Chapters 5, 6, 7 Newton's 3 Laws of Motion

Newton's first two laws define Force and tell us precisely what a force does.

Newton's third law describes how objects interact with each other (i.e. exert forces) through action-reaction pairs.

Our objective for today:

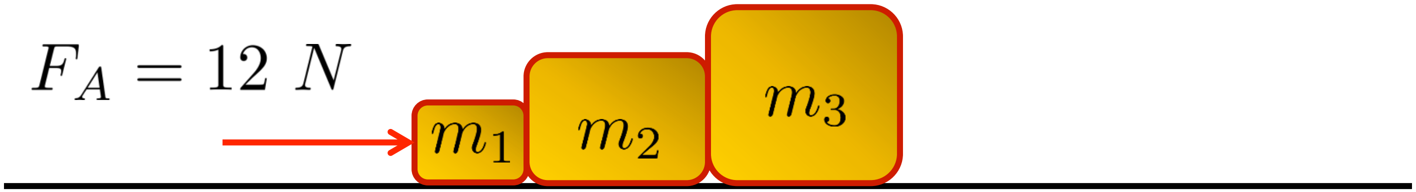
- Apply Newton's laws to analyze forces between interacting objects

Newton's 3 Laws of Motion (Sec 7.2, 7.3)

9. || Blocks with masses of 1 kg, 2 kg, and 3 kg are lined up in a row on a frictionless table. All three are pushed forward by a 12 N force applied to the 1 kg block.

a. How much force does the 2 kg block exert on the 3 kg block?

b. How much force does the 2 kg block exert on the 1 kg block?



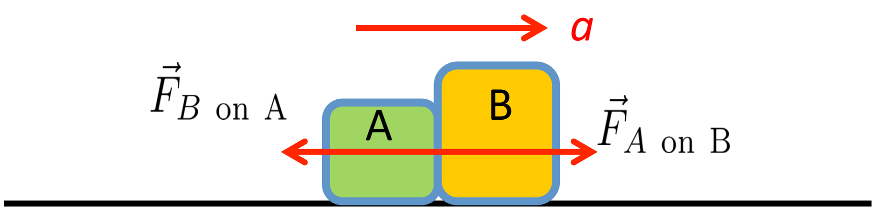
I think that we can all agree that the three blocks will have the same acceleration:

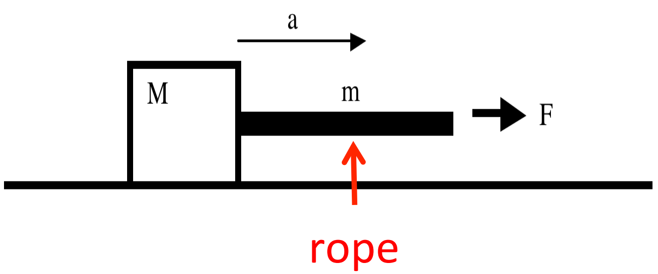
$$a = \frac{F_A}{(m_1 + m_2 + m_3)}$$

But how do we find the forces between the blocks? Draw the f. b. d. for each mass!!!!

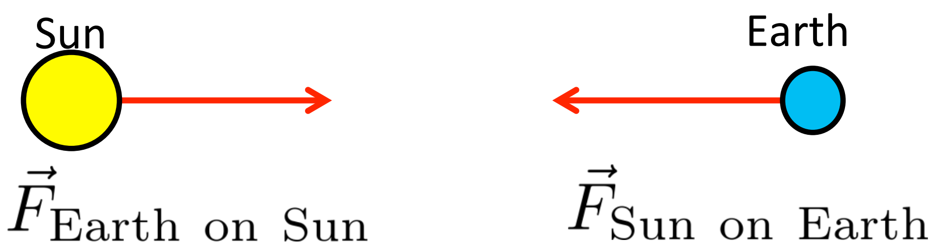
Action/Reaction Force Pairs (Sec 7.1 – 7.3)

For contact forces (usually normal, friction, and tension):





Long range forces (e.g. gravity)



Notice: Action/Reaction pair forces are always equal in magnitude, but in opposite directions. That's the essence of Newton's 3rd Law.

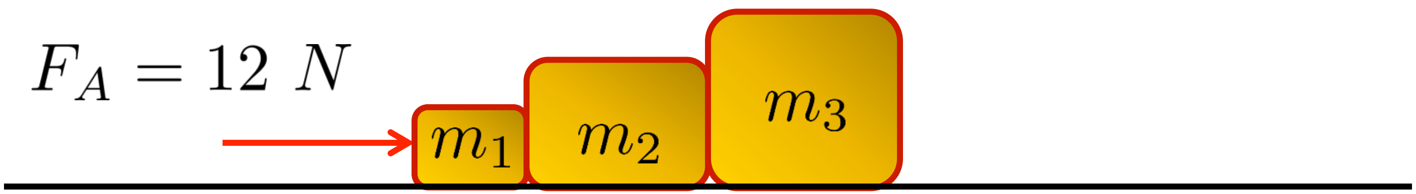
OK, Now Let's Solve Problem 7-9: Whiteboard 7.1

9. || Blocks with masses of 1 kg, 2 kg, and 3 kg are lined up in a row on a frictionless table. All three are pushed forward by a 12 N force applied to the 1 kg block.

a. How much force does the 2 kg block exert on the 3 kg block?

b. How much force does the 2 kg block exert on the 1 kg block?

$F_A = 12\ N$

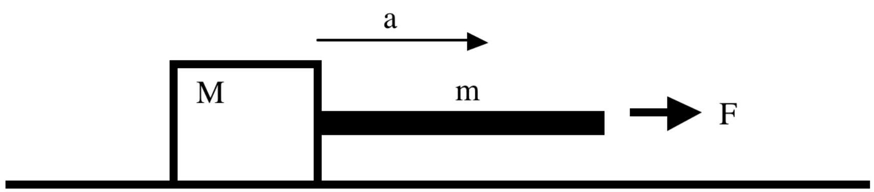


$m_1 = 1\ kg \quad m_2 = 2\ kg \quad m_3 = 3\ kg$

The system is the three blocks. The surface and the Earth are the environment.

Ropes: Tension revisited (Sec 7.4)

- Block pulled by thick rope on frictionless surface



Q1: What is F required to pull block and rope w/ acceleration a?

Q2: What is the tension T in the rope?

Q3: Draw the free-body diagram for the rope. Show all forces **on** the rope.

A common simplification: assume rope is very light compared to block.

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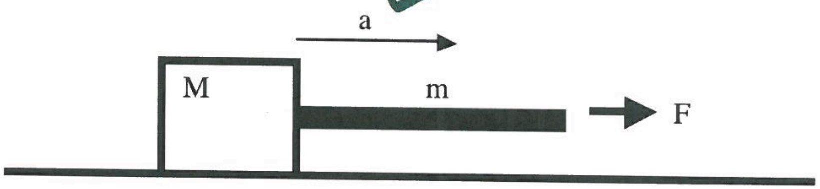

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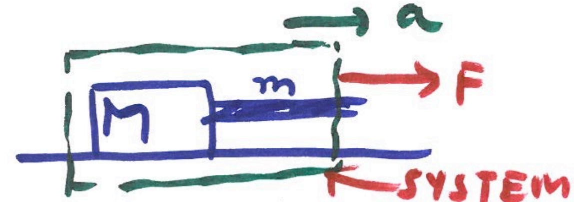
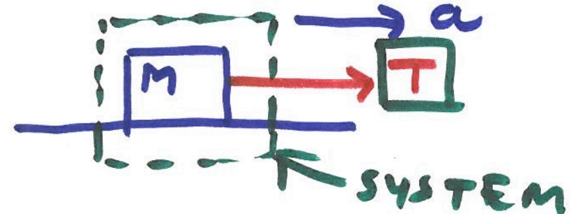
Q1:



$F_{net} = ma$

$F = (M+m)a$

Q2:

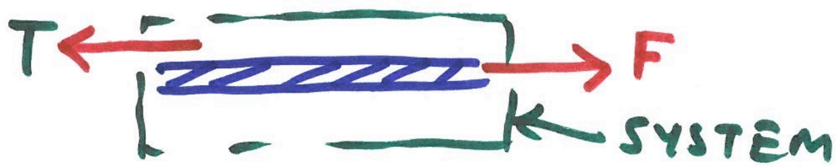


$F_{net} = ma$

$T = Ma < F$

Q3.

$m \simeq 0$



$F_{net} = ma$

$F - T = ma$

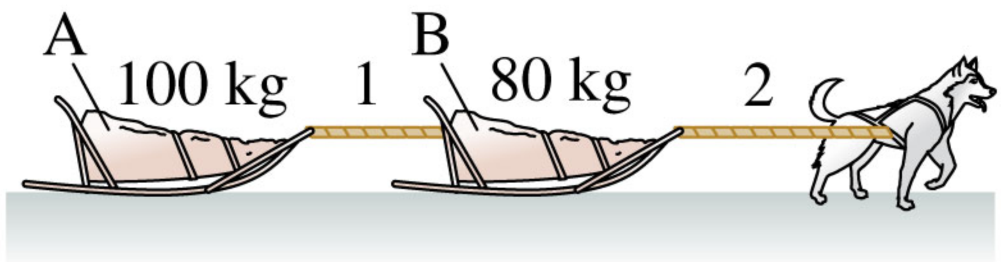
$F = (M + m)a$, with $m \to 0$

$T = Ma$

$F - T = ma$, with $m \to 0$

Problem 7-14: Whiteboard Problem 7.2

14. The sled dog in FIGURE P7.23 drags sleds A and B across the snow. The coefficient of friction between the sleds and the snow is 0.10. If the tension in rope 1 is 150 N, what is the tension in rope 2?



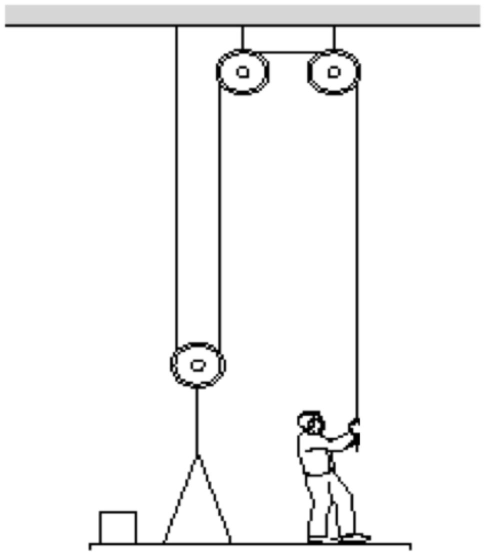
$$T_1 = 150\ N$$

$$\mu_k = 0.1$$

$$\text{Acceleration Constraint: } a_{x_A} = a_{x_B} = a$$

Pulleys (Sec 7.4)

Pulley: A simple device to enable moving of objects with application of a relatively smaller force.

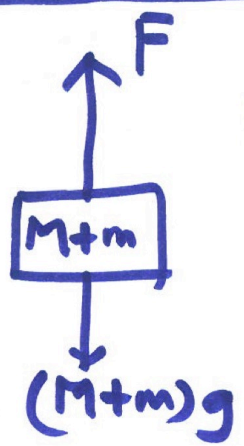


WHITEBOARD EXERCISE: Calculate the force with which the painter pushes down on the platform. Hint! You'll need to draw the f. b. d. for the painter now!

Pulleys (Sec 7.4)

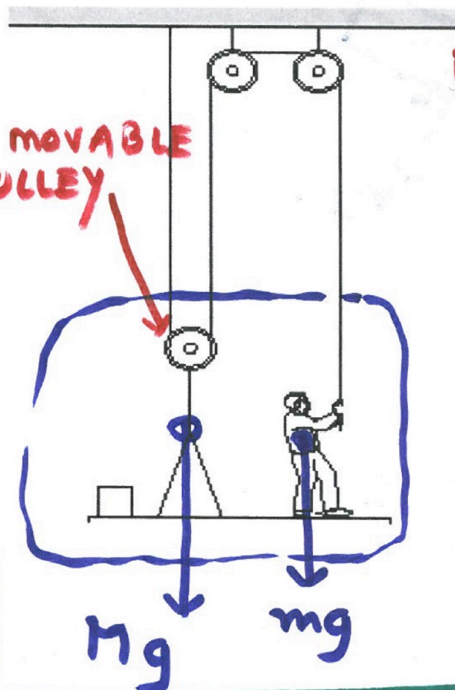
Pulley: A simple device to enable moving of objects with application of a relatively smaller force.

W/O PULLEY



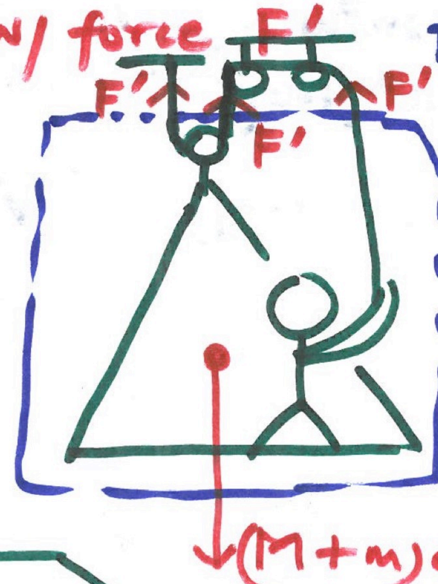
$F \geq (M+m)g$

MINIMUM $F = (M+m)g$



W/ PULLEY:

PAINTER PULLS DOWN ON ROPE W/ force F'



DRAW f.b.d. for "PAINTER + PLATFORM" SYSTEM

$3F' - (M+m)g \geq 0$

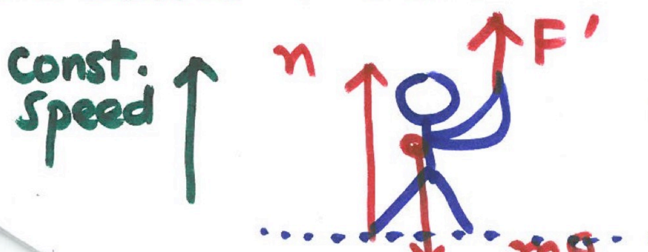
$F_{net} = ma$

MINIMUM F' needed is $3F' = (M+m)g$

$F' = \frac{(M+m)g}{3}$

Q: CALCULATE THE FORCE BETWEEN THE PAINTER & THE PLATFORM? [NORMAL FORCE BETWEEN TWO.]

WB: DRAW F.B.D. FOR JUST THE PAINTER!



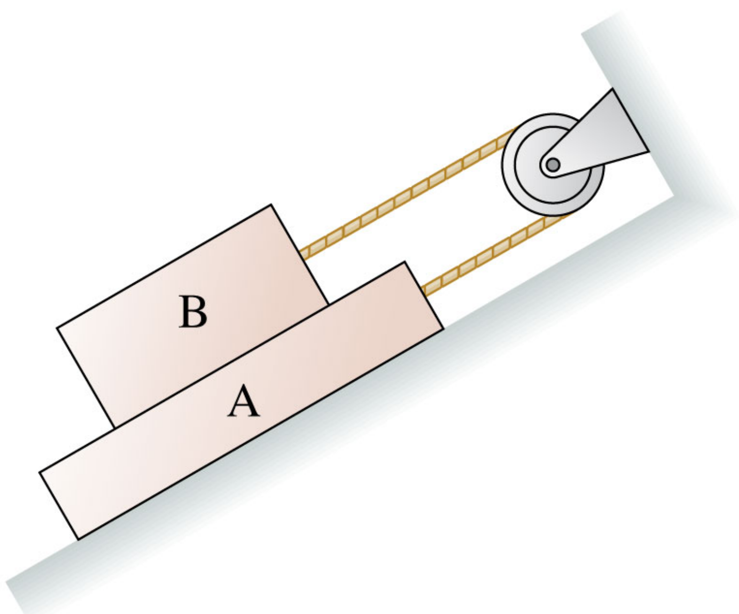
$F_{net} = ma$

$F' + n - mg = 0$

$n = mg - F'$

Problem 7.4, Whiteboard Problem 7.3

4. ‖ Block A in FIGURE EX7.5 is heavier than block B and is sliding down the incline. All surfaces have friction. The rope is massless, and the massless pulley turns on frictionless bearings. The rope and the pulley are among the interacting objects, but you'll have to decide if they're part of the system.

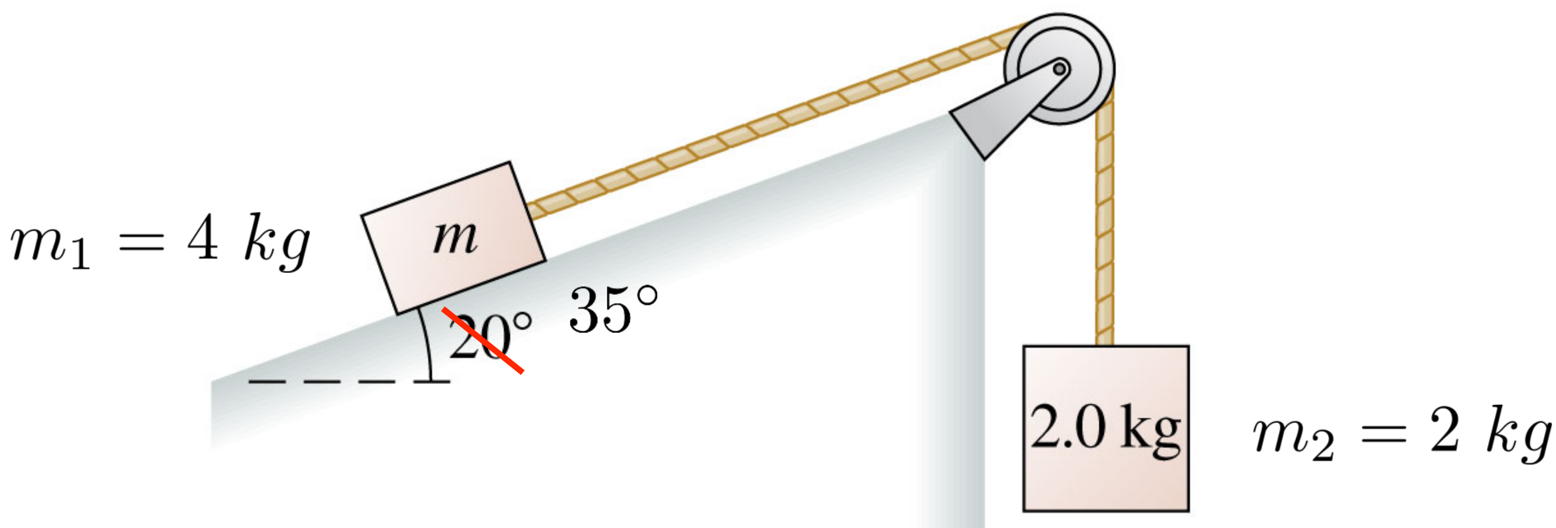


Draw free body diagrams for blocks A and B.

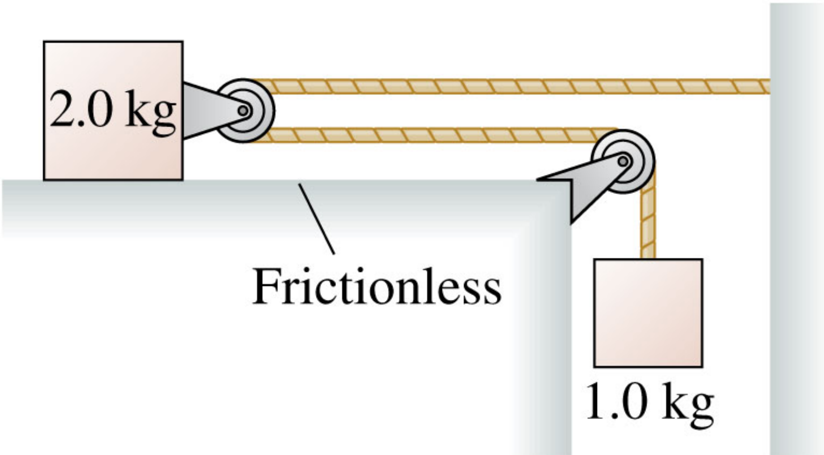
Problem 7.40: Whiteboard Problem: 7-4

40. A 4.0 kg box is on a frictionless 35° slope and is connected via a massless string over a massless, frictionless pulley to a hanging 2.0 kg weight. The picture for this situation is similar to FIGURE P7.41.

a. What is the tension in the string if the 4.0 kg box is *held* in place, so that it cannot move?
b. If the box is then released, which way will it move on the slope?
c. What is the tension in the string once the box begins to move?



Problem 7.55: Whiteboard Problem: 7-5



What is the acceleration of the 2.0 kg block across the frictionless table?

Hint: Q: Can you see what the acceleration constraint here is? Note that if the 1 kg block accelerates down with a_1, the 2 kg block accelerates to the right with acceleration $0.5a_1$! Can you see why??