Physics 105 Class 6
APPLICATIONS OF NEWTON'S LAWS

Neglecting Friction For Now! (Next Time)

Review Newton's Laws:

1)

2)

3)

Applications:

1) Objects in equilibrium
2) Ropes and pulleys
3) Inclined planes

Free-body diagram:

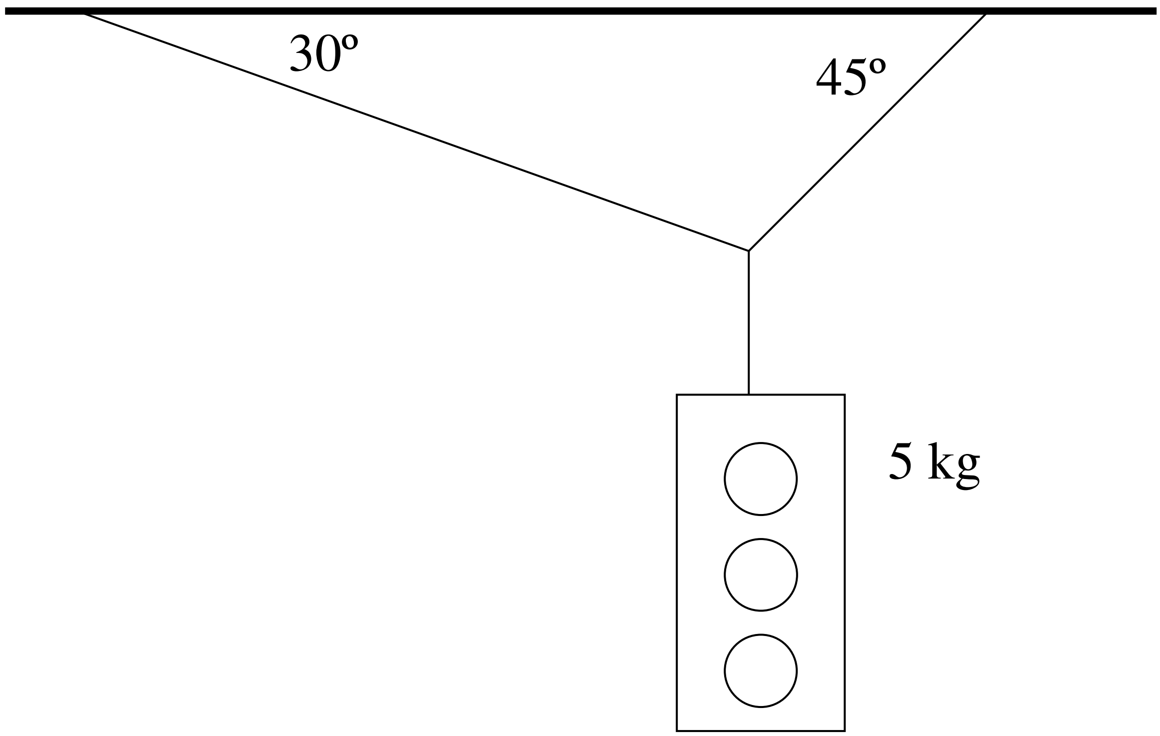
1. Draw the object of interest **alone** (you can combine several objects as a "single object" if they have the same **a**).
2. Draw forces on the object exerted by **other things**
3. Label each force with a different symbol
4. Choose a positive direction
5. Draw the vector **a** on the diagram, but not on the object (it's not a force)
6. For the FBD you can write

   $\Sigma F_x = ma_x$ and $\Sigma F_y = ma_y$

   (m is the mass of the object *in the diagram*)
7. Connected objects.
   - You need as many equations as you have unknowns. Substitute to solve system of equations.

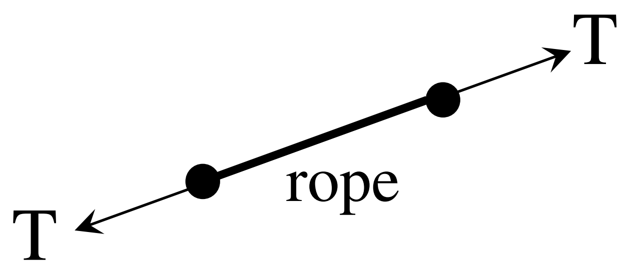
Shortcut: You can also draw a FBD for the objects as a **group**, and use the second law. *Sometimes* you don't need to solve equations simultaneously.

Objects in equilibrium (very similar to 6-1/6-2)



Ropes and pulleys

When we pull on a rope, we create tension (T) in it.



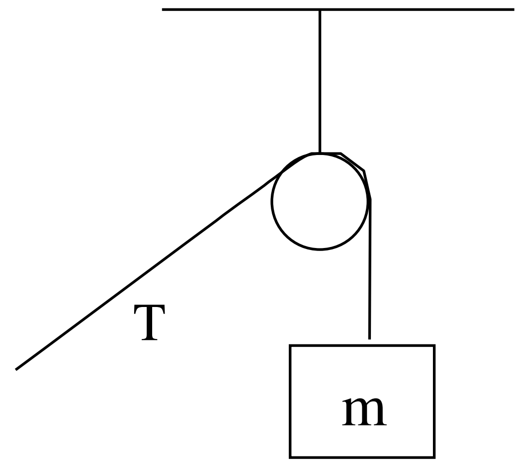
Same on both ends, so no net force on the rope.

Direction of force that a rope exerts on an object?

Physics 105 Class 6

Role of fixed pulleys

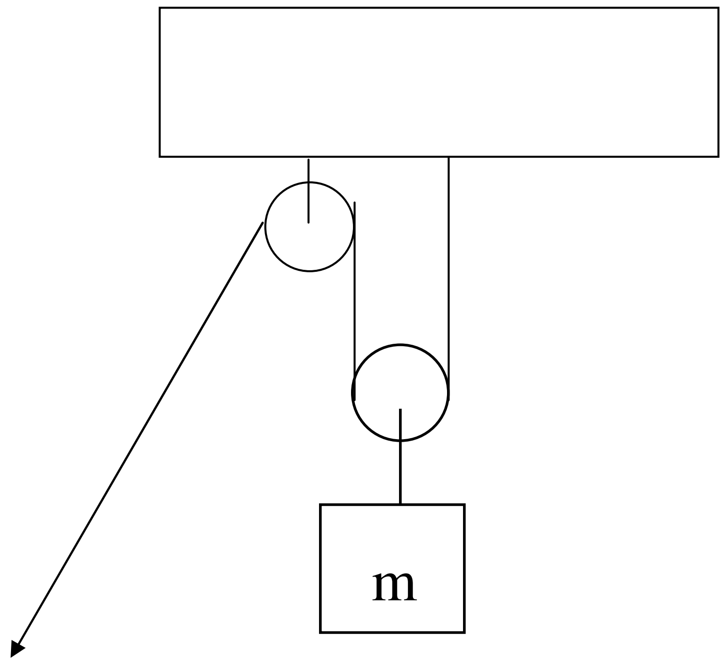
(frictionless, massless)



Tension when mass is not accelerated:

Tension with acceleration:

Moveable pulleys



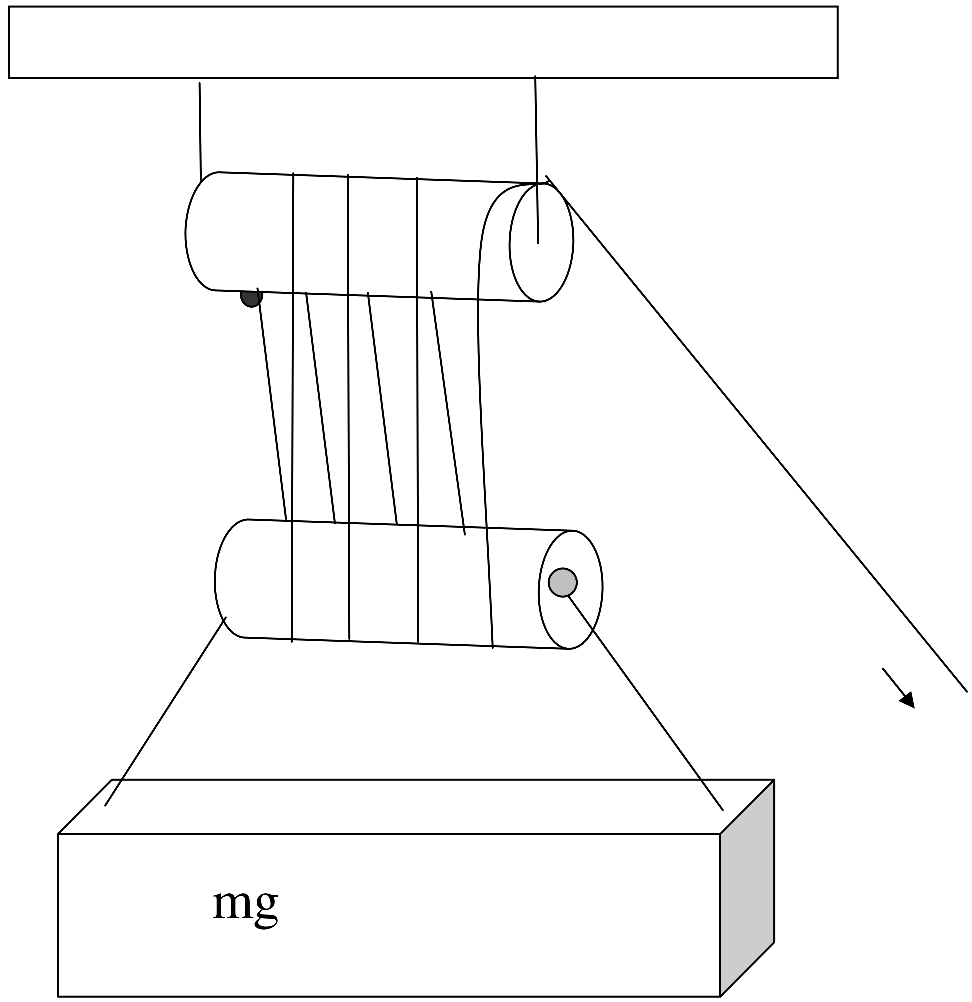
"Mechanical advantage"

tension required to hold or slowly lift is *lower*

Draw FBD of the moveable pulley

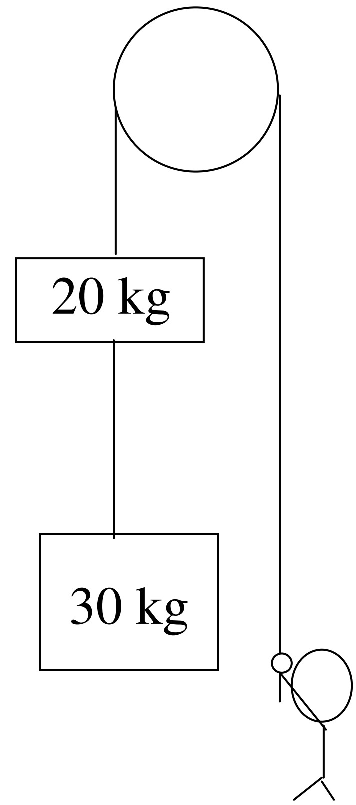
See how many T-vectors are pulling upward

Solve Newton's 2nd law



P4. Frictionless string (or good pulleys), and no acceleration. The tension in the string you pull is:

1. 8 mg
2. 6 mg
3. 4 mg
4. 2 mg
5. mg
6. mg/2
7. mg/4
8. mg/8

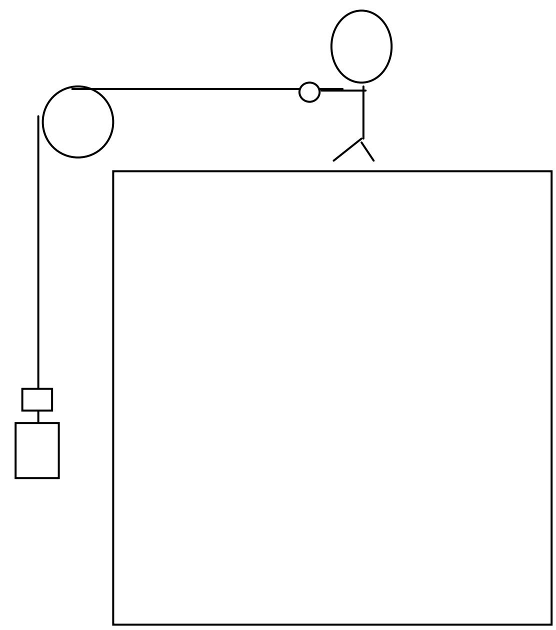


Gilbert pulls down on a rope over a pulley that is connected to two boxes, and the boxes accelerate upward at 1.5 m/s^2.

a. What force does Gilbert put on the rope?

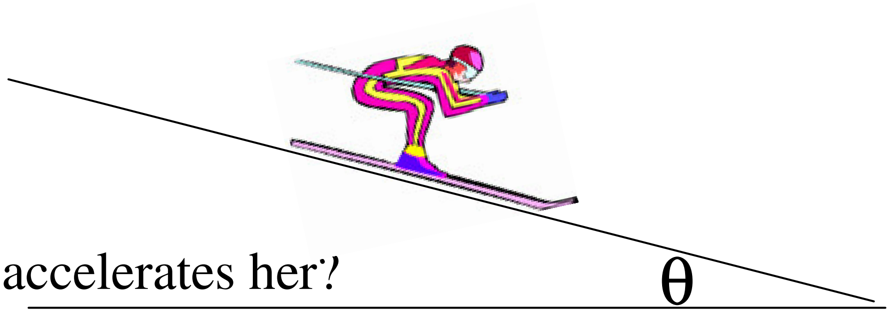
b. What is the tension in the rope between the boxes?

Gilbert (100 kg) is lifting the 50 kg group of boxes over a frictionless pulley while on top of a building. He then steps on some frictionless ice. What is his acceleration?



Inclined planes

A skier is on a hill with no friction. What is her acceleration?



Concept first:

What force is it that accelerates her?

What is the acceleration?

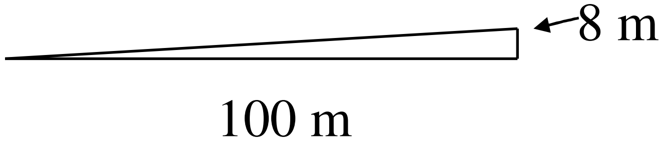
Two extremes:

level ground

infinite slope

a for any angle:

Example: 8% grade (slope) (max on most freeways)



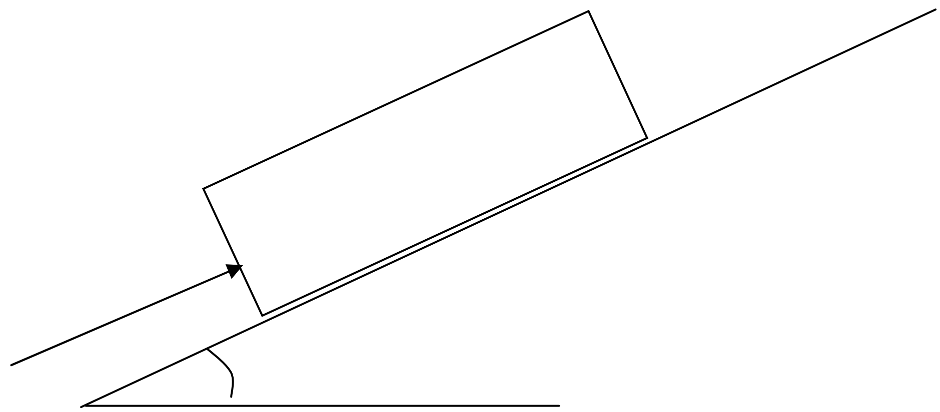
$$\theta = \tan^{-1}\frac{8}{100} = 4.59^0$$

$$a = \text{g}\sin\theta = .79 \text{ m/s}^2$$

0 to 60 in 34 s !
(or 60 to 120)!

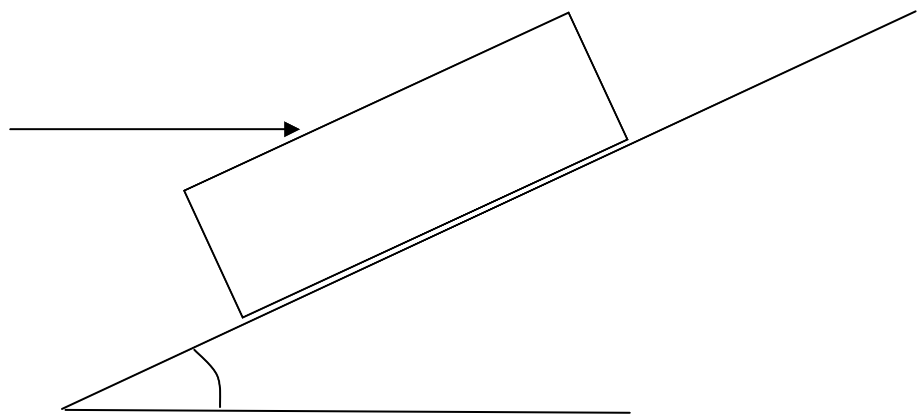
Physics 105 Class 6

You push upward with a force of 100 N on a 25 kg frictionless ice block which is on a hill sloping 30° above the horizontal. What is the acceleration of the block? (similar to 6-3)

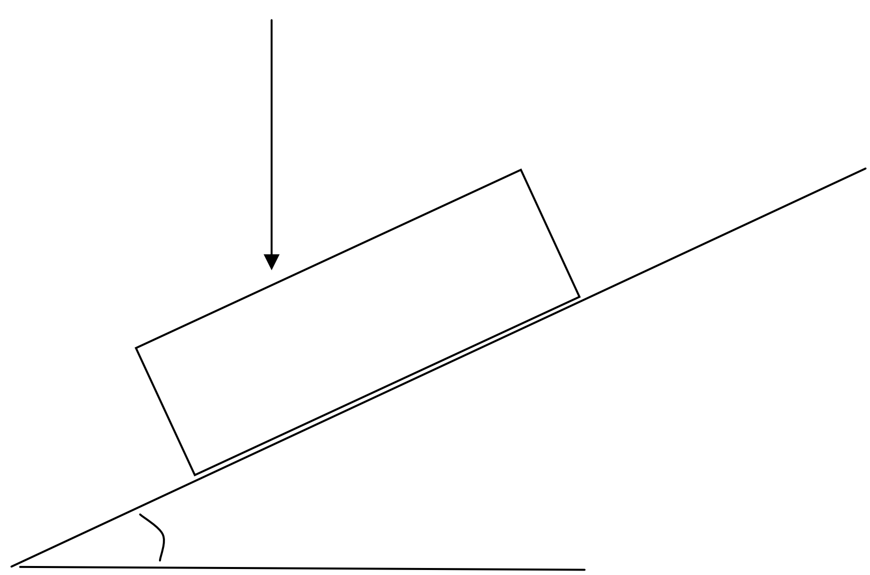


Physics 105 Class 6

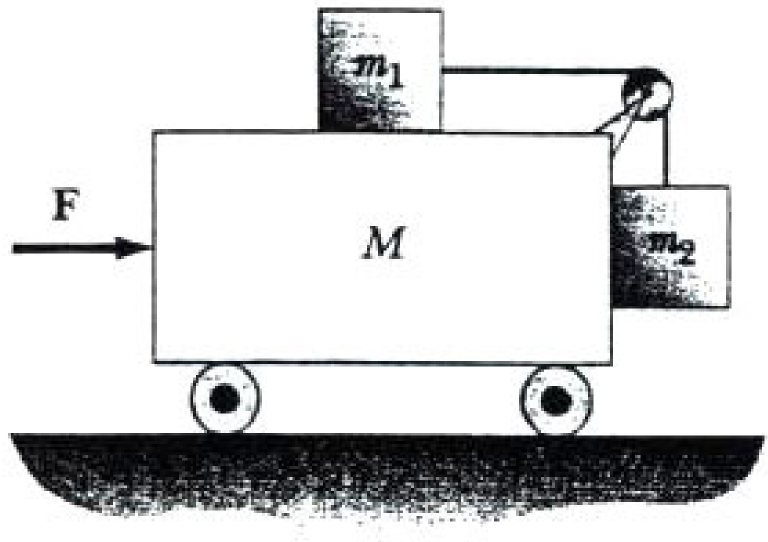
You push with a **horizontal** force of 100 N on a 25 kg frictionless ice block which is on a hill sloping 30° above the horizontal.



What if you push **vertically**?



What horizontal force **F** must be applied to the cart in the figure in order that the blocks remain stationary relative to the cart? Assume that all surfaces, wheels, and pulleys are frictionless.



1. Draw FBD of m_2

2. Draw FBD of m_1

3. Draw FBD of the entire moving system together.

Physics 105 Class 6

Using any of the symbols M, m_1, m_2 and g:

What must the **tension** be for the blocks not to slip on the cart? (Use FBD of m_2 and set $a_y = 0$)

Then what must be the acceleration of m_1 relative to the ground? (Use FBD of m_1)

What is the acceleration of the entire cart?

What must the force on the entire cart be to give this acceleration?

HOMEWORK 6 NOTES: