55)

(5-45) $W = 27.8 kN = 27.8 \times 10^3 N$ moves upward

a) Find F_t? when it moves upward at increasing speed at a rate $1.22 m/s^2$



$\sum \vec{F} = m\vec{a}$, $m = \frac{W}{g} = \frac{27.8 \times 10^3}{g}$

$F_t - mg = m(1.22)$

$m = 2.84 \times 10^3 kg$

$F_t - 27.8 \times 10^3 = (2.84 \times 10^3)(1.22$

$F_t = 27.8 \times 10^3 + 3.46 \times 10^3$

$= 31.3 \times 10^3 N = 31.3 kN$

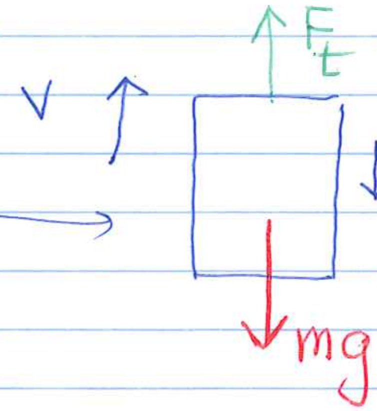
$F_t = 31.3 kN$

b) It moves upward with decreasing speed at a rate $1.22 m/s^2$?

Find F_t?

decreasing velocity means

$\vec{a}$cceleration opposes $\vec{V}$



$\sum \vec{F} = m\vec{a}$

$F_t - mg = m(-a)$

$F_t - 27.8 \times 10^3 = (2.84 \times 10^3)(-1.22)$

$F_t = 27.8 \times 10^3 - 3.46 \times 10^3$

$= 24.3 \times 10^3 N$

$F_t = 24.3 kN$

Solve Sample Problem 5.06