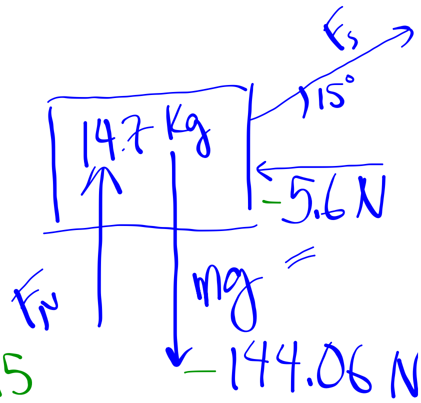
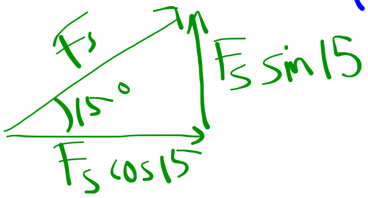
1. A box is being pulled along a horizontal table by a rope connected to a donkey's shoulders at an angle of 15° to the table. There is a spring between the rope and the box with k = 12.2 N/cm. The mass of the box is 14.7 kg. If friction is opposing the box's motion with a constant force of 5.6 N, and the box is accelerating at 4.1 m/s² horizontally:
   a. How many centimeters does the spring stretch? (5.59 cm)
   b. What is the size of the normal force? (126.41 N)

$F_s = kx$





$$\Sigma F_x = ma_x$$

$$F_s \cos 15 + {}^-5.6 = (14.7)(4.1)$$

$$F_s = 68.2\text{N}$$

$$F_s = kx$$

$$68.2 = 12.2x$$

$$\boxed{x = 5.59\text{cm}}$$

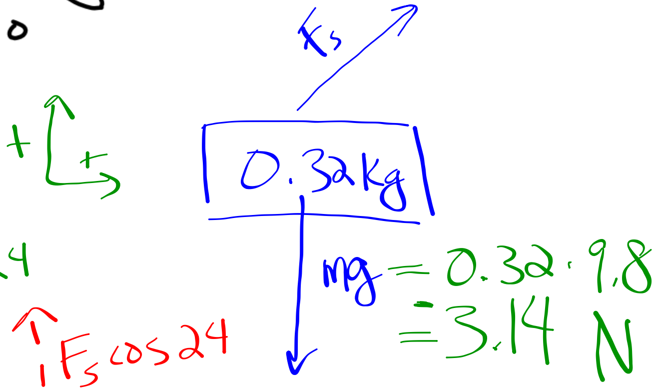
$$\Sigma F_y = \cancel{ma_y} = 0$$

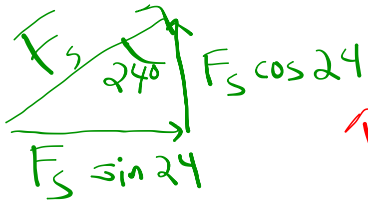
$$F_N + {}^-144.06 + (68.2 \sin 15) = 0$$

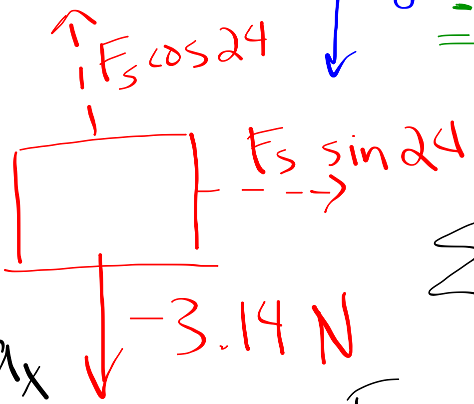
$$F_N = 126\text{ N}$$

2. A football with a mass of 0.32 kg is hooked to an airplane by a spring at a constant angle (with the vertical) of 24°. The spring is stretched out 11 cm. The football is not moving in the vertical direction.
    a. What is the spring constant of the spring (in N/cm)? (0.31 N/cm)
    b. How quickly is the football accelerating horizontally? (4.36 m/s²)

$F_s = k\boxed{x}$







$\Sigma F_x = m a_x$

$F_s \sin 24 = (.32) a_x$

$\Sigma F_y = m a_y^{\,0}$

$F_s \cos 24 - 3.14 = 0$

$F_s = \dfrac{3.14}{\cos 24} = 3.44$ N

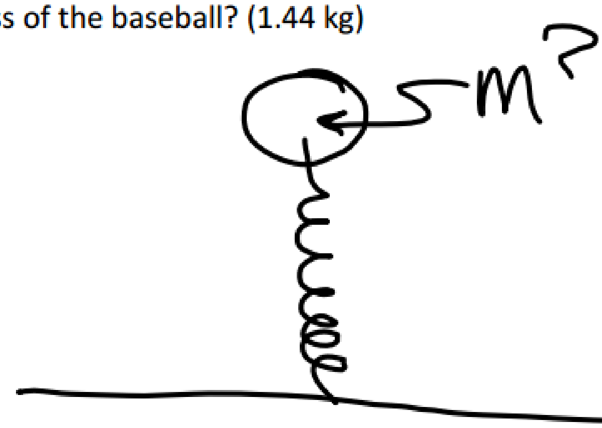
ⓐ $F_s = kx$

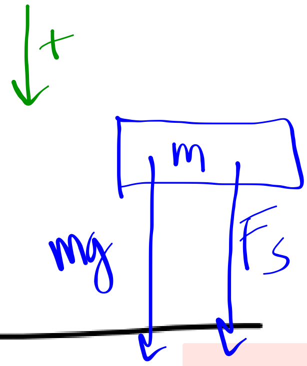
$3.44 = k(11)$

$\boxed{k = 0.31\ N/cm}$

ⓑ $\dfrac{(3.44)(\sin 24)}{0.32} = \boxed{a_x = 4.37\ m/s^2}$

3. A baseball is thrown directly up into the air. It is attached to a spring that is hooked to the ground. The spring has a k of 0.41 N/cm. When the spring has stretched out 5.6 cm, the baseball has an instantaneous acceleration of 11.4 m/s^2 downward. What is the mass of the baseball? (1.44 kg)





$\Sigma F = ma$

$m \cdot g + F_s = ma$

$F_s = kx$
$= (0.41)(5.6)$
$= 2.3\text{N}$

$m(9.8) + 2.3 = m(11.4)$

$-1.6m = -2.3$

$m = 1.44\text{kg}$

FRICTION:

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

Friction is a smart force -- it is there when it needs to be, and not when there is no relative motion.

What factors determine the size of the force of friction?

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

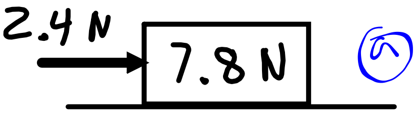
F_N = the force clamping the two surfaces together (and this usually is the normal force)

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
-- $\mu_{STATIC} > \mu_{KINETIC}$

Will generate a variable amount of friction (just enough to oppose an object's motion)

Will generate a constant frictional force in the apposite direction of motion

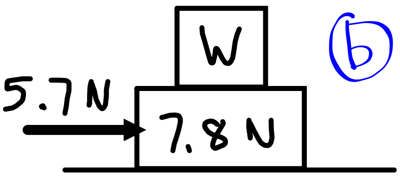
EXAMPLE 1



(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.

↳ a=0

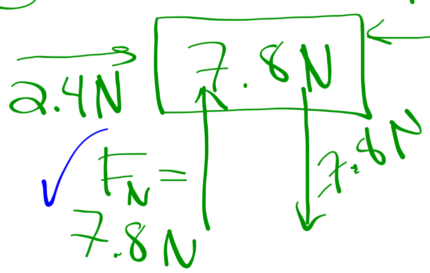


(b)

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.

(a)

$F_{fr} = 2.4N$ ✓



$F_{fr} = \mu F_N$

$\mu = \frac{F_{fr}}{F_N} = \frac{2.4}{7.8}$

$\mu =$