Dynamics Notes

1 – Newton's Laws

In 1665 Sir Isaac Newton formulated three laws that dictate the motion of objects. These three laws are universal and apply to all forces in the universe.

Newton's 1st Law: An object… and an object… unless…	Example:

Newton's 2nd Law: As a formula:	Example:

Newton's 3rd Law: For every… As a formula:	Examples:

Free Body Diagrams: (Draw one for **EVERY** force question)

1) Represent the object…
2) Represent all forces…
    -
    -
    -

Examples: Draw FBDs for each situation

1. A textbook sits motionless on a table.

2. A coconut falls from a tree (no air friction)

3. A puck slides along frictionless ice.

4. A dragster accelerates from rest.

5. A car drives at a constant velocity.

6. A block of wood slides down an incline

1. A student pulls straight upwards with a force of 650 N on their 15 kg backpack. What is the backpack's acceleration?

2. A 1200kg car accelerates at 5.85 m/s^2. If the force of friction acting on the car is 2800 N, how much force does the engine exert?

<u>Trickery Alert!</u>
Just when you though you were done with kinematics, they sneak back in. You will be expected to use kinematics to solve for acceleration to use in force problems and vice

<u>Even More Trickery!</u>
Remember that when determining the forces working on an object we need to consider their *directions*. If a force is working in the direction of acceleration we need to break it down into components.

<u>Ex:</u>
A 2.10 kg curling rock is hurled down ice at 6.5 m/s. It comes to a stop in 12.0 s.
What is the force of friction between the ice and the rock?

NOTE:

<u>Ex:</u>
A boy pulls his 8.0 kg toboggan by a rope that angles 32^o above the horizontal. If his 36.0 kg sister sits on the toboggan, how much force does he need to exert to accelerate them at 2.25 m/s^2?
(Assume no friction)

Dynamics Notes

2 - Friction Review

Friction is created whenever…

On the microscopic level…

Force of friction (F_f) is given by the equation:

Where: F_N =

μ =

=

There are 2 types of friction:

Static Friction:

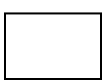
Kinetic Friction:

Note that the irregularities in a static object will tend to "dig in" more and generally:

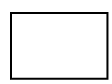
Friction$_{static}$ **Friction$_{kinetic}$**

μ_s μ_k

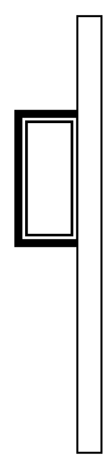
Ex 1:
A 3.75 kg block is pushed along a tabletop with a force of 45.0N. The coefficient of friction is 0.65.
a) Find the force of friction.
b) Find its acceleration.



Ex 2:
A 0.200 kg puck is pushed along a sheet of ice with a force of 0.240 N. If it moves at a constant velocity, find the coefficient of friction

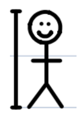


Ex 3:
A 1.12 kg textbook is pushed horizontally against a wall with a coefficient of friction of 0.465. What is the least amount of force required to keep the book from slipping?

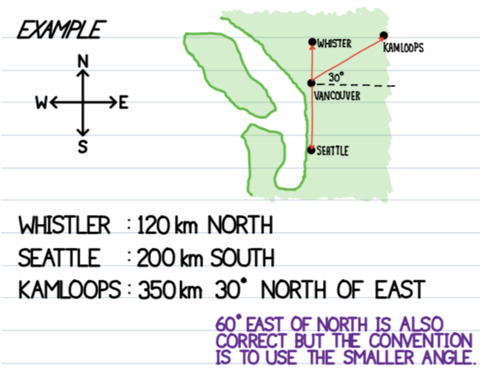


Dynamics Notes
3 – Vector Review

Measurable quantities are either __________ or _____________.

Scalars have only magnitudes (______)	**Vectors** have both magnitude and ____________
	

<u>Representing vectors</u>



A vector can be represented by an ___________

- The magnitude of the vector is represented by the _______ of the arrow
- The direction of the vector is represented by the _______ of the arrow
- A vector at an angle can be split into **horizontal and vertical** _______________

Example: Where is Kamloops from Vancouver?

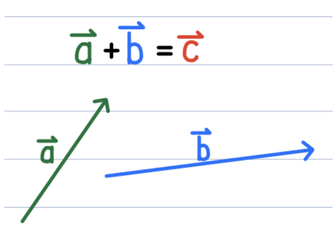
Example 1: Determine the components the following vector: **56 m/s 25° W of South**

<u>Vector Addition</u>

Method 1: Vectors can be added pictorially using the __________________________

- Draw the first vector
- Draw the second vector with its tail at the head of the first vector
- The ____________________ is drawn from the _________ of the first vector to the ______ of the second vector
- The magnitude and direction can be found using Sine Law or Cosine Law

Ex)



Example 2) Aaron walks **2.5 km East then 3 km 35° North of East**. What is his total displacement?

Method 2: Vectors can also be added using the ____________________ Method

- Split vectors into ___________ and ____________ components
- Add the horizontal and vertical components __________ to determine the components of the resultant vector
- Use the _______________ theorem and _________ to determine the magnitude and direction of the resultant vector.

Example 3) Aaron walks 2.5 km East then 3 km 35° North of East. What is his total displacement?

__Vector Subtraction__

- To subtract vector: _______ its ___________

Most often used to determine the change in a vector quantity:

Let try subtracting the following vectors

Example 4) A stationary observer is monitoring the movement of a dog. Initially, the dog is seen 5.0 m East of the observer. A few seconds later, the dog is 10 m 45° North of East. What is the displacement of the dog?

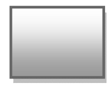
Dynamics Notes

4 – Forces in 2-D

As with any vectors, forces must be resolved with consideration to both their ____________ **and** ____________.

Ex

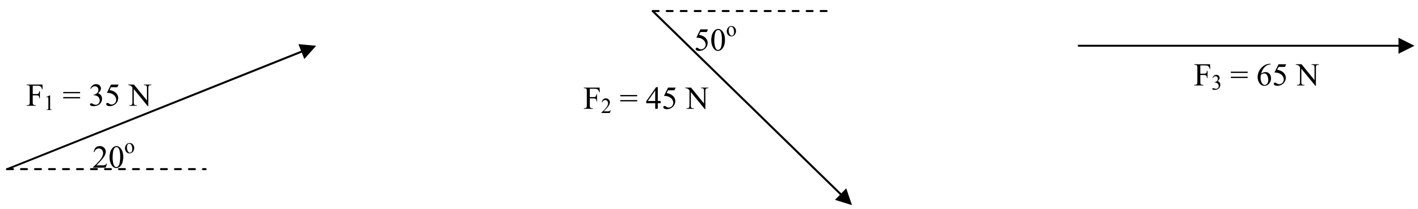
Two students push a crate across a frictionless surface. Student A pushes with 75 N East and Student B pushes with 48 N South.
What is the resultant force acting on the box?



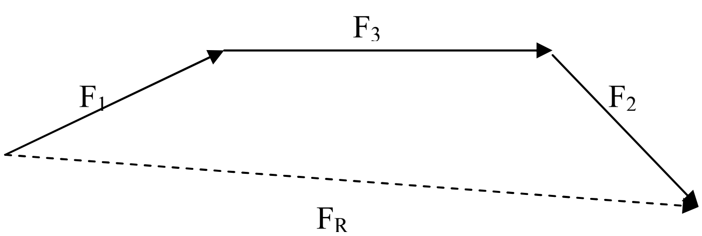
If there are more than two forces then it is best to solve for the resultant using the**...**

Ex

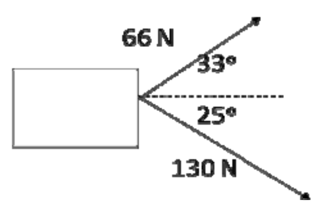
Resolve these force vectors into their x and y components



Ex 2 - Determine the resultant force if all three forces in the last example are applied to a single body.



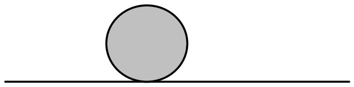
Ex 3: Two children pull a third child on a toboggan (shown from the top, assume up is north). Assuming that they pull on ropes that are parallel to the ground determine the magnitude of the force exerted on the toboggan.



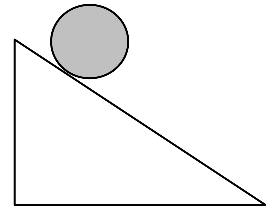
Dynamics Notes

5 – Inclines

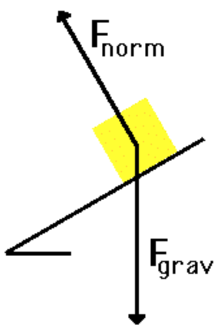
A ball sitting on a level surface will not roll because the forces on it are balanced ($F_{net} = 0$).



However, when the ball is placed on an *inclined plane* it will roll down the plane.

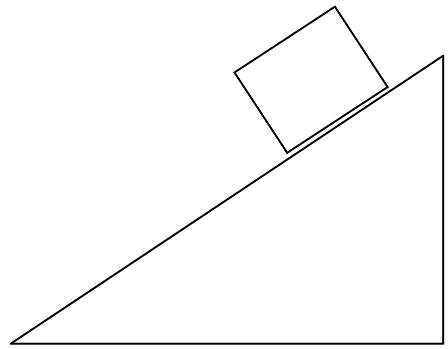


Although the F_g pulls **straight down** at all times…



F_N is always…

For inclined plane questions our first step should always be to resolve the object's F_g into two components:

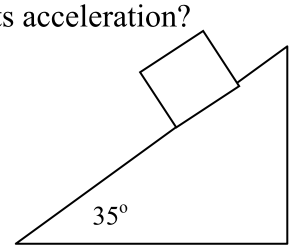


Two important things to notice:

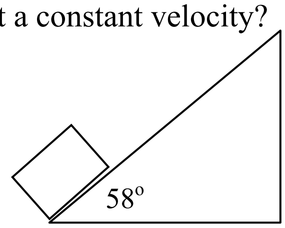
1) Only the _______________ ___________________ pulls down the ramp.

2) The ________________ _____________________ is equal and opposite to ____________.

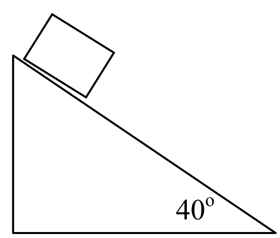
Ex
An 8.0 kg block slides down the frictionless inclined plane shown. What is its acceleration?



Ex
How much force is required to push an 11 kg block up the frictionless ramp shown at a constant velocity?



Ex
A 15 kg block sits on an inclined ramp whose coefficient of friction is 0.21. Find the block's acceleration.



Dynamics Notes

6 – Two Objects and Tension

There are a number of common force problems that involve 2 objects, that you will be expected to be able to solve. We will focus on 3 of these.

1) Atwood's Machine: Two masses suspended by a pulley

Diagram: **Include all forces at work on the two masses**.

Both masses have a F_g that pull downwards, but since they are connected by a pulley those forces work in _______________ ___________________.

The masses will accelerate so that the…

Since they are attached by a rope the acceleration of the masses must be

______________________.

Note that there is a force of *TENSION* (T) that exists along the rope. Tension acts the same as all other forces, with two important peculiarities:

1) It is an internal force, acting…

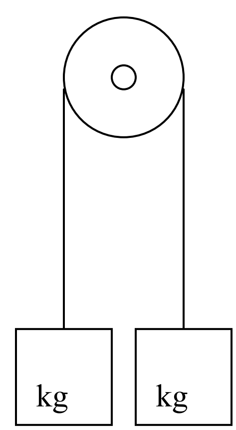
2) It cancels out…

The Strategies:

- When solving these problems it is easiest for us to choose the direction …
- Remember that the acceleration on the two masses...
- It can also be easier to conceptualize this problem if we "unfold" the masses and lay them out in a line, while keeping all of our forces as they are…I know that sounds weird so, here's an example.

Ex

Two masses are suspended from a lightweight rope over a frictionless pulley as shown. What will their acceleration be once released?



NOTE: When calculating the acceleration we use the ______________ because the F_{net} is accelerating the entire system (both masses)!

Alright that wasn't too hard, but can you find the tension in the rope?

If we use the same force diagrams and equations as before we hit a snag. The two tension forces ______________ !!!

This is because tension is an___________ ____________.

In order to solve for tension we have to consider…

Strategy: To solve for tension chop your diagram in half and only consider one of the masses. Either one is fine because…

Ex - Find the tension in the rope in the preceding example.

Note: When finding the tension we are only considering half of the equation therefore we only use ___________.

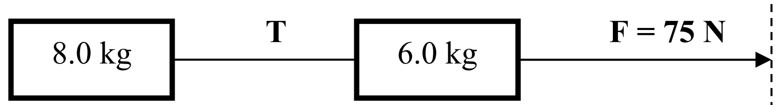
2) Multiple Horizontal Masses: Attached by a cord

Ex

Consider the masses shown. If $\mu = 0.25$ for both blocks, find:

a. the acceleration of the entire system

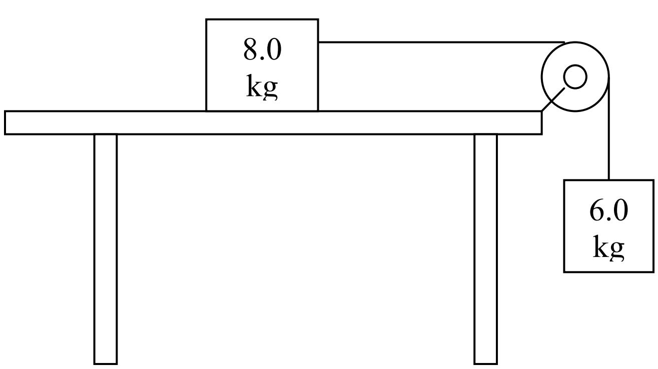
b. the tension T in the rope between the blocks.



3) The Hanging Mass: One mass hanging, one horizontal

Ex

Consider the two masses shown. Find their acceleration and the tension in the rope.



Dynamic Notes

7 – Two Objects and Inclines

Because one tricky concept is never enough, I give you… **Two Objects AND an Incline**

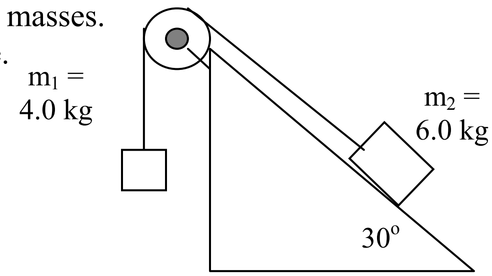
Ex

Two forces are attached by a rope over a frictionless pulley as shown.

(Assume the incline is frictionless) Determine:

a. The acceleration of the masses.

b. The tension in the rope.



Problem: What direction will they accelerate?

In earlier pulley problems it was obvious, the bigger mass always wins. When an inclined plane is involved this is not always the case because for the mass on an incline only...

So determine the forces on each one separately and see which one is the winner.

Force 1 =_________ | Force 2 = _________

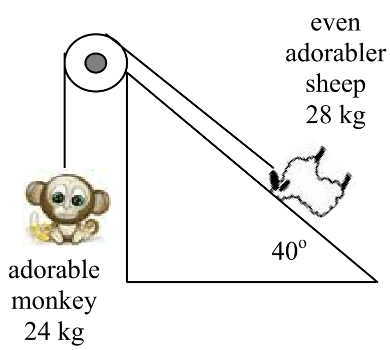
Ex

In the name of physics, a monkey is attached to a sleeping sheep on a ramp. Don't ask why.

As we all know, the coefficient of friction for a sleeping sheep on a ramp is precisely 0.15. Determine:

a. The acceleration of the system.

b. The tension in the rope.



Strategies:

1. Find the forces acting on the two bodies separately to determine a winner
2. Determine the friction on the sheep. Friction can work **either** up or down the ramp, because it **always** opposes motion, so we don't know which direction it is acting until we know the winner.
3. Based on the winner find the acceleration using m_{total}
4. Choose either body and examine it separately to determine the tension in the rope

Name:

Physics 11
M.

WS#3 More Vectors

Block:

1. Determine the horizontal and vertical components of the following vectors.
   a) 1.5 m 22° south of east
   b) 180 km/h 40° east of north
   c) 9.00 x 10^4 kg m/s 6.00° north of west
   d) 0.40 N 33° west of south

2. Add the following displacement vectors. Be sure to determine both the magnitude and direction of the resultant vector.
   a) 0.50 m south; 1.20 m north
   b) 19 m west; 19 m south
   c) 9.0 km north; 3.4 km 25° east of south
   d) 145 m south; 82 m west
   e) 1500 km 40° east of north; 2700 km south
   f) 984 m 35.0° north of east; 424 m 10.0° north of east

3. A duck is initially swimming at a velocity of 20.0 cm/s to the east. It is later seen swimming at a velocity of 20.0 cm/s to the south. What is the duck's change in velocity?

4. Katelyn drives down an 15° incline (measured above the horizontal). If she has descended 20.0 m vertically, how far has she driven along the incline?

5. Bob is swimming to the east across a river. If he swims at a speed of 2.6 m/s with respect to the water and there is a current to the south with a speed of 1.4 m/s, what is his velocity as seen by someone on the shore?

6. A stationary dog owner is watching his dog run in a park. The dog is first seen 25 m north. The dog is later seen 12 m 25° north of west. What is the displacement of the dog?

7. A plane is flying with a velocity of 190 km/h east with respect to the air. An observer on the ground sees the plane moving at a velocity of 210 km/h 10.0° north of east. What is the velocity of the wind?

8. Alex and Ryan are on opposite sides of a river. If Alex must swim directly east to reach his friend, what direction should he aim if he can swim at a speed of 2.5 m/s in still water and the current is 1.2 m/s to the north?

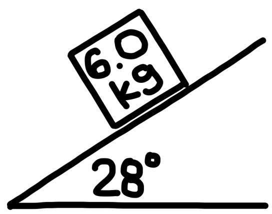
Name:

Physics 11

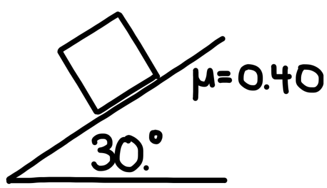
WS 4/5 - Forces at Angles

Block:

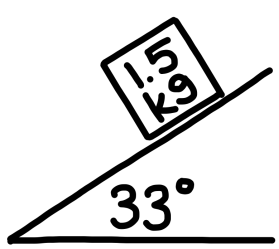
1. An 6.0 kg object is on a frictionless ramp as shown. What is the acceleration of the object?



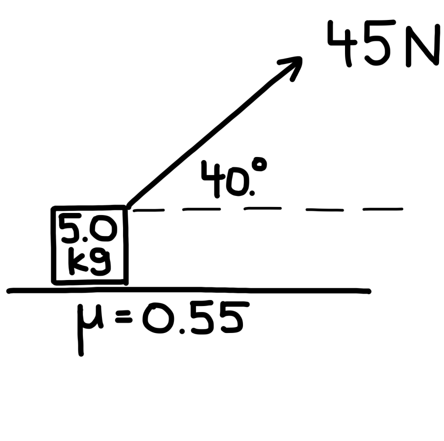
2. An object is on a ramp with a shown. If the coefficient of friction is 0.40, what is the acceleration of the object?



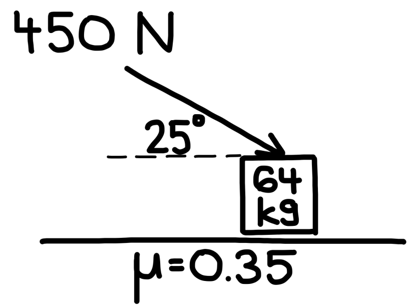
3. A 1.5 kg object is on a ramp as shown. If the object accelerates down the ramp at 3.0 m/s^2, what is the coefficient of friction between the object and the surface of the ramp?



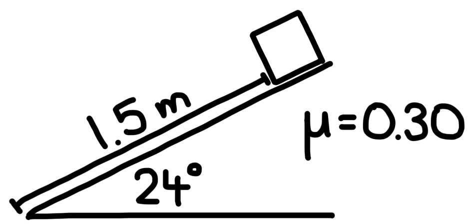
4. A 45 N force is applied to a 5.0 kg object as shown. If the coefficient of friction is 0.55, what is the acceleration of the object?



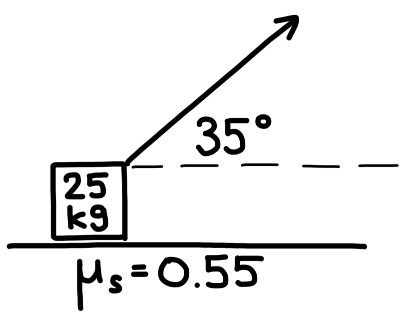
5. A 450 N force is applied to a 64 kg object as shown. If the coefficient of friction is 0.35, what is the acceleration of the object?



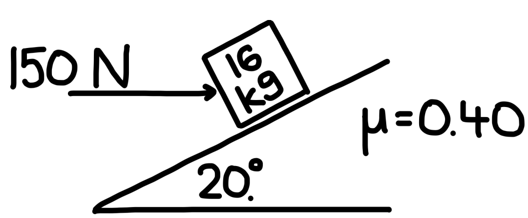
6. An object begins sliding down a ramp. If the object was initially at rest 1.5 m from the base of the ramp and the coefficient of friction is 0.30, how long does it take for the object to reach the bottom of the ramp?



7. The coefficient of static friction between a 25 kg object and a surface is 0.55. Determine the minimum force needed to move the object from rest if the force is applied at an angle of 35° above the horizontal.



8. A 16 kg object is pushed up a ramp with a 150 N force applied parallel to the ground as shown. If the coefficient of friction is 0.40, what is the acceleration of the object?



Name:

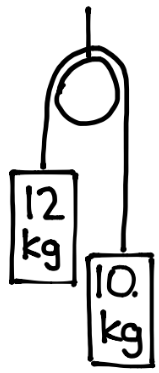
Physics 11

WS 6 - Multi-Body Systems

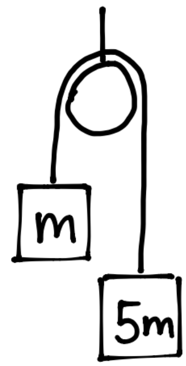
Block:

1. Determine the acceleration of the system and the tension of each rope.

a.



b.



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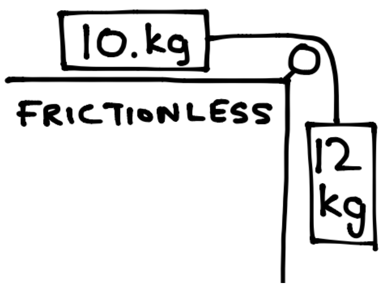

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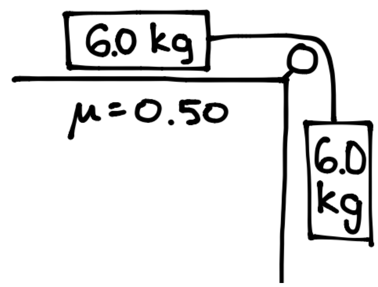
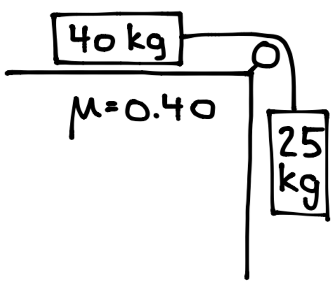
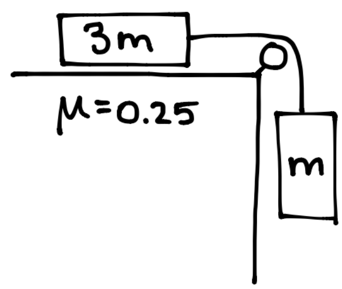


e.



f.



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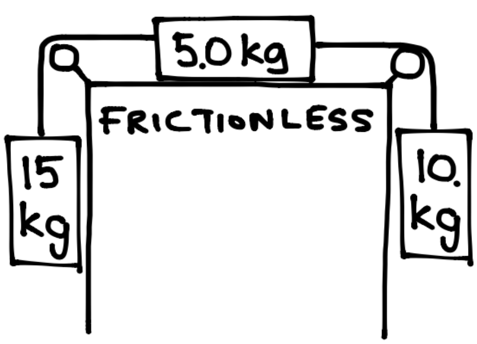
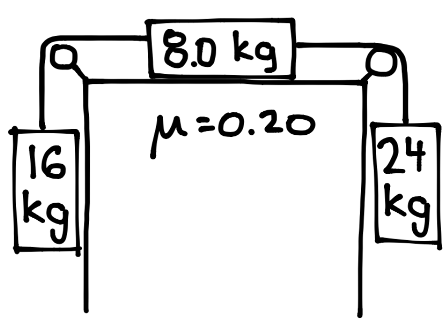
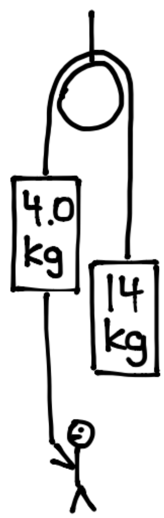


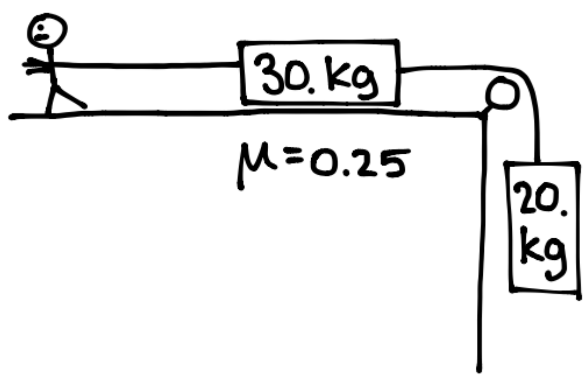
h.



2. The man pulls on a rope attached the 4.0 mass. What minimum force must he exert so the 14 kg mass does not hit his head? What would be the tension in the rope connecting the two masses?



3. The man pulls on a rope attached to 30. kg mass. If he exerts a force of 500. N, determine the acceleration of the system and the tension in the rope connecting the two masses.



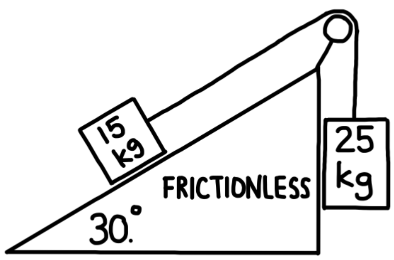
Name:

Physics 11

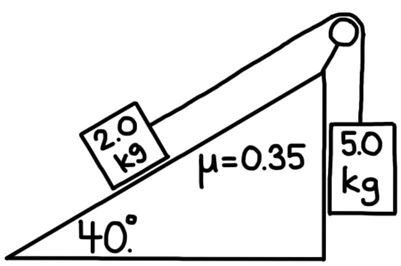
Block:

WS 7 - Multi-Body Systems II

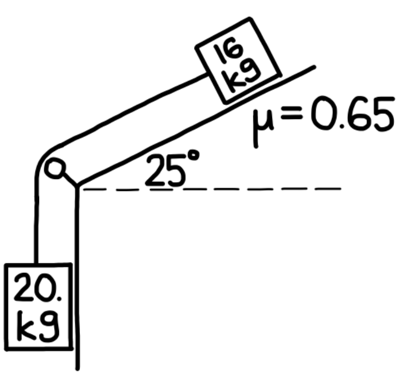
1. Determine the acceleration of the system and the tension of the rope.



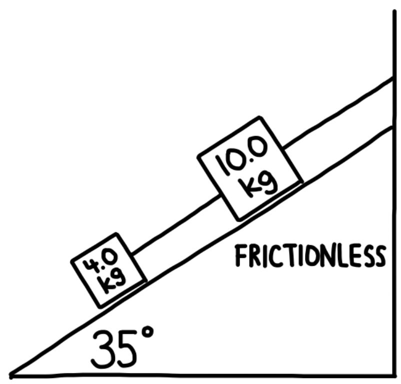
2. Determine the acceleration of the system and the tension of the rope.



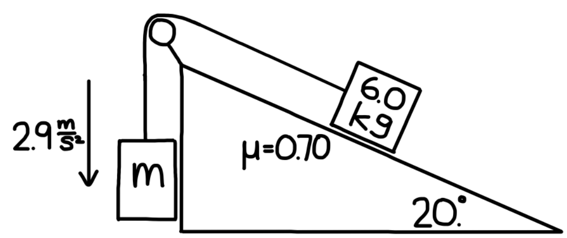
3. Determine the acceleration of the system and the tension of the rope.



4. Two masses on a 35° frictionless incline are connected together by a cord. The 10.0 kg mass is connected to a wall. Determine the tension in each cord.



5. The system below is accelerating at 2.9 m/s^2 as shown. Determine the mass *m*.



6. Three objects of equal mass are connected as shown. Determine the acceleration of the system.