FORCES PART 2

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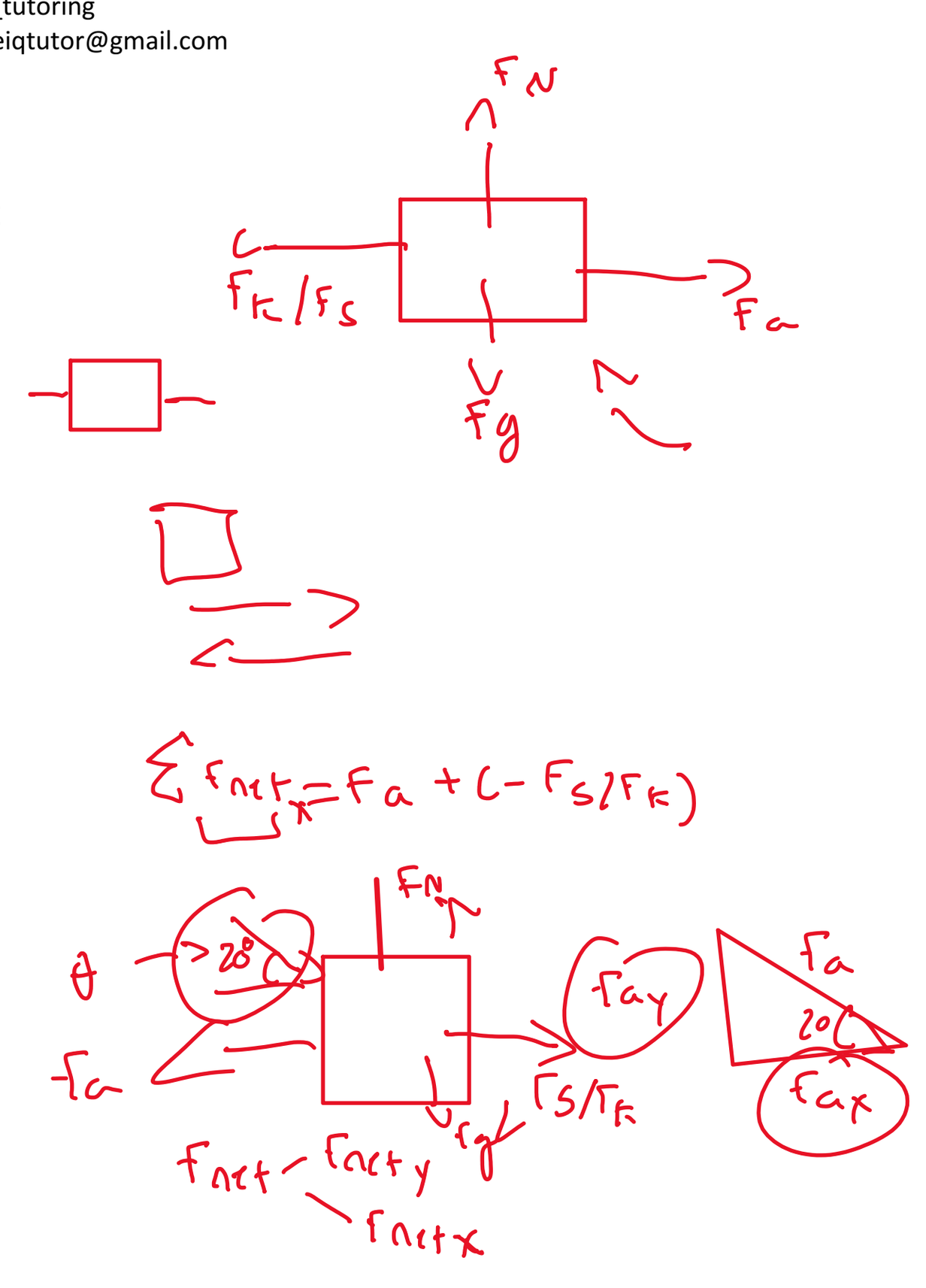
Normal force:
- Force exerted by a surface that supports the weight of an object resting on it; acts perpendicular to the surface

Static and kinetic:
- Static friction: prevents objects from starting to move
- Kinetic: acts on moving objects

Net force:
- Vector force of all forces acting on an object

Resolving forces into components:
- Used to analyze forces acting on an angle

Inclined plane forces:
- Require resolving weight into two components; parallel and perpendicular to the plane



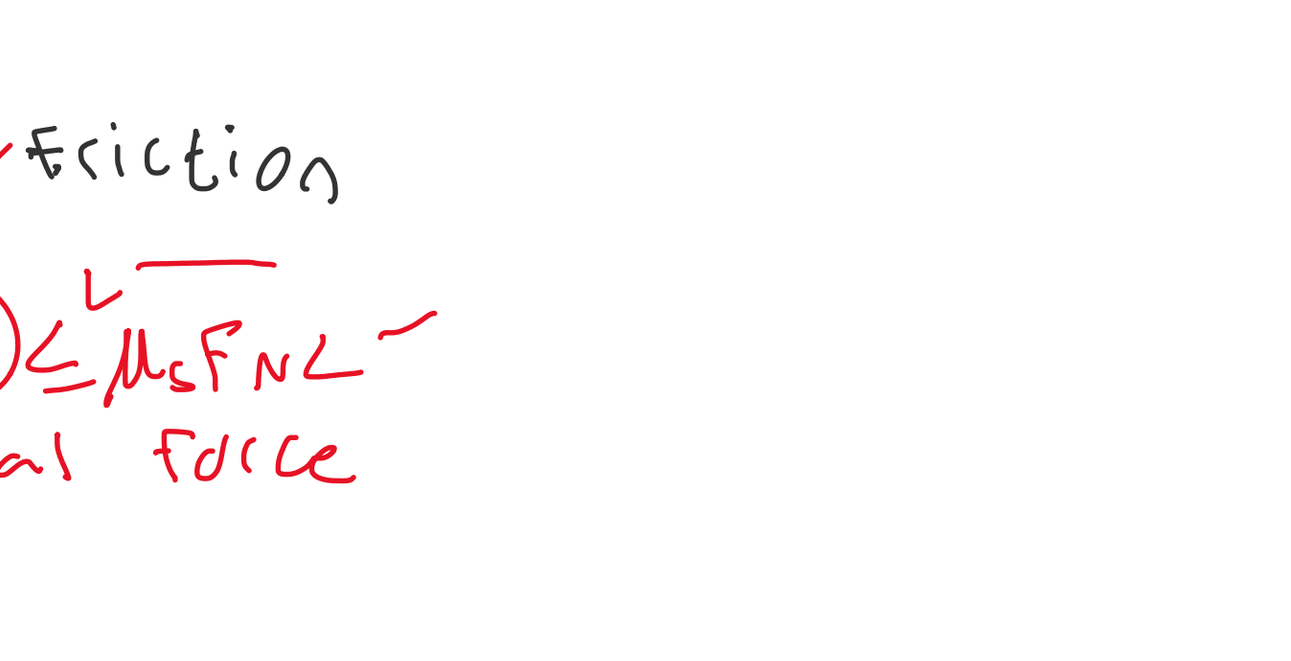
1 Normal force:

$F_N = mg$
$W = mg$ } $F_N = W$

Question: A book rests on horizontal table. If the mass of the book is 2kg, what is the normal force exerted by the table on the book?

Solution:
Givens/unknowns:

$m = 2kg$ $g = 9.81 m/s^2$
$F_N = ?$



$F_N = mg$
$= 2kg \cdot 9.81 m/s^2$
$= 19.6N$ ✓

2 Static and kinetic friction

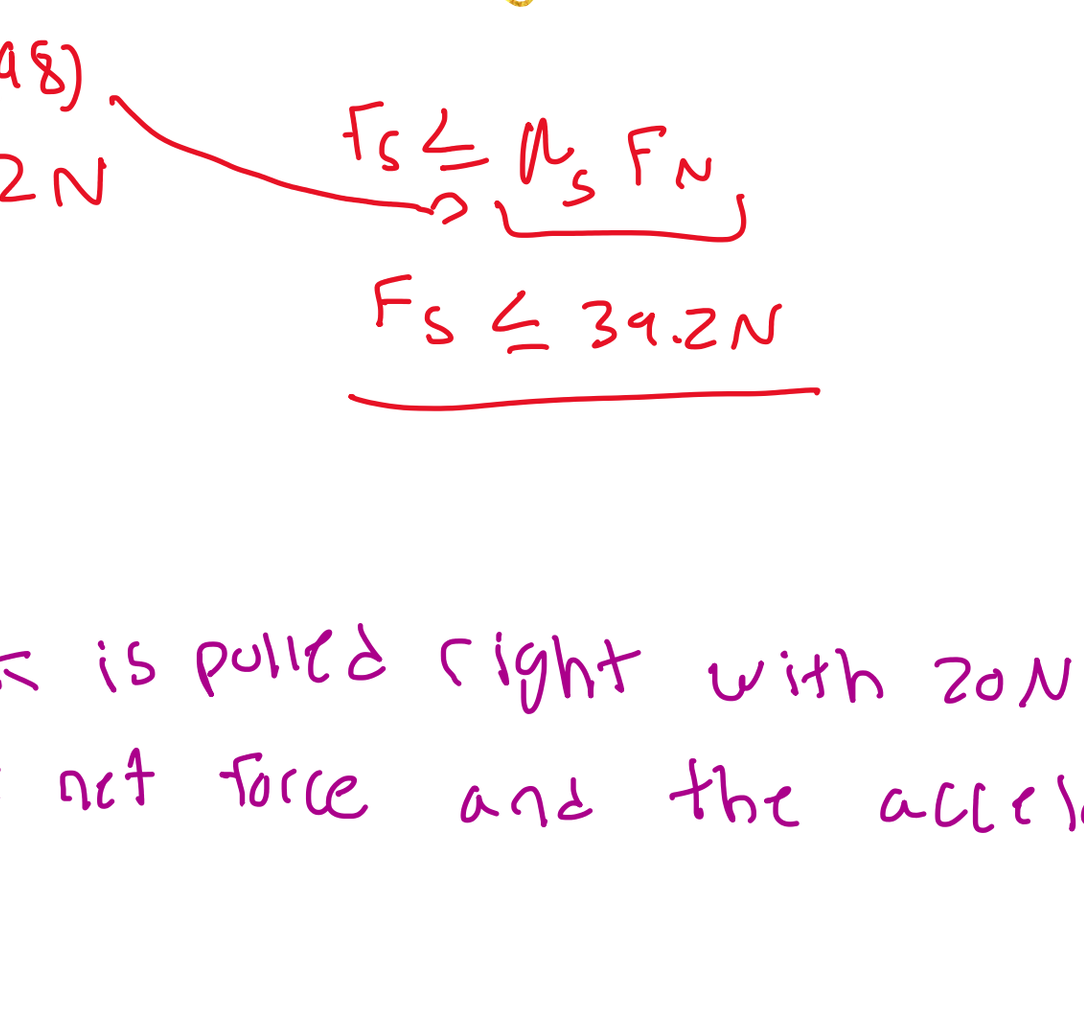
$F_k = \mu F_N$ $F_s \leq \mu_s F_N$

coefficient of friction; Normal force

Question: A 10kg box initially at rest is pushed with a horizontal force. If the coefficient of static friction is 0.4, what is maximum force that can be applied before the box starts to move?

Solution:
Givens/unknowns:

$m = 10kg$ $g = 9.81 m/s^2$
$\mu = 0.4$
$F_N = ?$
$F_f = ?$



$F_N = mg$
$= 10(9.81)$
$= 98N$

$F_f = \mu F_N$
$= 0.4(98)$
$= 39.2N$

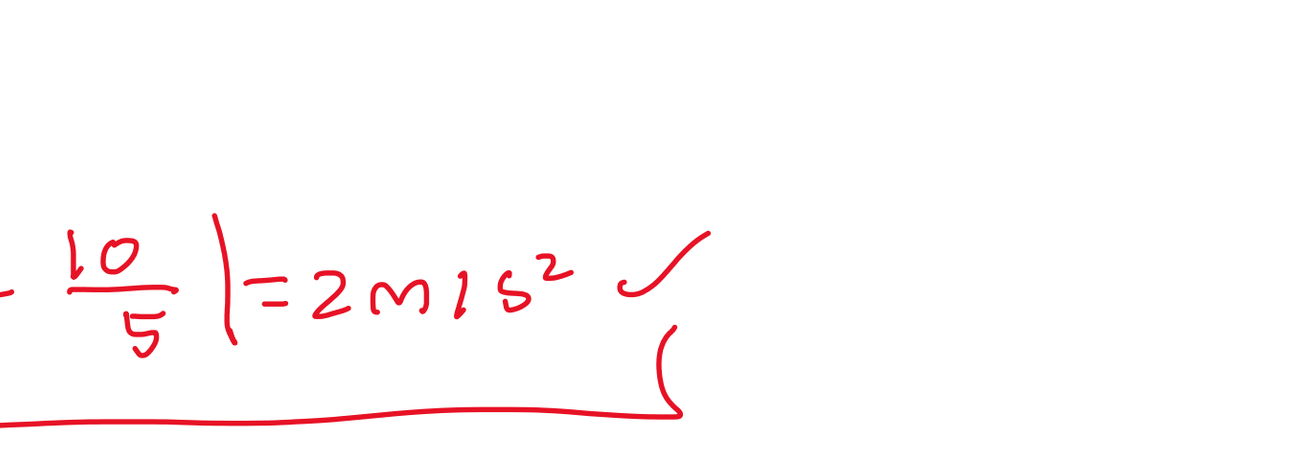
$F_s \leq \mu_s F_N$
$F_s \leq 39.2N$

3 Net Force:

Question: A 5kg block is pulled right with 20N and left with 10N. Calculate the net force and the acceleration

Solution:
Givens/unknown:

$m = 5kg$
$F_a = 20N$
$F_f = 10N \rightarrow -10N$
$a_x = ?$
$F_{net_x} = ?$



$F_{net} = F_A - F_f$
$= 20 - 10$
$= 10N$ ✓

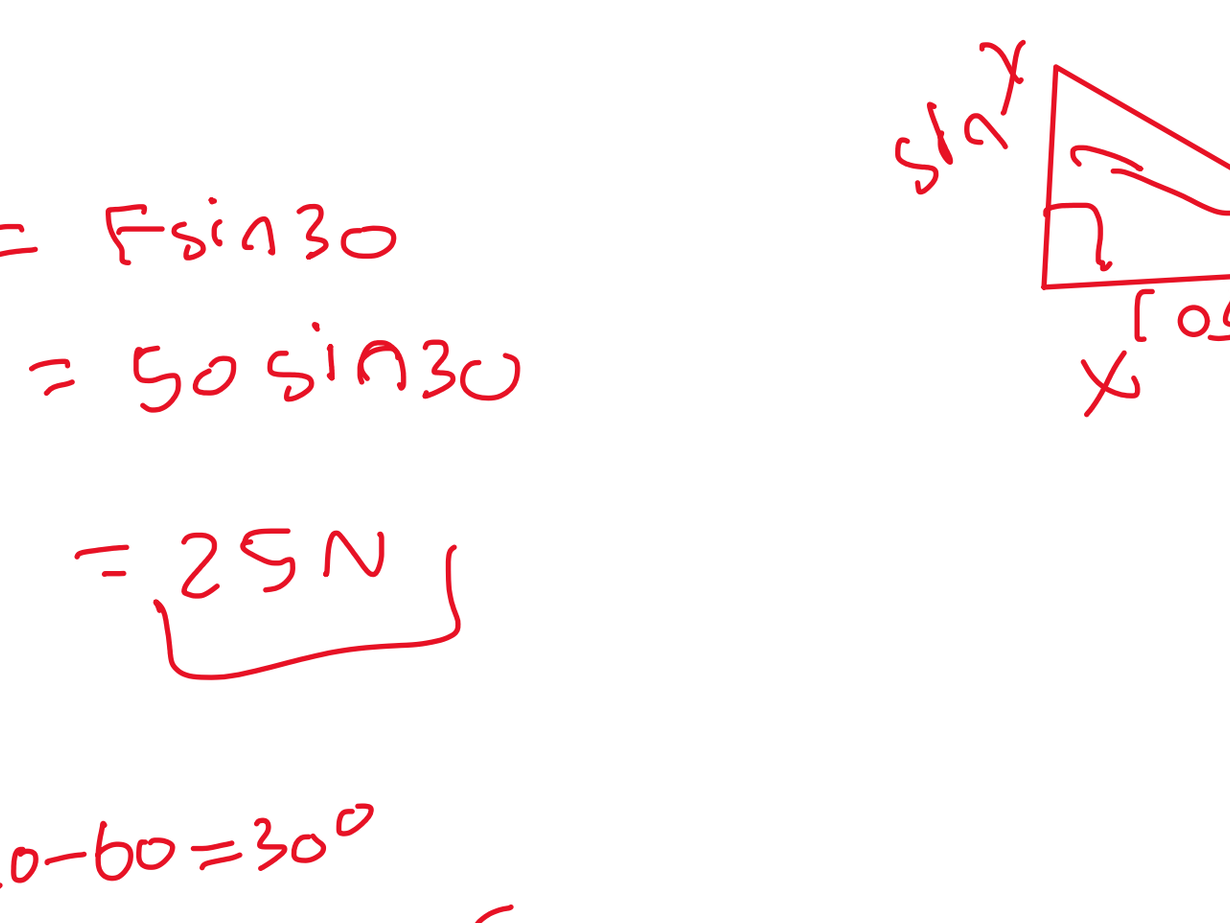
$\frac{F_{net}}{m} = \frac{ma}{m}$ $a = \frac{F_{net}}{m} = \frac{10}{5} = 2 m/s^2$ ✓

4 Resolving Force components

Question: A force of 50N is applied at an angle of 30° to the horizontal. Calculate the horizontal and vertical components.

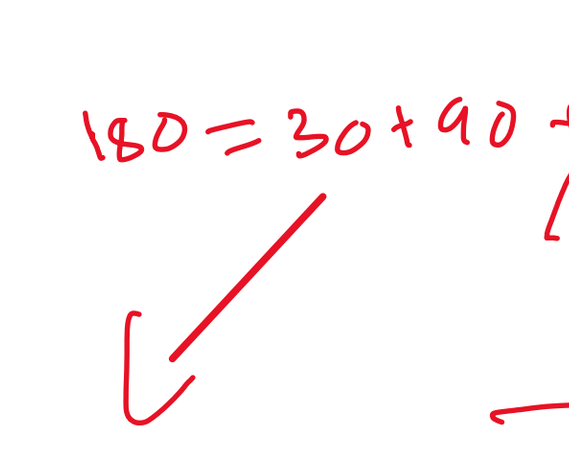
Solution:
Givens/unknowns

$F_a = 50N$
$\theta = 30°$
$F_x = ?$
$F_y = ?$



$F_{ax} = F\cos 30$
$= 50\cos 30$
$= 43.3N$

$F_{ay} = F\sin 30$
$= 50\sin 30$
$= 25N$



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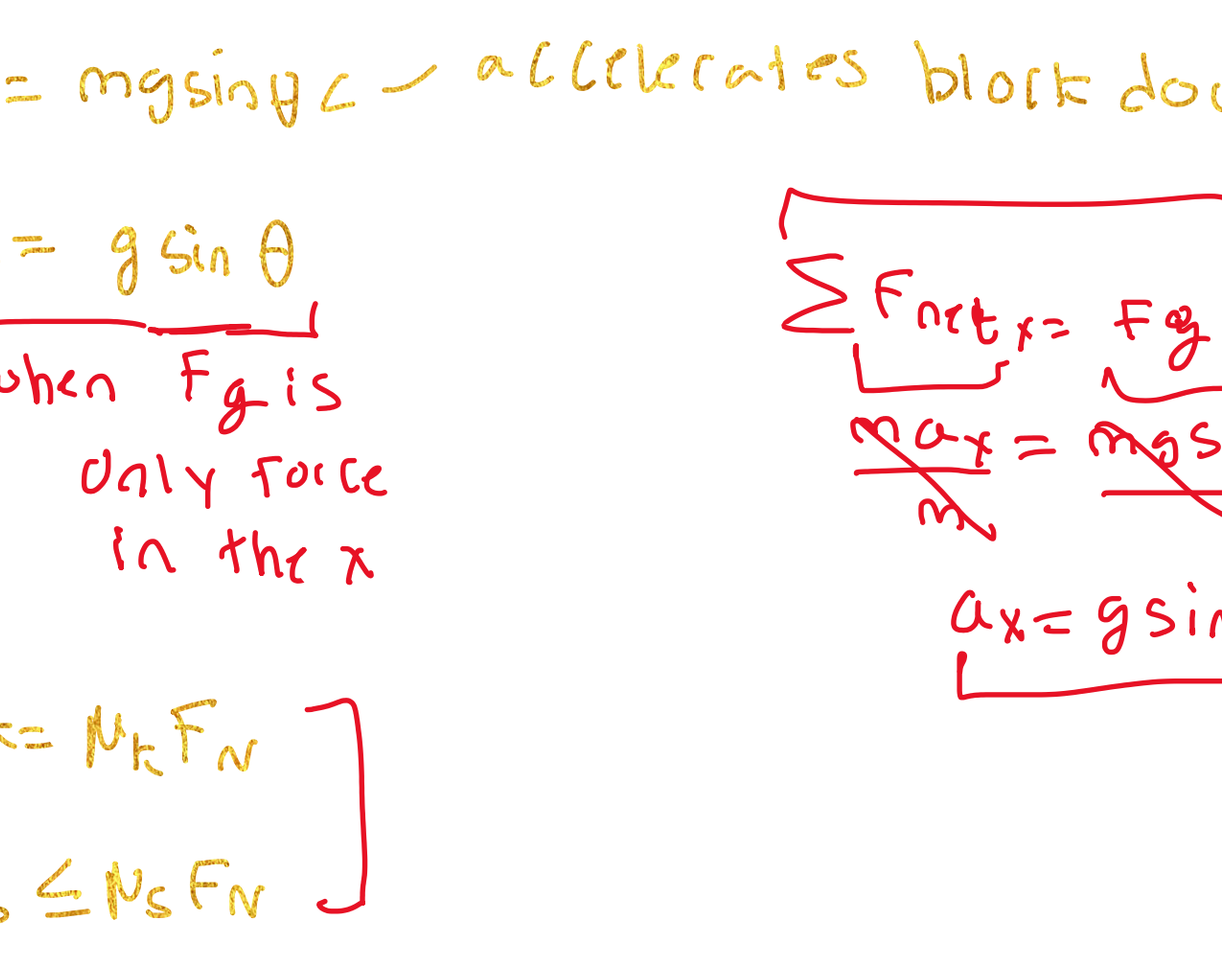
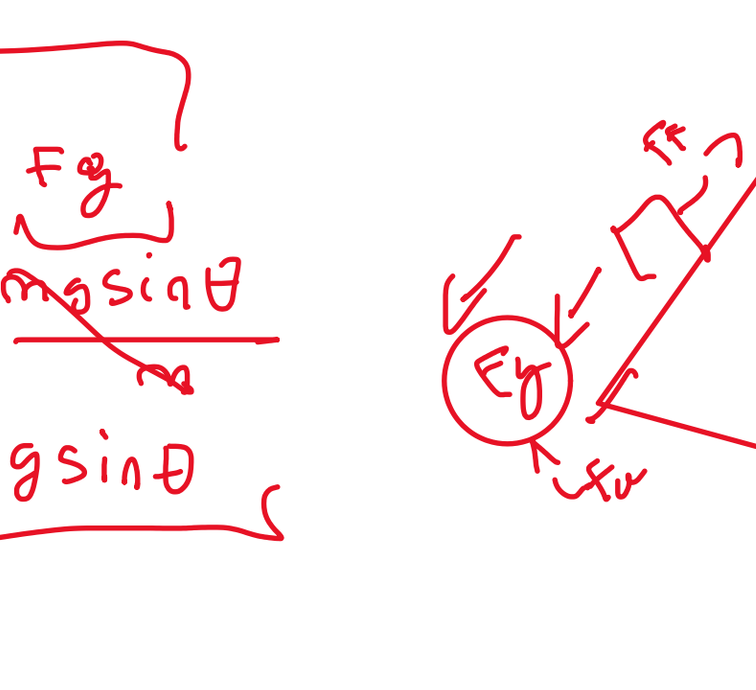
5 Inclined Force



$90 - 60 = 30°$



→ FN

$180 = 30 + 90 + x$ $x = 60$

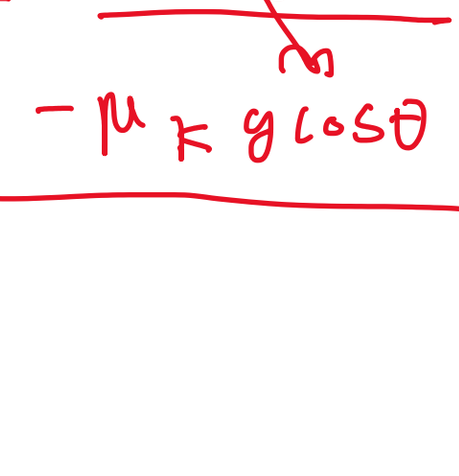
General Rules:

$F_N = mg\cos\theta$

$F_g = mg\sin\theta$ ← accelerates block down incline

$a_x = g\sin\theta$ — when F_g is only force in the x

$\Sigma F_{net_x} = F_g$
$ma_x = mg\sin\theta$
$a_x = g\sin\theta$

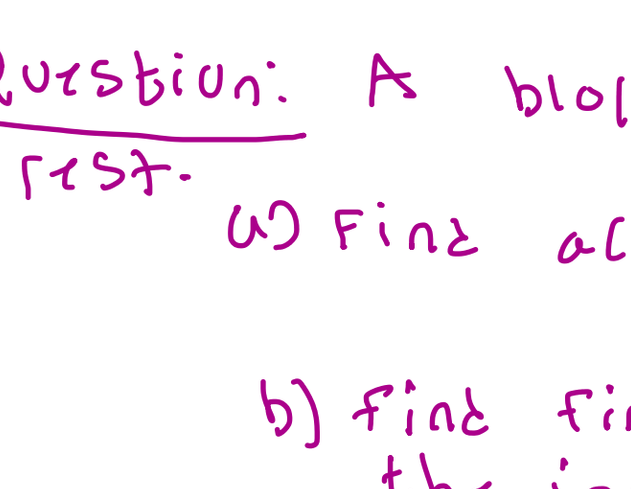


$F_k = \mu_k F_N$
$F_s \leq \mu_s F_N$

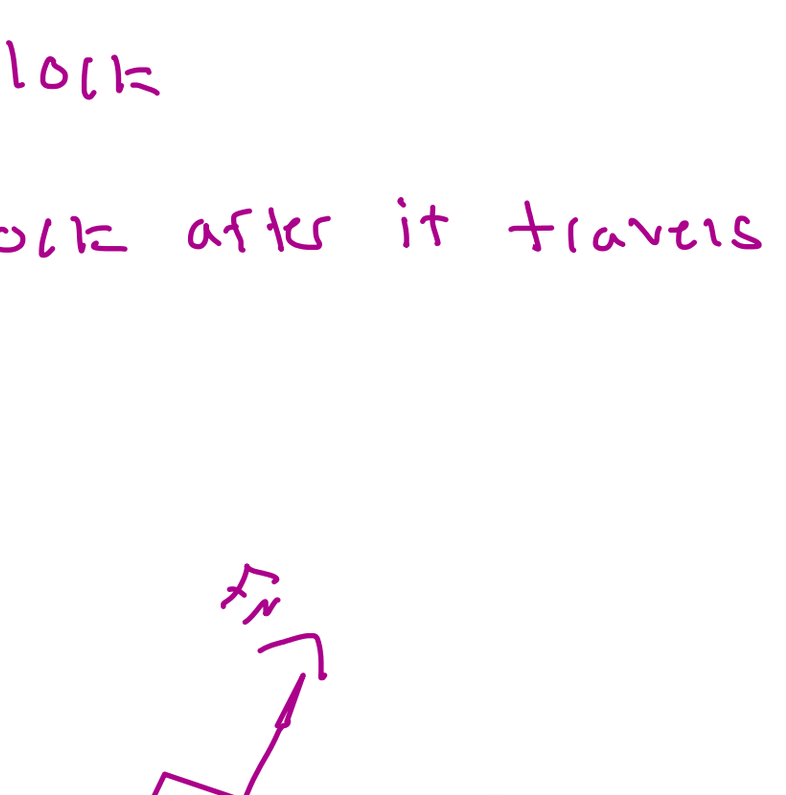
$a_x = g\sin\theta - \mu_k g\cos\theta$ — when there is friction moving down block

$\Sigma F_x = F_g + (-F_k)$ $F_k = \mu_k F_N$
$ma_x = mg\sin\theta - \mu_k mg\cos\theta$
$a_x = g\sin\theta - \mu_k g\cos\theta$

$a_x = -g\sin\theta - \mu_k g\cos\theta$ — moving up the incline



$a_x = -g\sin\theta + \mu_k g\cos\theta$ — when moving up reverse incline



Question: A block slides down a 30° incline starting from rest.
a) Find acceleration of block
b) Find final speed of block after it travels 200m down the incline.

Solution:

Givens/unknowns:

$\theta = 30°$ $V_i = ?$
$\Delta d = 200m$
$a_x = ?$
$V_f = ?$

$F_g = mg\sin\theta$

$\Sigma F_{net_x} = F_g$
$ma_x = mg\sin\theta$

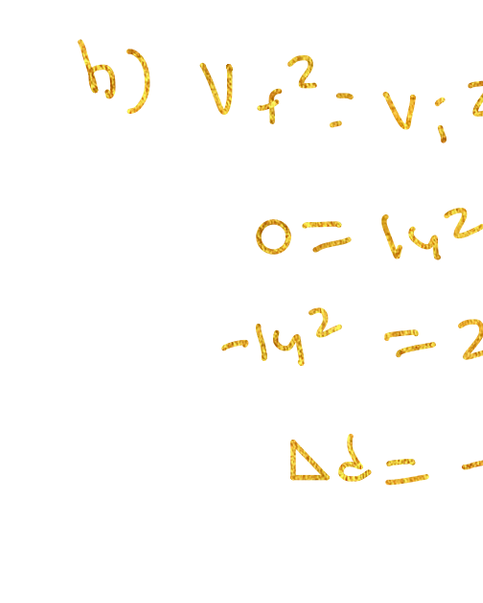
$a_x = g\sin\theta$
$= 9.81\sin 30$
$= 4.905 m/s^2$

$V_f^2 = V_i^2 + 2a\Delta d$ ← Big 5
$V_f^2 = 0 + 2(4.905)200$
$\sqrt{V_f^2} = \sqrt{1960}$
$V_f = 44.27 m/s$ ✓

Question: A block travels up a 25° incline plane with initial velocity of 14m/s.
a) Find the acceleration of the block
b) Find how far it will go
c) Find the time it takes for the block to stop

Solution:
Givens/Unknowns:

$V_i = 14 m/s$
$\theta = 25°$ $V_f = 0 m/s$
$a_x = ?$ $\Delta t = ?$
$\Delta d = ?$



a) $\Sigma F_x = F_g$

$ma_x = -mg\sin\theta$

$a_x = -g\sin\theta$
$= -9.81\sin 25$
$= -4.14 m/s^2$

b) $V_f^2 = V_i^2 + 2a\Delta d$
$0 = 14^2 + 2(-4.14)\Delta d$
$-14^2 = 2(-4.14)\Delta d$
$\Delta d = \frac{-196}{2(-4.14)}$
$\Delta d = 23.67m$

c) $V_f = V_i + a\Delta t$
$0 = 14 + (-4.14)\Delta t$
$-14 = -4.14\Delta t$
$\Delta t = \frac{-14}{-4.14}$
$\Delta t = 3.38s$ ✓