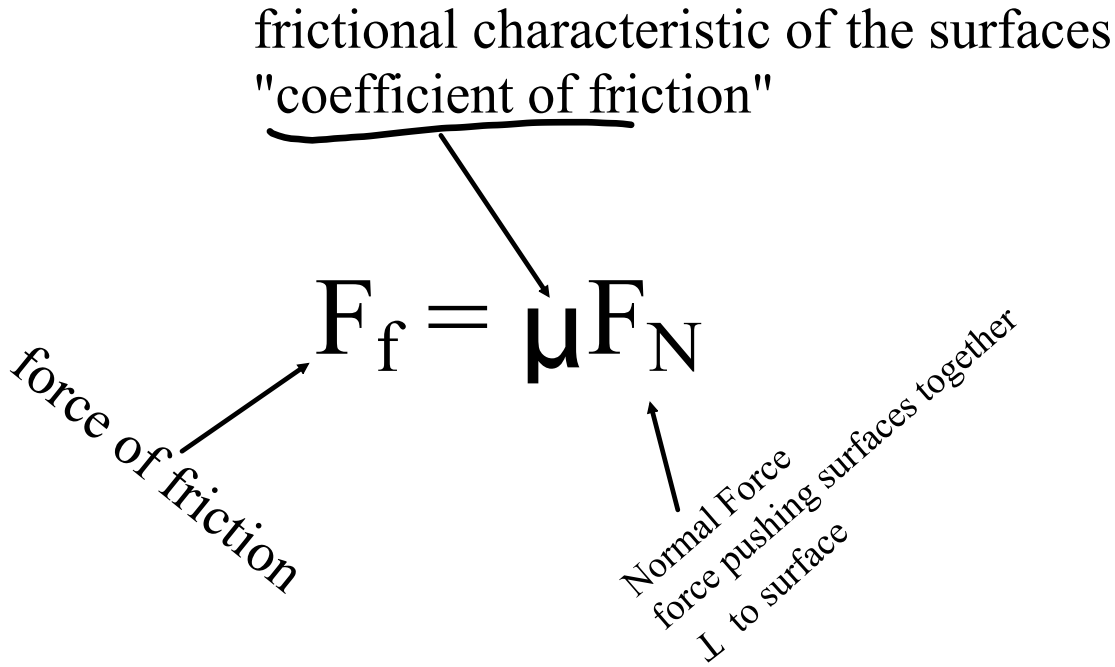
# Friction:

1) caused by the interaction of 2 + objects

2) opposite (opposes) motion

3) Types- Kinetic, static, sliding, rolling

4) size determined by:
nature of surfaces
force pushing surfaces together



"μ" is the "coefficient of friction" and is the frictional property of the two surfaces in contact. Each pair of surfaces has its own unique value of μ. Note that μ is a ratio of forces, and therefore a pure number.

$$\mu = F_f / F_N$$

$F_f$ is **parallel** to surface $F_N$ is **perpendicular** to surface

plane of motion!

You pull a 25.0 kg box across a floor at a consant velocity with a horizontal force of 125 N. What is μ?

1) data?

You pull a 25.0 kg box across a floor at a consant velocity with a horizontal force of 125 N. What is μ?

$m_{box}$ = 25 kg
$f_h$ = 125 N
$v_c$
μ?

Plane of motion: Motion is along the horizontal

*With the question of Type Motion and Type force you have to consider planes **parallel** and **perpendicular** to motion.*

2) Type motion?

3) Type force?

You pull a 25.0 kg box across a floor at a consant velocity with a horizontal force of 125 N. What is μ?

$m_{box}$ = 25 kg
$f_h$ = 125 N
$v_c$
μ?

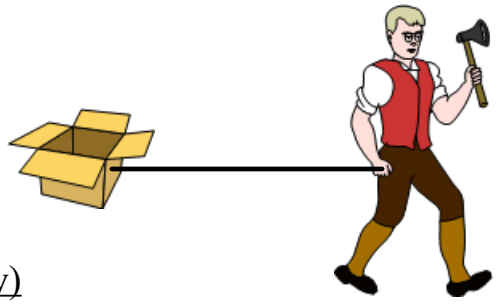
| horizontal (x) *parallel* | vertical (y) *perpendicular* |
|---|---|
| $v_c$ ∴ 1st Law<br>ΣF = 0 | rest ∴ 1st Law<br>ΣF = 0 |

as the box slides across the floor in is not moving up or down, therefore it is at rest in the "y" (perpendicular) axis

4) picture? (diagram)

You pull a 25.0 kg box across a floor at a consant velocity with a horizontal force of 125 N. What is μ?

$m_{box}$ = 25 kg
$f_h$ = 125 N
$v_c$
μ?

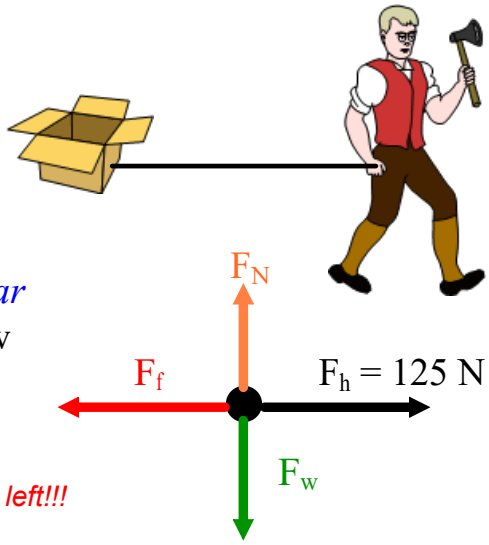


| horizontal (x) | vertical (y) |
|---|---|
| *parallel* | *perpendicular* |
| $v_c$ ∴ 1st Law | rest ∴ 1st Law |
| ΣF = 0 | ΣF = 0 |

5) force diagram

You pull a 25.0 kg box across a floor at a consant velocity with a horizontal force of 125 N. What is μ?

$m_{box}$ = 25 kg
$f_h$ = 125 N
$v_c$
μ?



| horizontal (x) | vertical (y) |
|---|---|
| *parallel* | *perpendicular* |
| $v_c$ ∴ 1st Law | rest ∴ 1st Law |
| ΣF = 0 | ΣF = 0 |



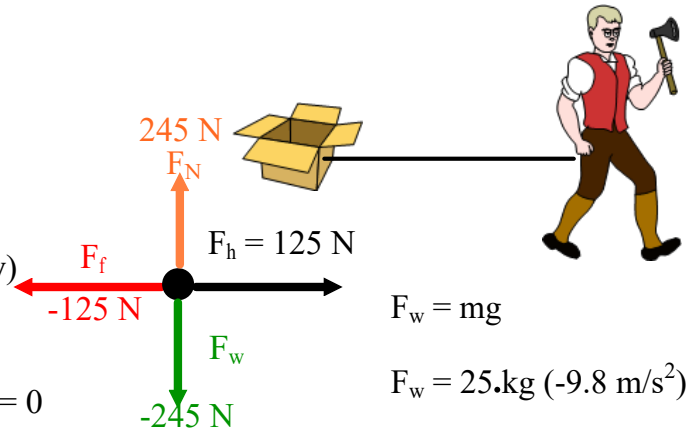

*the box is sliding right, there $F_f$ is left!!!*

6) Determine any forces you don't know

You pull a 25.0 kg box across a floor at a consant velocity with a horizontal force of 125 N. What is μ?

| | horizontal (x) | vertical (y) |
|---|---|---|
| | *parallel* | *perpendicular* |
| $v_c$ ∴ 1st Law | | rest |
| ΣF = 0 | | ΣF = 0 |

$m_{box} = 25$ kg
$f_h = 125$ N
$v_c$
μ?




"||" horizontal (x)

ΣF = 0

$F_f + F_h = 0$

$F_f = -F_h$

$F_f = -(125\ N)$

$F_f = -125$ N

"⊥" vertical (y)

ΣF = 0

$F_w + F_N = 0$

$F_N = -F_w$

$F_N = -(mg)$
$F_N = -(-245\ N)$
$F_N = (245\ N)$

$F_w = mg$

$F_w = 25.\text{kg}\ (-9.8\ m/s^2)$

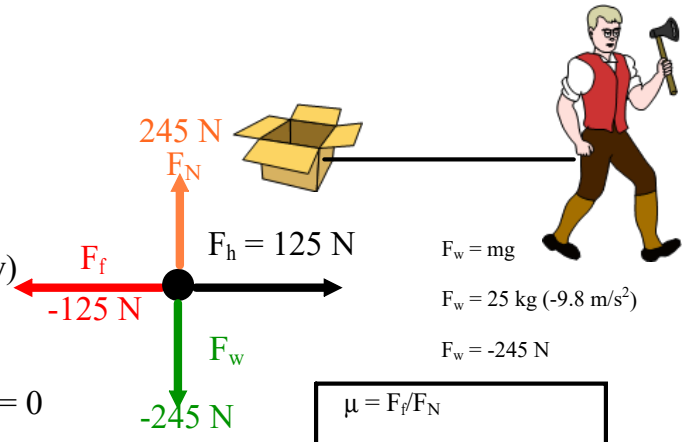
$F_w = -245$ N

7) Find unknown

You pull a 25.0 kg box across a floor at a consant velocity with a horizontal force of 125 N. What is μ?

| | horizontal (x) | vertical (y) |
|---|---|---|
| | *parallel* | *perpendicular* |
| $v_c$ ∴ 1st Law | | rest |
| ΣF = 0 | | ΣF = 0 |

$m_{box} = 25$ kg
$f_h = 125$ N
$v_c$
μ?




horizontal (x)

ΣF = 0

$F_f + F_h = 0$

$F_f = -F_h$

$F_f = -(125\ N)$

$F_f = -125$ N

vertical (y)

ΣF = 0

$F_w + F_N = 0$

$F_N = -F_w$

$F_N = -(mg)$
$F_N = -(-245\ N)$
$F_N = (245\ N)$

$F_w = mg$

$F_w = 25\ \text{kg}\ (-9.8\ m/s^2)$

$F_w = -245$ N

$\mu = F_f/F_N$

$\mu = -125\ N/245\ N$

$\mu = 0.510$

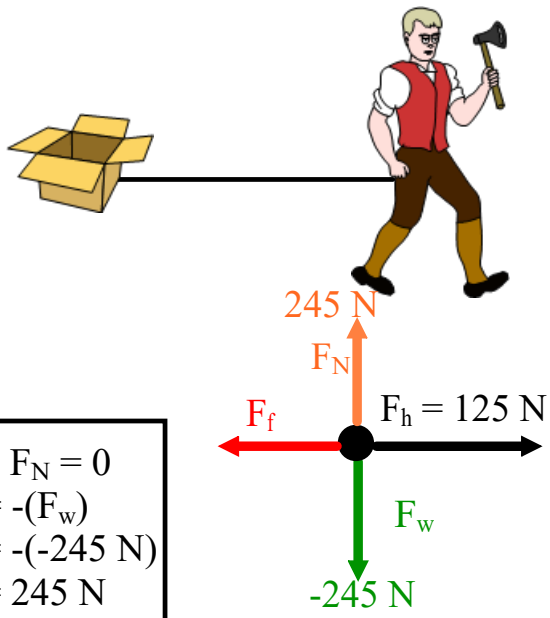
The "-" in μ is meaningless because it is a vector direction and μ is not a vector- it is a pure number (ratio of forces), therefore it is dropped

7) Find unknown

You pull a 25.0 kg box across a *waxed* floor with an acceleration of 2.50 $m/s^2$ with a horizontal force of 125 N. What is μ?

You pull a 25.0 kg box across a *waxed* floor with an acceleration of 2.50 $m/s^2$ with a horizontal force of 125 N. What is μ?

$m_{box} = 25$ kg
$f_h = 125$ N
$a = 2.50\ m/s^2$
μ?




| horizontal | vertical |
| --- | --- |
| $a$ ∴ 2nd Law | rest |
| $\Sigma F = ma$ | $\Sigma F = 0$ |

$F_f + F_h = ma$

$F_f = ma - F_h$

$F_f = 25.0\ kg(2.50\ m/s^2) - (125\ N)$

$F_f = 62.5\ N - (125\ N)$

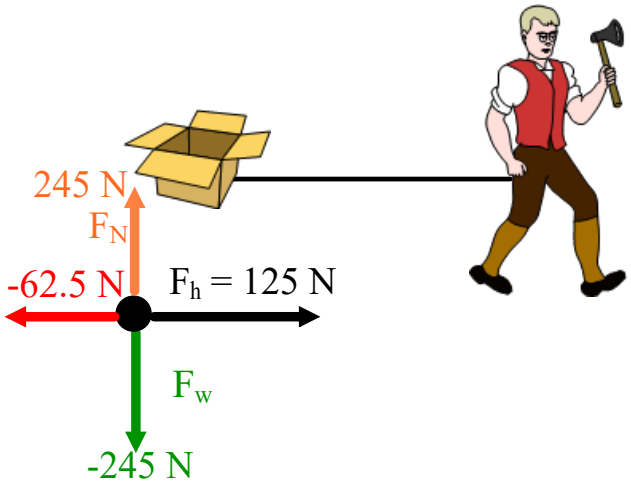
$F_f = -62.5\ N$

$F_w + F_N = 0$
$F_N = -(F_w)$
$F_N = -(-245\ N)$
$F_N = 245\ N$

You pull a 25.0 kg box across a *waxed* floor with an acceleration of 2.50 m/s$^2$ with a horizontal force of 125 N. What is μ?

$m_{box}$ = 25 kg
$f_h$ = 125 N
a = 2.50 m/s$^2$
μ?

| horizontal | vertical |
|---|---|
| *a* ∴ 2nd Law | rest |
| ΣF = ma | ΣF = 0 |

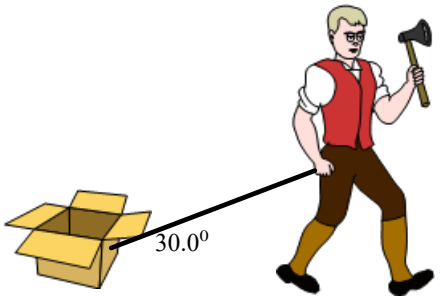



$\mu = F_f/F_N$

$\mu$ = -62.5 N/245 N

$\mu = 0.255$

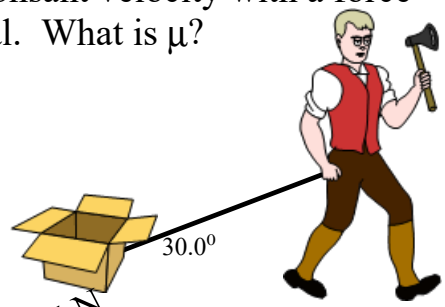
You pull a 25.0 kg box across a floor at a consant velocity with a force of 125 N directed 30.0$^0$ above the horizontal. What is μ?

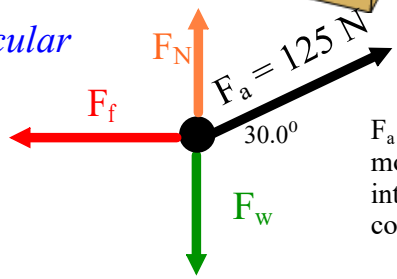


You pull a 25.0 kg box across a floor at a consant velocity with a force of 125 N directed $30.0^0$ above the horizontal. What is μ?

$m_{box}$ = 25 kg
$f_a$= 125 N at $30.0^0$
$v_c$
μ?

| horizontal | vertical |
|---|---|
| *parallel* | *perpendicular* |
| $v_c$ ∴ 1st Law | rest |
| ΣF = 0 | ΣF = 0 |



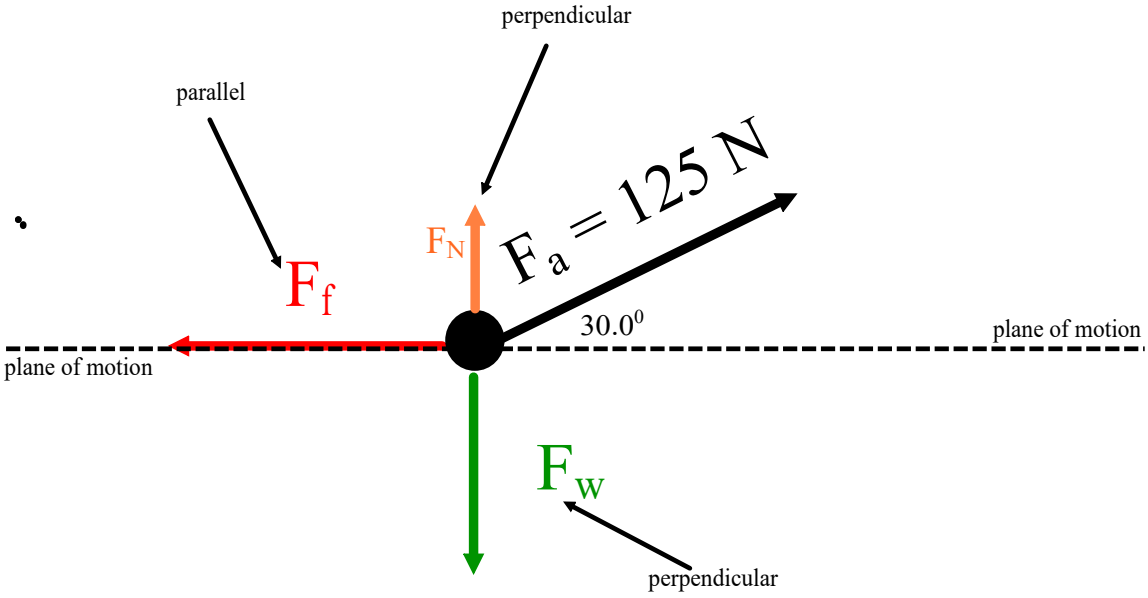

$F_a$ isn't parallel or perpendicular to motion, it's both, so break it down into its parallel and perpendicular components.

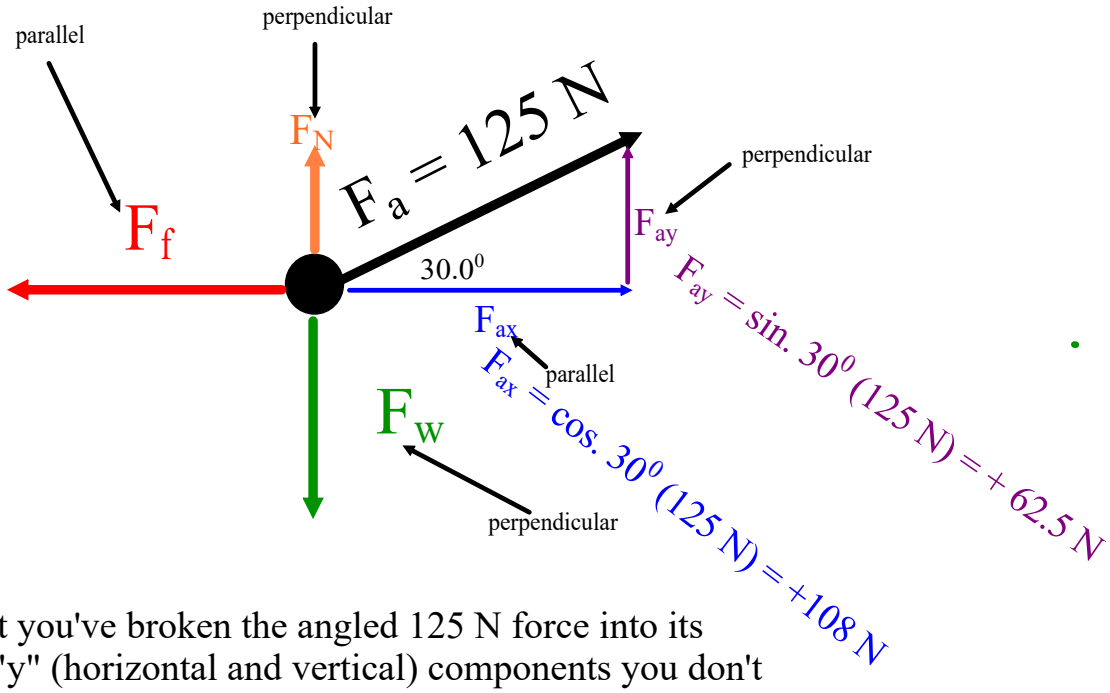
parallel to motion

$\mu = F_f/F_N$

perpendicular to motion

break down (resolve) all forces into their parallel and perpendicular components!!!!!






Now that you've broken the angled 125 N force into its "x" and "y" (horizontal and vertical) components you don't use it (the 125 N force), you just use its components!!!

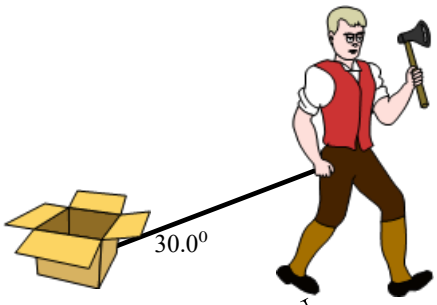
You pull a 25.0 kg box across a floor at a consant velocity with a force of 125 N directed $30.0^0$ above the horizontal. What is μ?

$m_{box} = 25$ kg
$f_a = 125$ N at $30.0^0$
$v_c$
μ?

$F_w = mg$

$F_w = 25\ kg\ (-9.8\ m/s^2)$

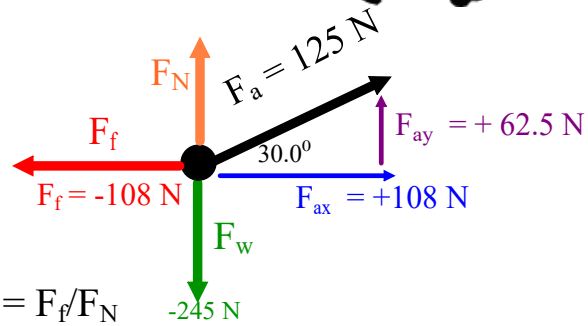
$F_w = -245$ N




| horizontal | vertical |
|---|---|
| *parallel* | *perpendicular* |
| $v_c$ ∴ 1st Law | rest |
| $\Sigma F = 0$ | $\Sigma F = 0$ |

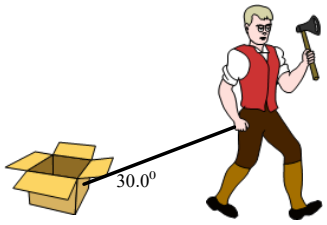
$\Sigma F = 0$
$F_f + F_{ax} = 0$
$F_f = -F_{ax}$
$F_f = -(108N)$
$F_f = -108$ N

$\Sigma F = 0$
$F_w + F_N + F_{ay} = 0$
$F_N = -F_w - F_{ay}$
$F_N = -(-245\ N) - (62.5N)$
$F_N = 182.5$ N




$\mu = F_f/F_N$
$\mu = -108\ N/182.5\ N$
$\mu = 0.592$

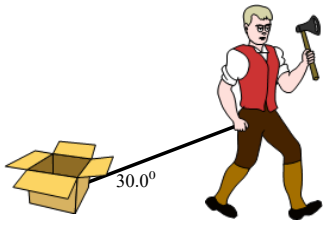
You pull a 25.0 kg box across a waxed floor with an acceleration of 2.00 $m/s^2$ with a force of 125 N directed $30.0^0$ above the horizontal. What is μ?




You pull a 25.0 kg box across a waxed floor with an acceleration of 2.00 $m/s^2$ with a force of 125 N directed $30.0^0$ above the horizontal. What is μ?

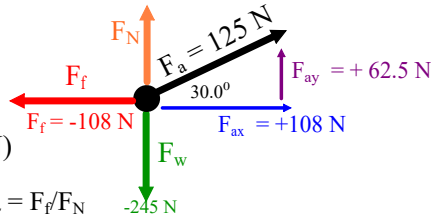
$m_{box}$ = 25 kg
$f_a$= 125 N at $30.0^0$
*acceleration*
μ?

$F_w = mg$
$F_w = 25\ kg\ (-9.8\ m/s^2)$
$F_w = -245\ N$




| horizontal | vertical |
|---|---|
| *parallel* | *perpendicular* |
| *a* ∴ 2nd Law | rest |
| ΣF = ma | ΣF = 0 |
| | ΣF = 0 |
| | $F_w + F_N + F_{ay} = 0$ |
| $F_f + F_{ax} = ma$ | $F_N = -F_w - F_{ay}$ |
| $F_f = ma - F_{ax}$ | $F_N = -(-245\ N) - (62.5N)$ |
| | $F_N = 182.5\ N$ |

$F_f = 25.0\ kg(2.00\ m/s^2) - (108N)$
$F_f = -58\ N$




$\mu = F_f/F_N$
$\mu = -58\ N/182.5\ N$
$\mu = 0.32$

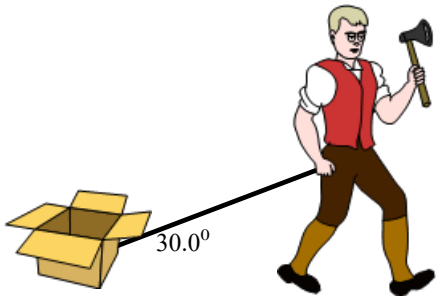
1) You pull a 25.0 kg box across a waxed floor with an acceleration of 2.00 $m/s^2$ with a force of 125 N directed $30.0^0$ above the horizontal. What is μ?

$m_{box}$ = 25 kg
$f_a$ = 125 N at $30.0^0$
*acceleration*
μ?

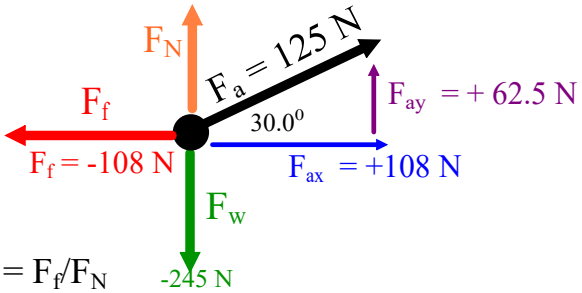
$F_w = mg$

$F_w = 25\ kg\ (-9.8\ m/s^2)$

$F_w = -245\ N$




| horizontal | vertical |
|---|---|
| *parallel* | *perpendicular* |
| *a* ∴ 2nd Law | rest |
| ΣF = ma | ΣF = 0 |




$F_f + F_{ax} = ma$
$F_f = ma - F_{ax}$

$\Sigma F = 0$
$F_w + F_N + F_{ay} = 0$
$F_N = -F_w - F_{ay}$
$F_N = -(-245\ N) - (62.5N)$
$F_N = 182.5\ N$

$F_f = 25.0\ kg(2.00\ m/s^2) - (108N)$
$F_f = -58\ N$

$\mu = F_f/F_N$
$\mu = -58\ N/182.5\ N$
$\mu = 0.32$