$\cancel{F = ma}$ (close . . .)

What is the mathematical relationship between FORCE, MASS, & ACCELERATION?

- Use the generic login
- Click on → choose "Hidden Network" with !

Name is: CV-AP

$\boxed{12:23}$

For textbook:

$F = 100\ N$

$m = 10\ kg$

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

$a\text{(actual)} = 8.04\ m/s^2$

For dog:

$F = 250\ N$

$m = 25\ kg$

$a\text{(predicted)} = 10\ m/s^2$

$a\text{(actual)} = 5.10\ m/s^2$

F	m	a
=	=	=
Net force or Overall force or <u>Sum</u> of all forces acting on the object.	mass of an object experiencing forces	rate of change in that object's velocity (includes direction)

★ Forces are vectors — we need to add our forces using vector arithmetic

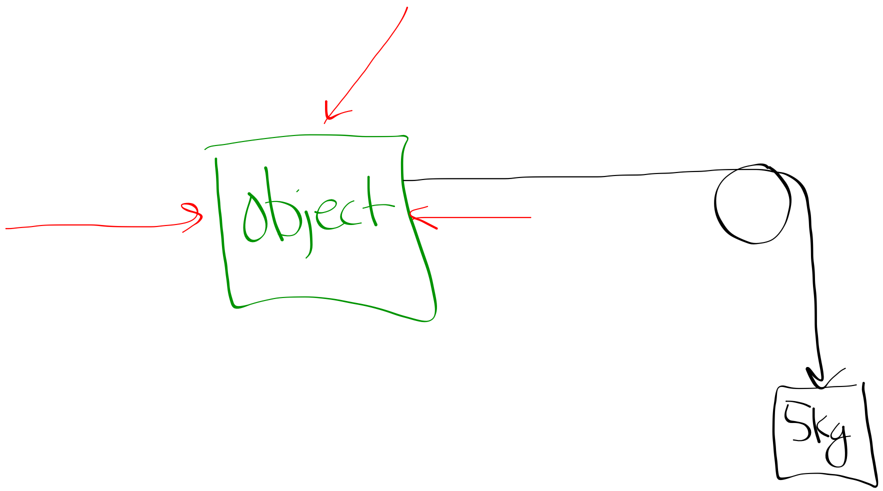
→ Apply a known force

→ Note the resulting force of friction

→ Predict the acceleration

→ Check with acceleration graph

$$\boxed{\Sigma F} = m \cdot a$$



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

Dynamics: The case where forces do not all cancel.

If forces in any direction are not balanced, the object will accelerate in that direction. $\sum F \neq 0$

Newton's 2nd Law governs this situation:

$$\sum F = m \cdot a$$

Steps For Solving Dynamics Problems:

1. Draw a picture.
2. Establish a reference frame.

combine

3. Identify variables / check units.
4. Draw a FBD. CRITICAL
5. Resolve all forces into X and Y components. CRITICAL
6. $\sum F_x = ma_x$
7. $\sum F_y = ma_y$
8. Solve for unknowns.

Note: A static situation is just a special case of the more general dynamic situation -- when the object(s) is not accelerating.

$$\Sigma F = ma$$

IF $a = 0$, THEN

$$\Sigma F = m(0) = 0$$

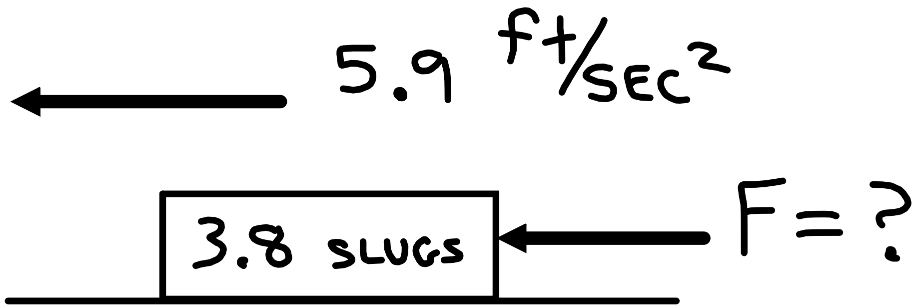
$$\Sigma F = 0 \quad \text{(STATICS)}$$

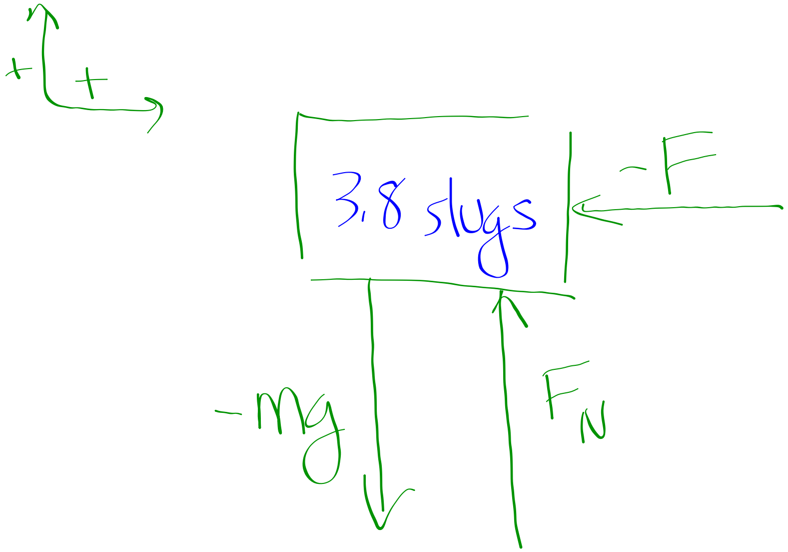
So, if you only end up remembering one thing, let it be this:

$$\boxed{\Sigma F = ma}$$

EXAMPLE 1:

Assume there is no friction in this and all of the following problems



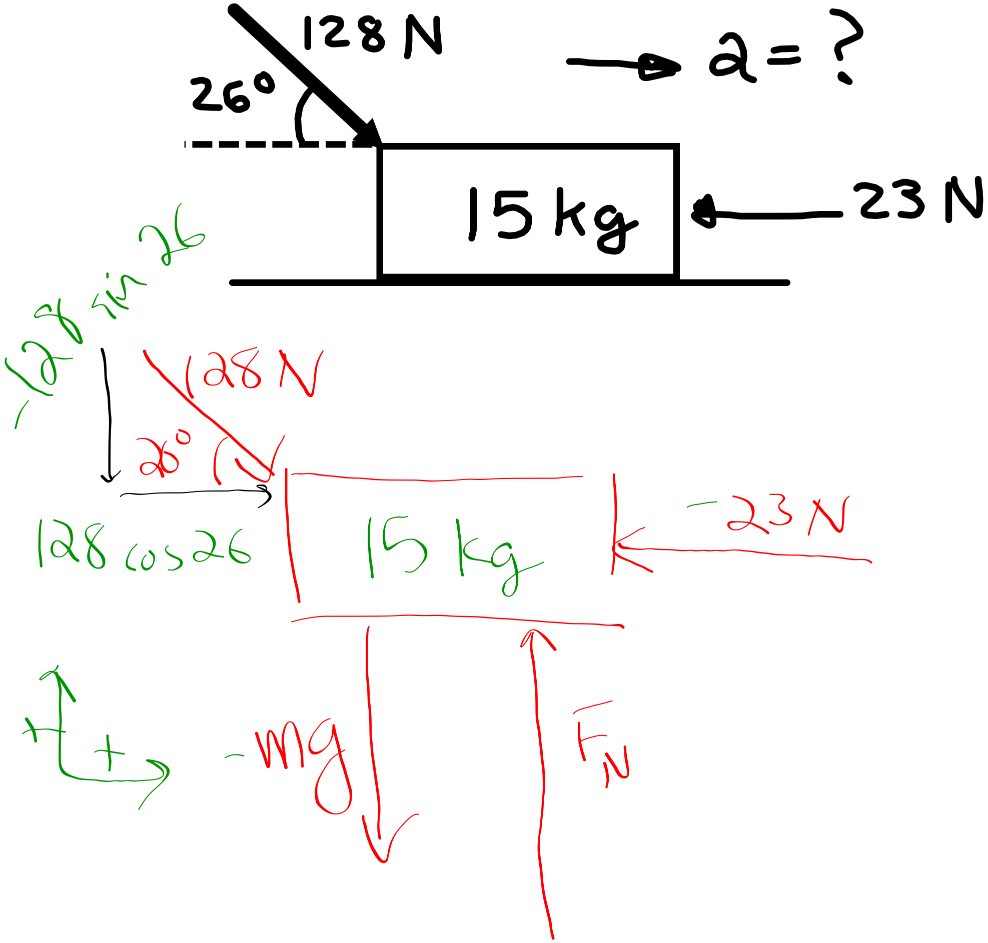


$$\Sigma F_x = m a_x$$

$$-F = (3.8)(5.9)$$

$$F = 22.42 \text{ lb}$$

Example 2:

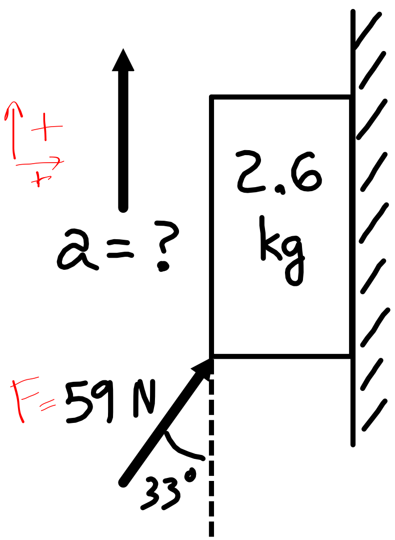


$$\Sigma F_x = m a_x$$

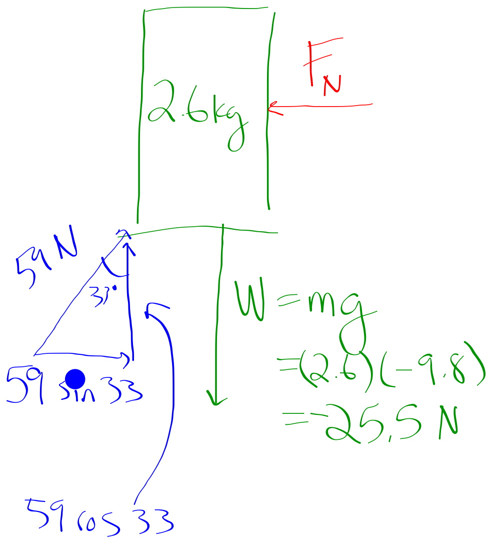
$$128\cos 26 + {}^{-}23 = 15 a_x$$

$$a_x = 6.14\ m/s^2$$

Example 3:



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



$$\Sigma F_x = 0$$

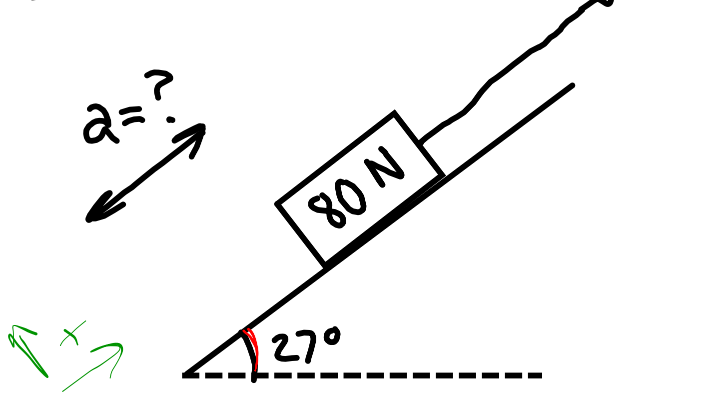
$$59 \sin 33 + F_N = \emptyset \quad (m a_x = \emptyset)$$

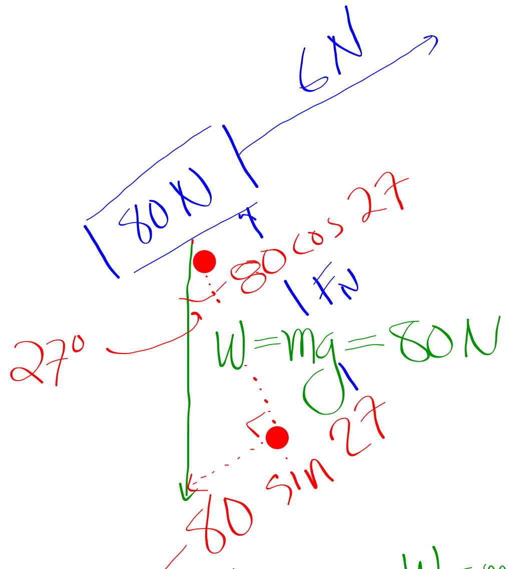
$$\Sigma F_y = m a_y$$

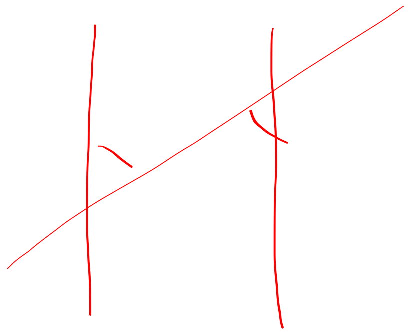
$$59 \cos 33 - 25.5\,N = m a_y$$

$$a_y = \frac{59 \cos 33 - 25.5}{2.6} = 9.2\ m/s^2$$

Example 4 :







$$\Sigma F_y = ma_y = \emptyset$$

$$-80\cos 27 + F_N = \emptyset$$

$$W = mg = 80N$$

$$m = 80/g = 80/9.8 = \boxed{8.16\ kg}$$

$$\Sigma F_x = ma_x$$

$$-80\sin 27 + 6N = (8.16)a_x$$

$$\boxed{a_x = -3.7\ m/s^2}$$

FRICTION

FRICTION:

The force between two surfaces in contact with one another that ALWAYS resists relative motion between the two surfaces.

(Force of friction is always opposite the direction of motion)

Friction is a smart force -- it is there when it needs to be, and not when there is no relative motion. (Force of friction on a moving object is constant)

What factors determine the size of the force of friction?

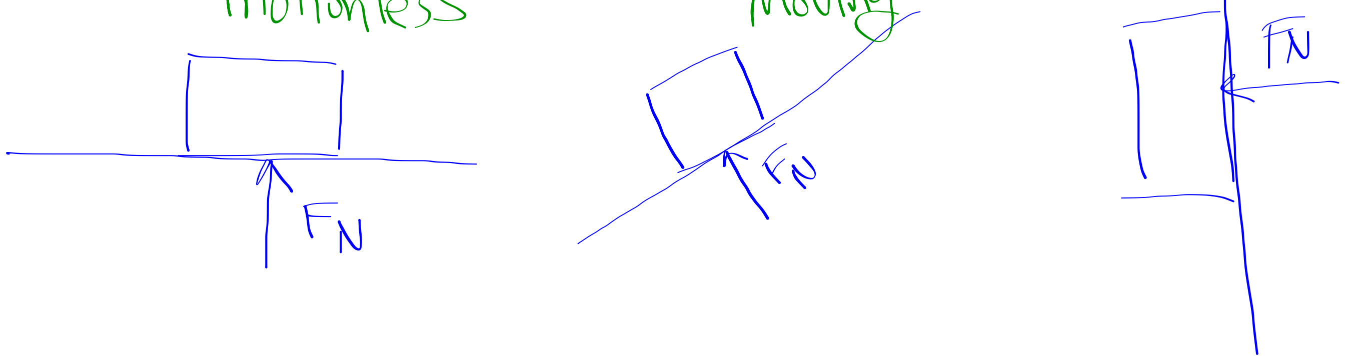
$$F_{FRICTION} = \mu F_N$$

F_N = the force clamping the two surfaces together (and this usually is the normal force)

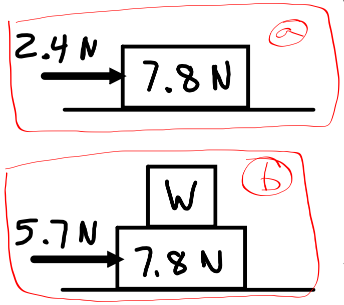
The "surface force": a force pushes on an object in a direction perpendicular to the surface.

μ = the coefficient of friction
-- It is unitless
-- It is usually less than 1.0 (but it can be bigger)
-- It is specific and unique for any two surfaces
-- $\mu_{STATIC} > \mu_{KINETIC}$

motionless Moving



EXAMPLE 1



For the 7.8 N object to move across the surface by itself at constant speed, a 2.4 N force must be applied.

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.

ⓐ

2.4N → | 7.8 N | ← $-F_{Fr}$

F_N ↑ ↓ $-mg = -7.8N$

$\Sigma F_x = ma_x = 0$

$2.4N + -F_{Fr} = 0$

$F_{Fr} = 2.4N$

$\Sigma F_y = ma_y = 0$

$F_N + -7.8 = 0$

$F_N = 7.8N$

$F_{Fr} = \mu F_N$

$2.4 = \mu 7.8$

$\mu = 0.31$

ⓑ

5.7N → | 7.8N + W | ← $-F_{Fr}$

F_N ↑ ↓ $-mg$ $-(7.8+W)$

$\Sigma F_x = 0$

$5.7 + F_{Fr} = 0$

$F_{Fr} = 5.7N$

$\Sigma F_y = 0$

$F_N + -(7.8+W) = 0$

$W = F_N - 7.8$

$F_{Fr} = \mu F_N$

$5.7 = 0.31(F_N)$

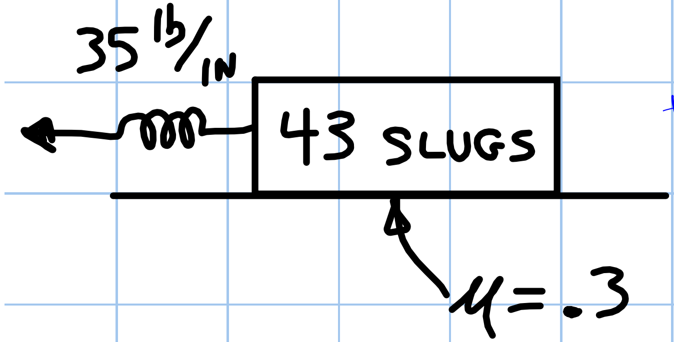
$F_N = 18.39N$

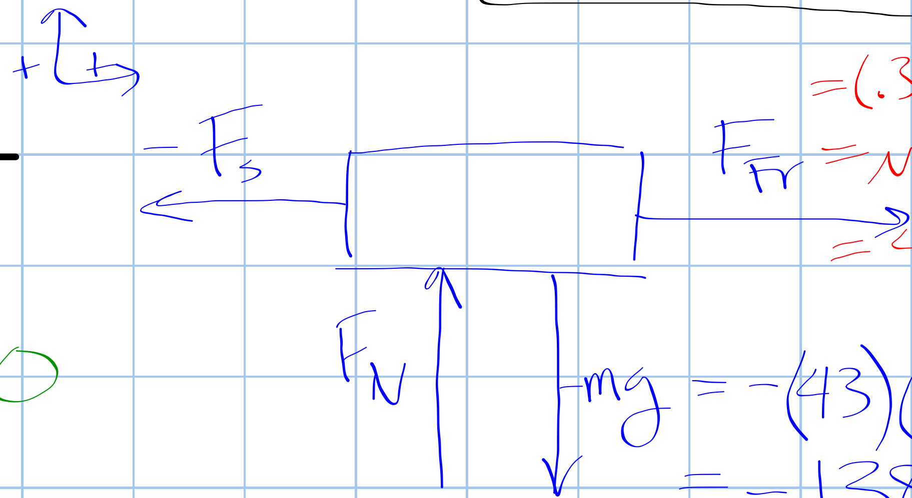
$W = 18.39 - 7.8$

$= 10.59\ N$

EXAMPLE 2

How far must the spring be stretched to slide the mass along the surface at constant speed?





$F_{Fr} = \mu F_N = (.3)(1384.6) = 415.38\,lb$

$mg = -(43)(32.2) = -1384.6\,lb$

$\Sigma F_y = m\cancel{a_y} = 0$

$F_N + -1384.6 = 0$

$F_N = 1384.6$

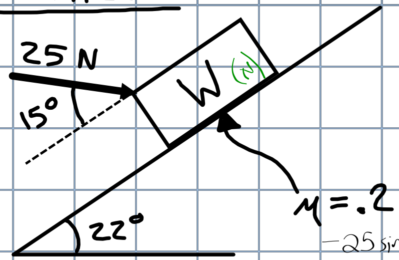
$\Sigma F_x = m\cancel{a_x} = 0$

$-F_s + 415.38 = 0$

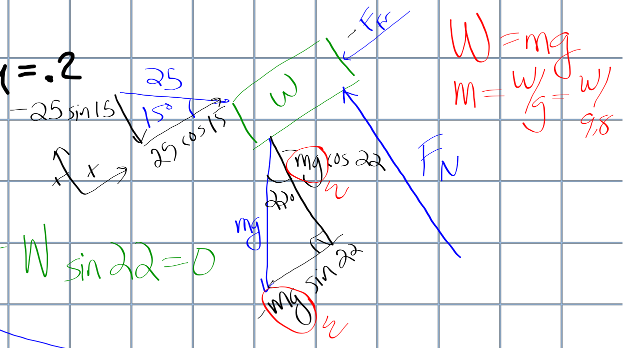
$F_s = 415.38 = kx = 35\,lb/in\;x$

$x = 11.9\,in$

Example 3



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



$W = mg$

$m = \frac{W}{g} = \frac{W}{9.8}$

$\Sigma F_x = ma_x = 0$

$25\cos 15 + -F_{Fr} + -W\sin 22 = 0$

$\Sigma F_y = ma_y = 0$

$-W\cos 22 + -25\sin 15 + F_N = 0$

$F_{Fr} = \mu \cdot F_N = \boxed{0.2 F_N}$

$25\cos 15 + -0.2F_N + -W\sin 22 = 0$

$\boxed{F_N} = W\cos 22 + 25\sin 15$

$\boxed{F_N} = \frac{25\cos 15 + -W\sin 22}{0.2}$

$W\cos 22 + 25\sin 15 = \frac{25\cos 15 + -W\sin 22}{0.2}$

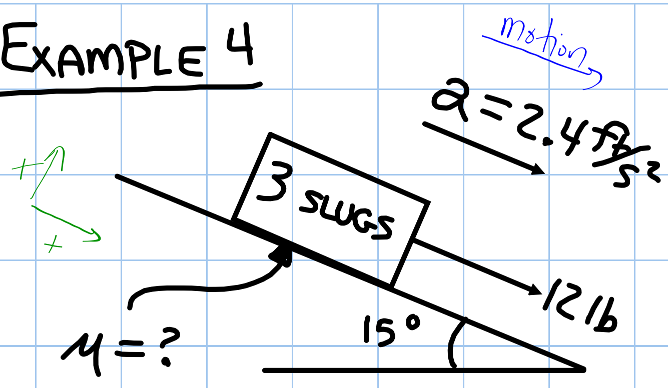
$0.93W + 6.5 = \frac{24.1 - 0.37W}{0.2}$

$0.19W + 1.3 = 24.1 - 0.37W$

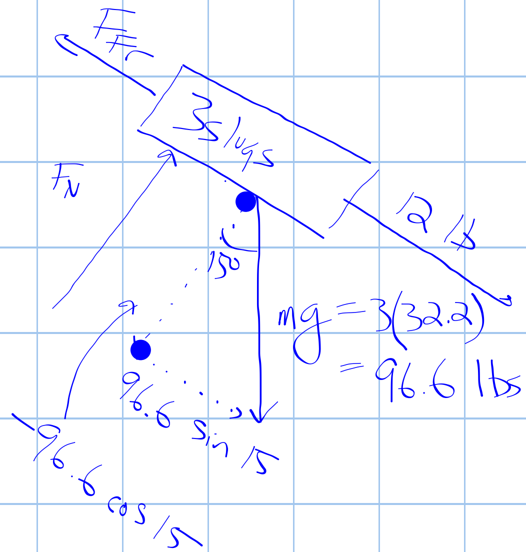
$0.56W = 22.8$

$W = 40.7\ N$

Example 4



What must μ be?



$$\Sigma F_y = ma_y = \emptyset$$

$$F_N - 96.6\cos 15 = \emptyset$$

$$F_N = 93.3\text{ lbs}$$

$$\Sigma F_x = ma_x$$

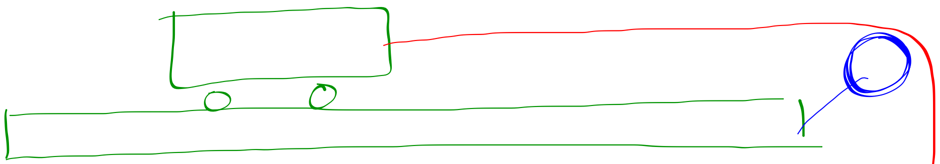
$$96.6\sin 15 + 12 + F_{Fr} = (3)(2.4)$$

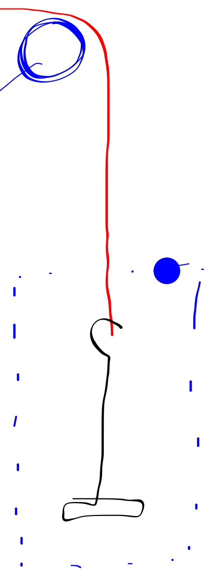
$$F_{Fr} = -29.8\text{ lbs}$$

$$F_{Fr} = \mu F_N$$

$$29.8 = \mu(93.3)$$

$$\boxed{\mu_k = 0.32}$$





Δt

Δx

v_0, v

Forces

What is F_{Fr} on the cart as it rolls on the track?

~~$F_{Fr} = \mu_k F_N$~~

is F_{Fr} only

$\Sigma F_x = ma_x$

How will you find this?

T in the string is not necessarily equal to the weight of the hanging mass