

Friction:

- 1) caused by the interaction of 2 + objects
- 2) opposite (opposes) motion
- 3) Types- Kinetic, static, sliding, rolling
- 4) size:
 - nature of surfaces
 - force pushing surfaces together

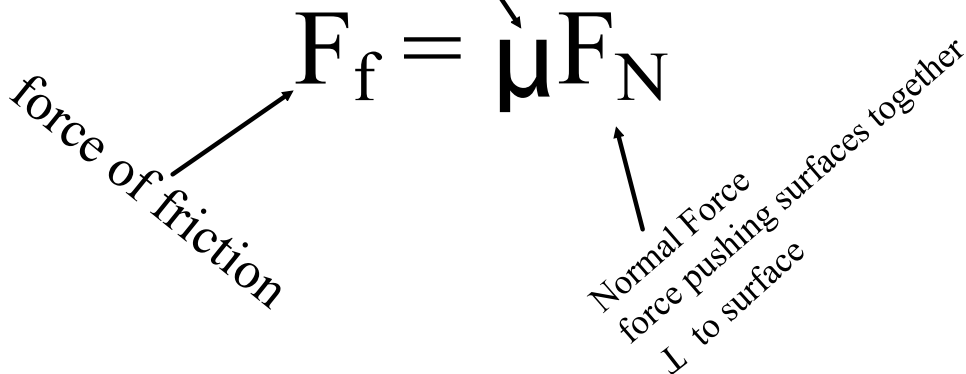
Nov 13-8:22 AM

frictional characteristic of the surfaces
"coefficient of friction"

$$F_f = \mu F_N$$

force of friction

Normal Force
force pushing surfaces together
⊥ to surface



Nov 14-7:49 AM

" 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.

$$\mu = F_f / F_N$$

Nov 14-7:50 AM

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

Nov 14-8:12 AM

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

1) data?

Nov 14-8:08 AM

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

$$m_{\text{box}} = 25 \text{ kg}$$

$$f_h = 125 \text{ N}$$

$$v_c$$

$$\mu?$$

*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?

Nov 14-8:08 AM

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

$$m_{\text{box}} = 25 \text{ kg}$$

$$f_h = 125 \text{ N}$$

$$v_c$$

$$\mu?$$

horizontal (x)

parallel

$v_c \therefore 1^{\text{st}} \text{ Law}$

$$\Sigma F = 0$$

vertical (y)

perpendicular

rest

$$\Sigma F = 0$$

4) picture? (diagram)

Nov 14-8:08 AM

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

$$m_{\text{box}} = 25 \text{ kg}$$

$$f_h = 125 \text{ N}$$

$$v_c$$

$$\mu?$$

horizontal (x)

parallel

$v_c \therefore 1^{\text{st}} \text{ Law}$

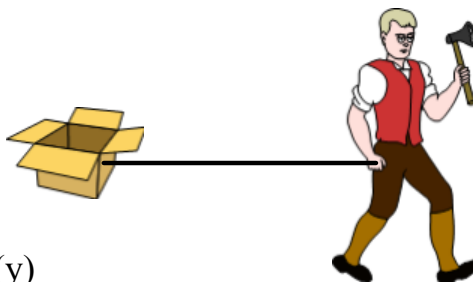
$$\Sigma F = 0$$

vertical (y)

perpendicular

rest

$$\Sigma F = 0$$



5) force diagram

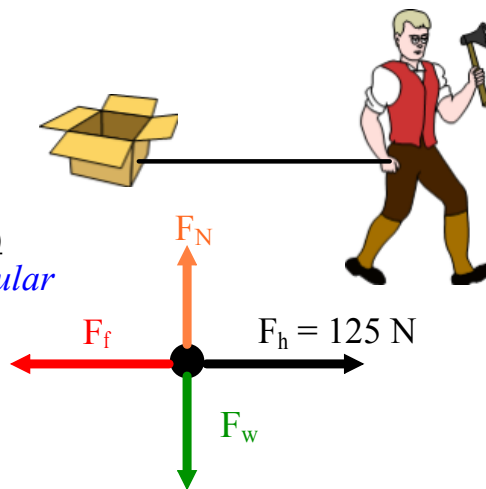
Nov 14-8:09 AM

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

$m_{\text{box}} = 25 \text{ kg}$
 $f_h = 125 \text{ N}$
 v_c
 $\mu?$

horizontal (x)
parallel
 $v_c \therefore 1^{\text{st}} \text{ Law}$
 $\Sigma F = 0$

vertical (y)
perpendicular
 rest
 $\Sigma F = 0$

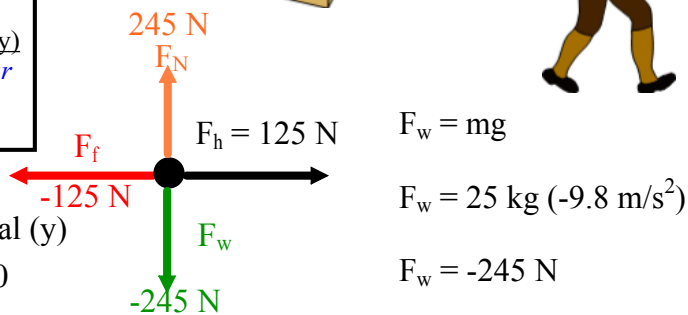


6) Determine any forces you don't know

Nov 14-8:09 AM

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

$m_{\text{box}} = 25 \text{ kg}$	
$f_h = 125 \text{ N}$	
v_c	
$\mu?$	
<u>horizontal (x)</u>	<u>vertical (y)</u>
<i>parallel</i>	<i>perpendicular</i>
$v_c \therefore 1^{\text{st}} \text{ Law}$	rest
$\Sigma F = 0$	$\Sigma F = 0$



horizontal (x)
 $\Sigma F = 0$

vertical (y)
 $\Sigma F = 0$

$F_f + F_h = 0$

$F_w + F_N = 0$

$F_f = -F_h$

$F_N = -F_w$

$F_f = -(125 \text{ N})$

$F_N = -(mg)$
 $F_N = -(-245 \text{ N})$

$F_f = -125 \text{ N}$

$F_N = (245 \text{ N})$

$F_w = mg$

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

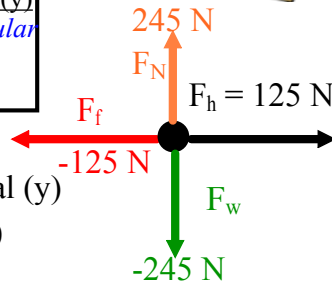
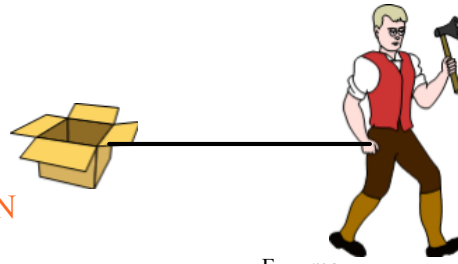
$F_w = -245 \text{ N}$

7) Find unknown

Nov 14-7:55 AM

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

$m_{\text{box}} = 25 \text{ kg}$	
$f_h = 125 \text{ N}$	
v_c	
$\mu?$	
<u>horizontal (x)</u>	<u>vertical (y)</u>
<i>parallel</i>	<i>perpendicular</i>
$v_c \therefore 1^{\text{st}} \text{ Law}$	rest
$\Sigma F = 0$	$\Sigma F = 0$



$$F_w = mg$$

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

$$F_w = -245 \text{ N}$$

horizontal (x)	vertical (y)
$\Sigma F = 0$	$\Sigma F = 0$
$F_f + F_h = 0$	$F_w + F_N = 0$
$F_f = -F_h$	$F_N = -F_w$
$F_f = -(125 \text{ N})$	$F_N = -(mg)$
$F_f = -125 \text{ N}$	$F_N = -(-245 \text{ N})$
	$F_N = (245 \text{ N})$

$\mu = F_f/F_N$ $\mu = -125 \text{ N}/245 \text{ N}$ $\mu = 0.510$
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Nov 14-7:55 AM

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 ?

Nov 14-8:24 AM

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 ?

$$m_{\text{box}} = 25 \text{ kg}$$

$$f_h = 125 \text{ N}$$

$$a = 2.50 \text{ m/s}^2$$

$$\mu?$$

horizontal
 $a \therefore 2^{\text{nd}} \text{ Law}$
 $\Sigma F = ma$

vertical
 rest
 $\Sigma F = 0$

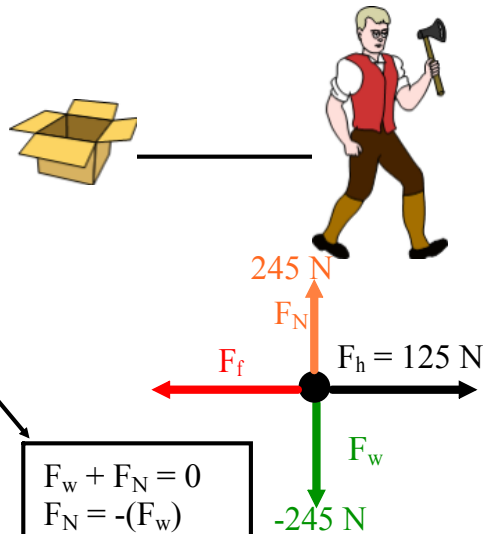
$$F_f + F_h = ma$$

$$F_f = ma - F_h$$

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

$$F_f = 62.5 \text{ N} - (125 \text{ N})$$

$$F_f = -62.5 \text{ N}$$



$$F_w + F_N = 0$$

$$F_N = -(F_w)$$

$$F_N = -(-245 \text{ N})$$

$$F_N = 245 \text{ N}$$

Nov 14-8:25 AM

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 ?

$$m_{\text{box}} = 25 \text{ kg}$$

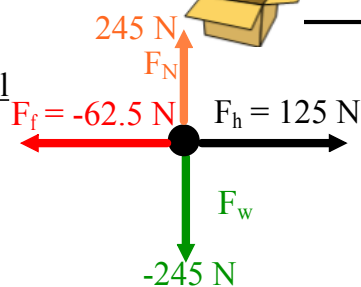
$$f_h = 125 \text{ N}$$

$$a = 2.50 \text{ m/s}^2$$

$$\mu?$$

horizontal
 $a \therefore 2^{\text{nd}} \text{ Law}$
 $\Sigma F = ma$

vertical
 rest
 $\Sigma F = 0$



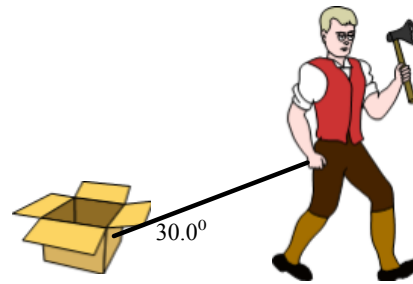
$$\mu = F_f / F_N$$

$$\mu = -62.5 \text{ N} / 245 \text{ N}$$

$$\mu = 0.255$$

Nov 14-8:25 AM

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



Nov 14-10:08 AM

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

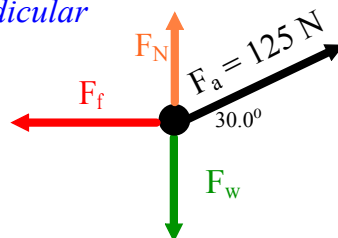
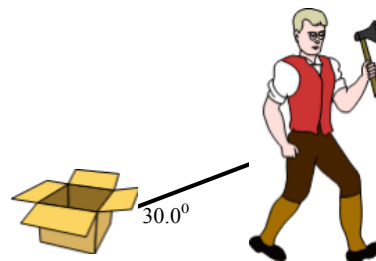
$m_{\text{box}} = 25 \text{ kg}$
 $F_a = 125 \text{ N at } 30.0^\circ$
 v_c
 $\mu?$

horizontal
parallel

vertical
perpendicular

$v_c \therefore 1^{\text{st}} \text{ Law}$
 $\Sigma F = 0$

rest
 $\Sigma F = 0$



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

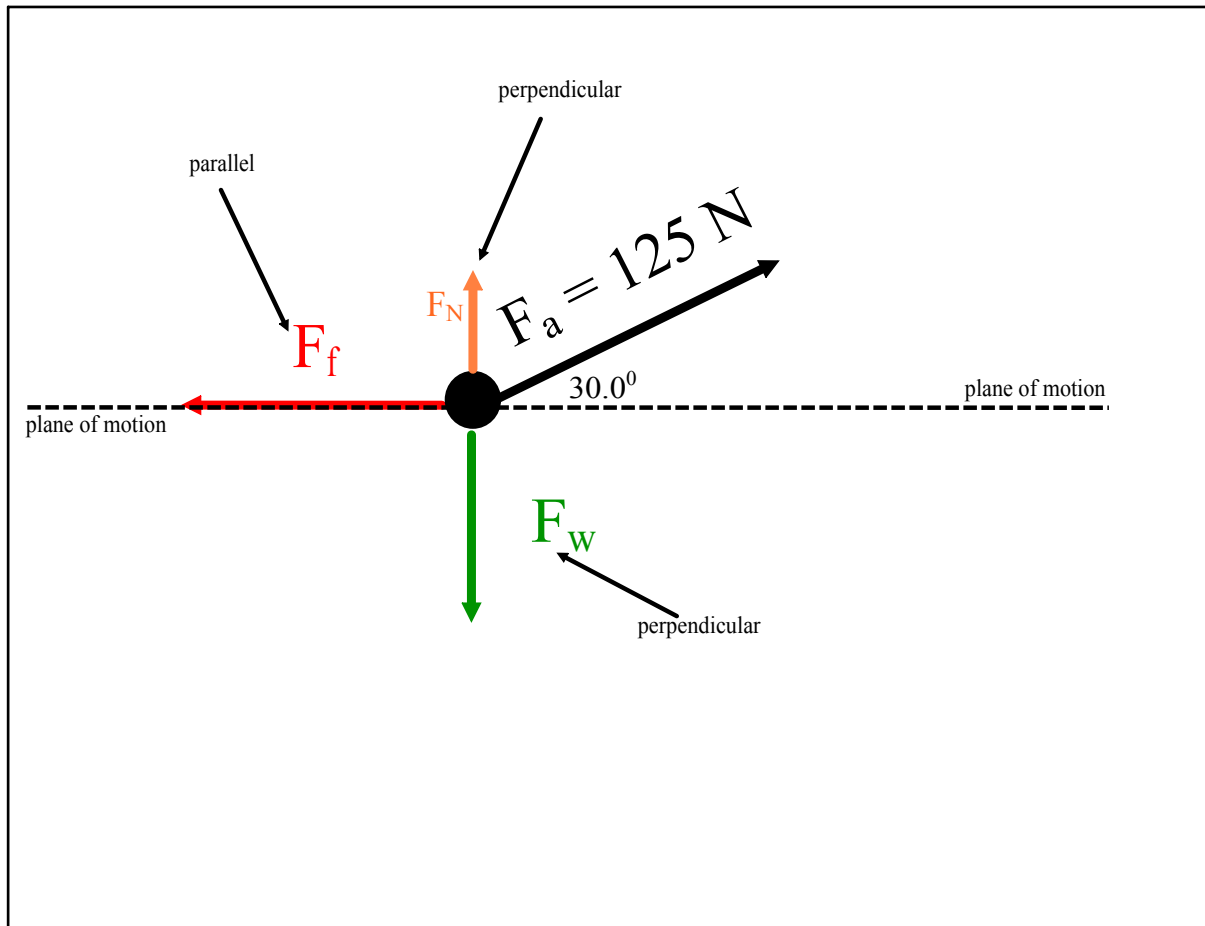
parallel to motion

$$\mu = F_f / F_N$$

perpendicular to motion

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

Nov 14-10:06 AM



Nov 14-10:14 AM

A free-body diagram similar to the one above, but with the angled force $F_a = 125\text{ N}$ decomposed into its horizontal and vertical components. A blue arrow labeled F_{ax} points horizontally to the right from the dot, with a label "parallel" pointing to it. A purple arrow labeled F_{ay} points vertically upwards from the dot, with a label "perpendicular" pointing to it. The angle 30.0° is shown between the original F_a vector and the F_{ax} component. The other forces (F_N , F_w , F_f) and their labels remain the same.

$$F_{ay} = \sin. 30^\circ (125\text{ N}) = +62.5\text{ N}$$

$$F_{ax} = \cos. 30^\circ (125\text{ N}) = +108\text{ N}$$

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!!!

Nov 14-10:16 AM

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

$$m_{\text{box}} = 25 \text{ kg}$$

$$f_a = 125 \text{ N at } 30.0^\circ$$

$$v_c$$

$$\mu?$$

horizontal

parallel

$v_c \therefore 1^{\text{st}} \text{ Law}$

$$\Sigma F = 0$$

vertical

perpendicular

rest

$$\Sigma F = 0$$

$$\Sigma F = 0$$

$$F_f + F_{ax} = 0$$

$$F_f = -F_{ax}$$

$$F_f = -(108\text{N})$$

$$F_f = -108 \text{ N}$$

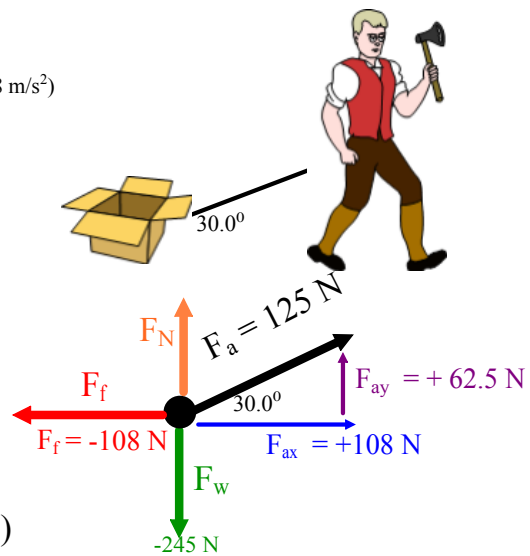
$$\Sigma F = 0$$

$$F_w + F_N + F_{ay} = 0$$

$$F_N = -F_w - F_{ay}$$

$$F_N = -(-245 \text{ N}) - (62.5\text{N})$$

$$F_N = 182.5 \text{ N}$$



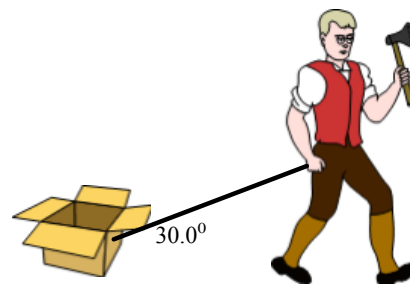
$$\mu = F_f / F_N$$

$$\mu = -108 \text{ N} / 182.5 \text{ N}$$

$$\mu = 0.592$$

Nov 14-10:06 AM

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° above the horizontal. What is μ ?



Nov 14-10:08 AM

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° above the horizontal. What is μ ?

$$m_{\text{box}} = 25 \text{ kg}$$

$$f_a = 125 \text{ N at } 30.0^\circ$$

acceleration

μ ?

horizontal

parallel

$a \therefore 2^{\text{nd}} \text{ Law}$

$$\Sigma F = ma$$

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

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

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

$$F_f = -58 \text{ N}$$

$$F_w = mg$$

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

$$F_w = -245 \text{ N}$$

vertical

perpendicular

rest

$$\Sigma F = 0$$

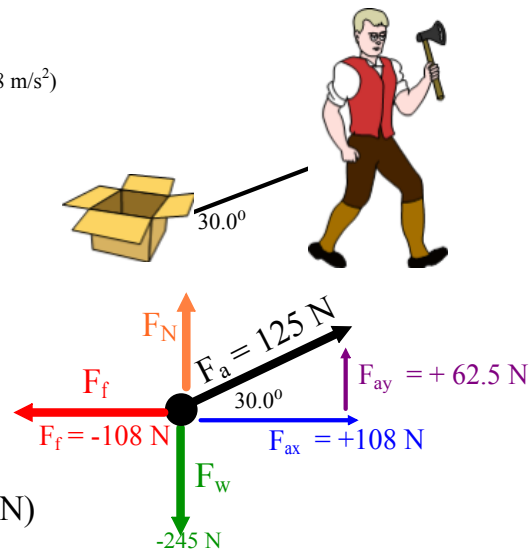
$$\Sigma F = 0$$

$$F_w + F_N + F_{ay} = 0$$

$$F_N = -F_w - F_{ay}$$

$$F_N = -(-245 \text{ N}) - (62.5 \text{ N})$$

$$F_N = 182.5 \text{ N}$$



$$\mu = F_f / F_N$$

$$\mu = -58 \text{ N} / 182.5 \text{ N}$$

$$\mu = 0.32$$

Nov 14-10:06 AM