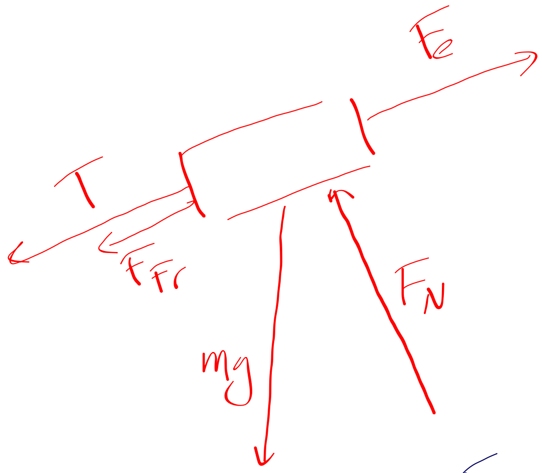
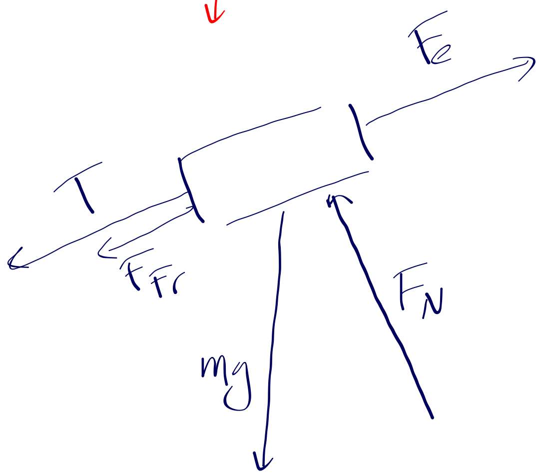


constant speed

$\Sigma F = \emptyset$ (static)



acceleration

$\Sigma F \neq \emptyset$ (dynamic)

What is the Mathematical Relationship between Force, Mass, and Acceleration?

$\cancel{F = m \cdot a}$

For the textbook:

- F = 100 N
- m = 10 kg

$F = ma$; $a = F/m$

$a = \frac{100}{10} = 10\ m/s^2$

$8.04\ m/s^2$?

For the dog:

- F = 250 N
- m = 25 kg

$F = ma$; $a = F/m$

$a = \frac{250}{25} = 10\ m/s^2$

$\sim 5\ m/s^2$?

$$\underbrace{\Sigma F}_{\text{sum of all forces (includes direction)}} = \underbrace{m}_{\text{mass of an object (or a combined mass)}} \times \underbrace{a}_{\text{resulting acceleration (in direction of overall force)}}$$

Dynamics (Newton's 2nd Law)

Objectives:

- Students will understand the mathematics and concepts behind Newton's 2nd Law
- Students will be able to use Newton's 2nd Law to solve problems
- Students will know what friction is, understand the difference between kinetic and static friction, and be able to use friction to solve problems

Steps For Solving Dynamics Problems:

1. Draw a picture / establish a reference frame.

2. Identify variables / check units.

3. Draw a FBD.

4. Resolve all forces into X and Y components.

5. $\Sigma F_x = ma_x$

6. $\Sigma F_y = ma_y$

7. Solve for unknowns.

Note: A static situation (zero or constant velocity) is described by Newton's 2nd Law, just like a dynamic situation:

$$\sum F = ma$$

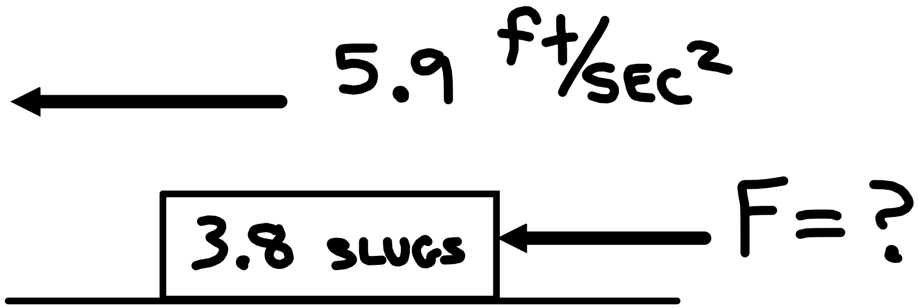
($a = \emptyset$ for statics...)

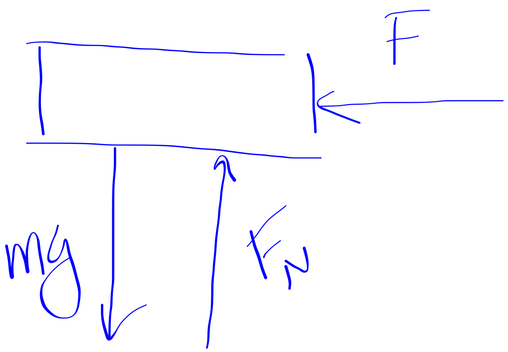
$$\sum F = m(\emptyset) = \emptyset$$

So really all we need to remember is $\boxed{\sum F = ma!}$

EXAMPLE 1:

Assume there is no friction in any problem unless stated otherwise ...

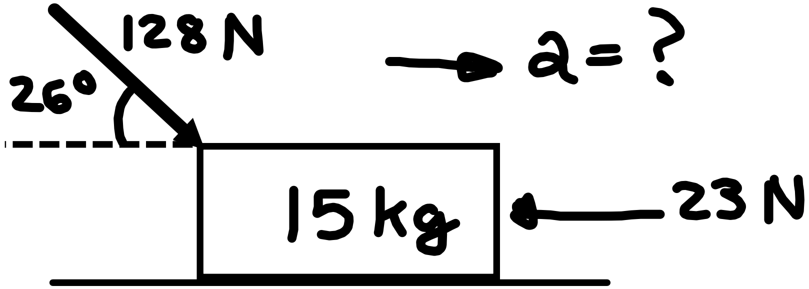


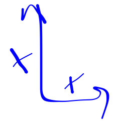


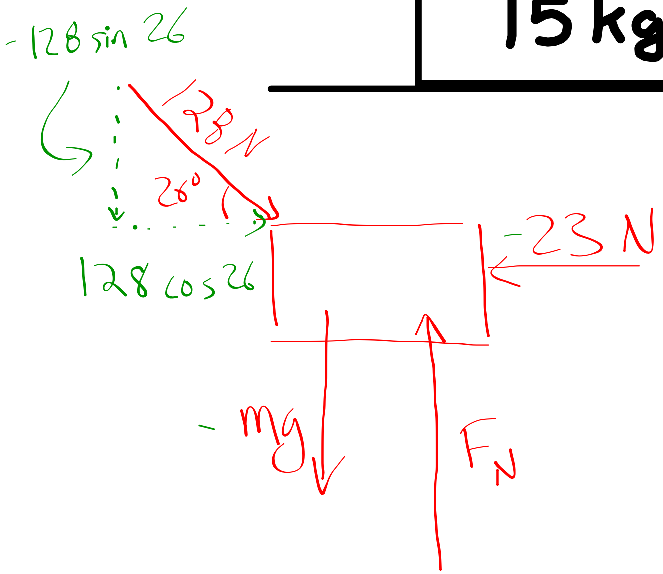
$\Sigma F_x = ma_x$

$F = (3.8)(5.9)$

Example 2:





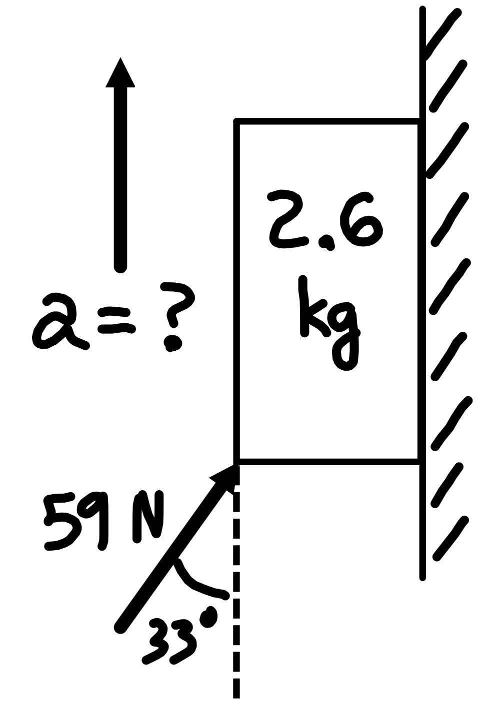


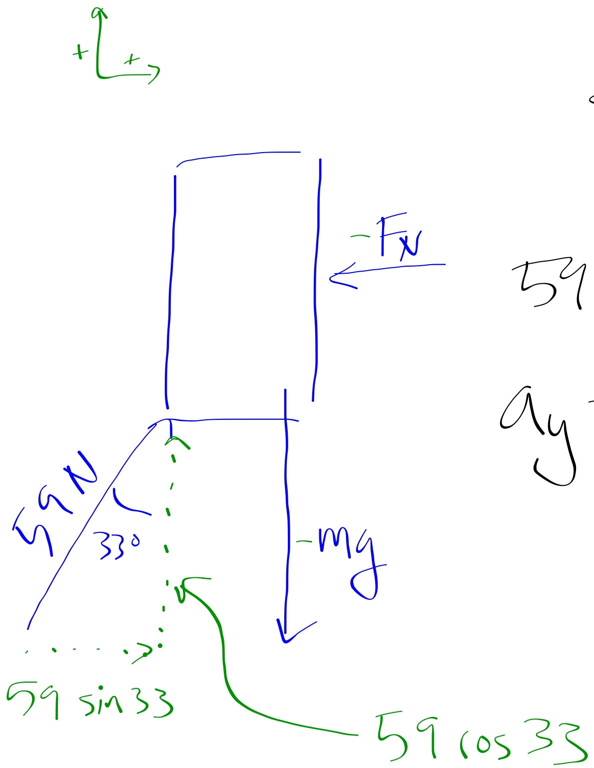
$$\Sigma F_x = ma_x$$

$$128\cos 26 + -23 = (15)a_x$$

$$a_x = \frac{128\cos 26 + -23}{15}$$

EXAMPLE 3:



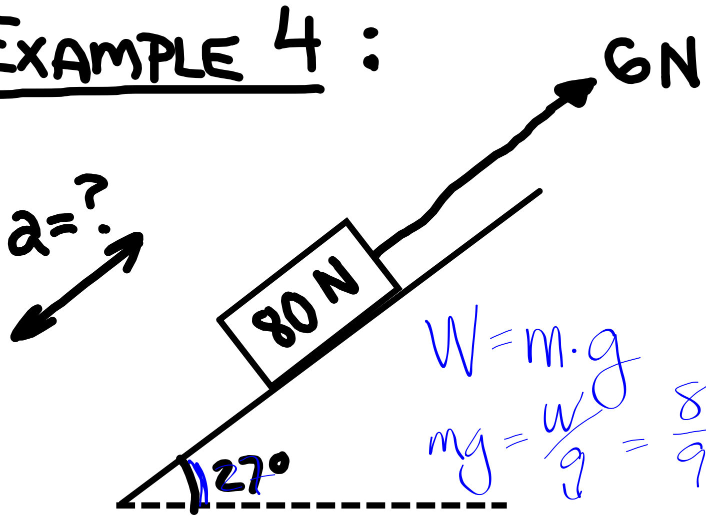


$$\Sigma F_y = ma_y$$

$$59\cos 33 + {}^{-}mg = 2.6a_y$$

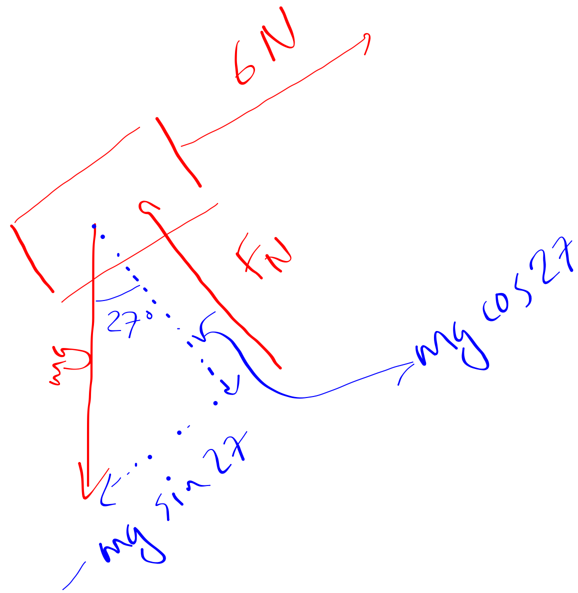
$$a_y = \frac{59\cos 33 - mg}{2.6}$$

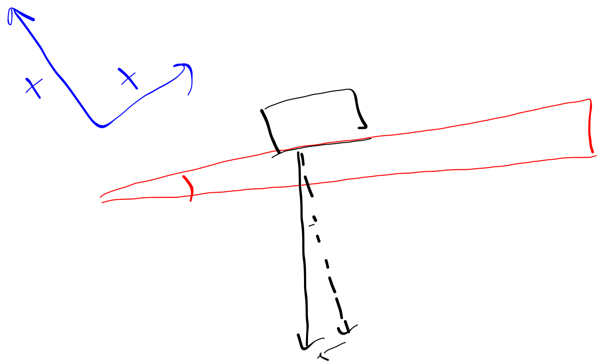
EXAMPLE 4:



$W = m \cdot g$

$mg = \frac{w}{g} = \frac{80}{9.8}$





$\sum F_x = m a_x$

$-mg \sin 27 + 6 = \left(\frac{80}{9.8}\right) a_x$

$a_x = \frac{(-80 \sin 27 + 6) \cdot 9.8}{80}$

$a_x = -3.71\ m/s^2$

Friction:

A force! It pushes or pulls just like any other force.

Exists between two surfaces in contact with one another.

Resists relative motion between the two surfaces.

Always opposite direction of motion (or potential motion - in absence of friction).

The force of friction can change:

- Static friction: Friction force between objects that aren't sliding.
- Kinetic friction: Friction force between objects that are sliding.

Friction = coefficient x "clamping force"

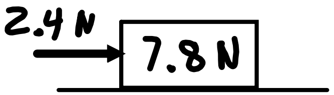
$$F_{fr} = \mu F_n$$

F_n = the force clamping the two surfaces together (usually the normal - perpendicular - force)

μ = the coefficient of friction

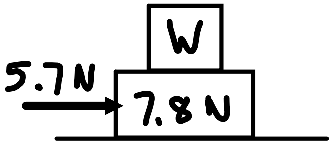
- > Unitless (reflects that the force of friction is related to the normal force)
- > Usually less than 1.0 (but not always)
- > Unique to any two surfaces
- > Two kinds:
  - μ_k: coefficient of kinetic friction
  - μ_s (always greater than kinetic...): coefficient of static friction (the maximum amount we multiply F_N) - tells us the maximum amount of $F_{static\ Fr}$

EXAMPLE 1



a) For the 7.8 N object to move across the surface by itself at constant speed, a 2.4 N force must be applied. What is the coefficient of kinetic friction?

$a = \emptyset$

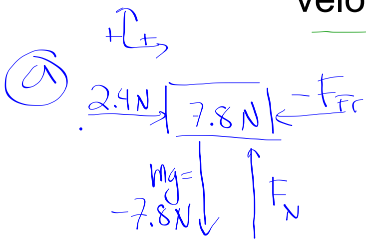


b) If the 2.4 N force must be increased to 5.7 N when an object with weight W is placed on the 7.8 N object, what is W? Assume the two blocks move at constant velocity.

$\hookrightarrow a = \emptyset$

$F_{Fr} = \mu F_N$

(a)



$\Sigma F_x = \emptyset$

$2.4 + -F_{Fr} = \emptyset$

$F_{Fr} = 2.4N$

$\Sigma F_y = \emptyset$

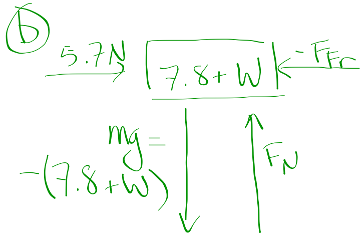
$-7.8 + F_N = \emptyset$

$F_N = 7.8$

$2.4 = \mu(7.8)$

$\mu = 0.31$

(b)



$\Sigma F_x = \emptyset$

$5.7 + -F_{Fr} = \emptyset$

$F_{Fr} = 5.7N$

$\Sigma F_y = \emptyset$

$-(7.8+W) + F_N = \emptyset$

$F_N = 7.8 + W$

$F_{Fr} = \mu F_N$

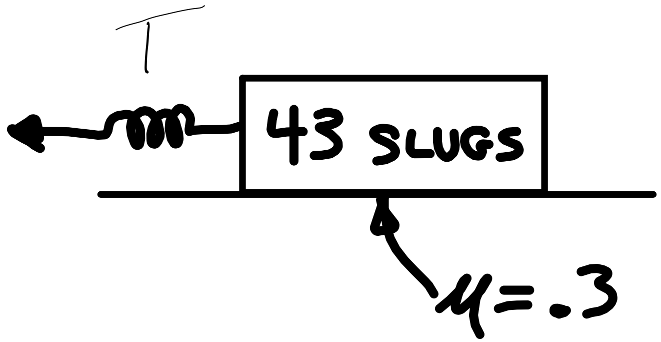
$5.7 = (0.31)(7.8 + W)$

$5.7 = 2.42 + 0.31W$

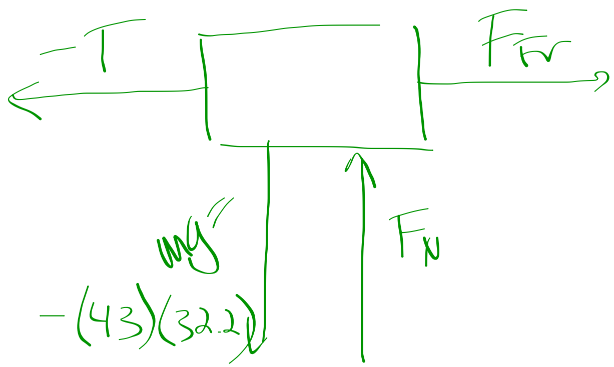
$\boxed{W = 10.58 N}$

EXAMPLE 2

What must the tension in the spring be in order to slide the mass along the surface at constant speed?



$a = 0$



$\Sigma F_x = 0$

$-T + F_{Fr} = 0$

$F_{Fr} = T$

$\Sigma F_y = 0$

$-(43)(32.2) + F_N = 0$

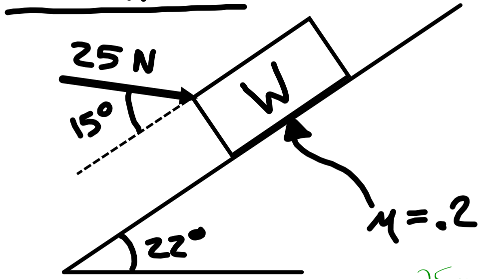
$F_N = 1384.6 \text{ lb}$

$F_{Fr} = \mu F_N$

$T = (0.3)(1384.6)$

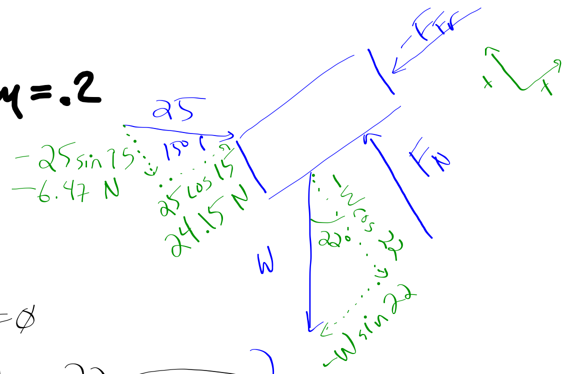
$\boxed{T = 415.2 \text{ lb}}$

Example 3



What is W if the object moves up the incline at constant speed? (W is a weight)

$a = 0$



$\Sigma F_x = 0$

$24.15 - W\sin 22 - F_{Fr} = 0$

$F_{Fr} = 24.15 - W\sin 22$

$\Sigma F_y = 0$

$F_N + -6.47 + -W\cos 22 = 0$

$F_N = 6.47 + W\cos 22$

$F_{Fr} = \mu F_N$

$24.15 - W\sin 22 = (0.2)(6.47 + W\cos 22)$

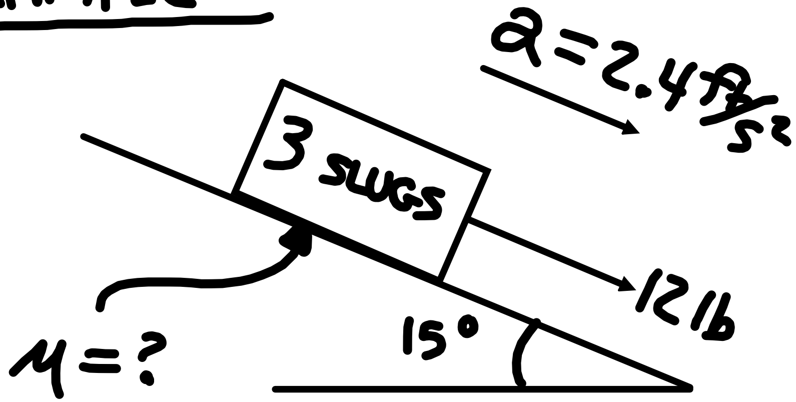
$24.15 - W\sin 22 = 1.29 + (0.2)(W)(\cos 22)$

$W\sin 22 + (0.2)(W)\cos 22 = 22.86$

$W(\sin 22 + (0.2)\cos 22) = 22.86$

$W = \dfrac{22.86}{\sin 22 + 0.2\cos 22} = \dfrac{22.86}{0.375 + 0.185} = \boxed{40.82\text{ N}}$

EXAMPLE 4



WHAT MUST μ BE?