**Dynamics Notes**

1 – Newton’s Laws

Newton’s 3rd Law:

For every…

As a formula:

Newton’s 2nd Law:

As a formula:

Newton’s 1st Law:

An object…

and an object…

unless…

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

1. Represent the object as a box and,
2. Represent all forces as arrows
* The arrows are vectors so their direction is critical
* Start in the center and draw outwards
* The size of the arrow represents the magnitude of the force

3. A block of wood slides down an incline

1. A puck slides along frictionless ice.

2. A dragster accelerates from rest.

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

Ex. A 1200kg car accelerates at 5.85 m/s2. If the coefficient of friction acting on the car is roughly 0.24, how much force does the engine exert?

Ex: A boy pulls his 8.0 kg toboggan by a rope that angles 32o 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/s2? Assume that friction is negligible.

Ex: 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?

Ex: Two blocks (m1 = 2.0 kg and m2 = 3.0 kg) are connected by a rope as shown. m1 is pulled to the right with a force of 18 N along a frictionless surface. What is the tension in the rope connecting the two masses?

Ex: A 65 kg student stands on a bathroom scale in an elevator and notices that it reads 520 N.
Determine the magnitude and direction of the acceleration of the elevator.

m1

m2

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2 – 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 and determine the total net force.

F2 = 45 N

50o

F1 = 35 N

20o

F3 = 65 N

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3 – Inclines

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

A ball sitting on a level surface will not roll because the forces on it are balanced (Fnet = 0).

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

**FN is always…**

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

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

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

Ex

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

35o

58o

40o

**Dynamics Notes**

4 – 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.

**Atwood’s Machine**: Two masses suspended by a pulley

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

Both masses have a Fg 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

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

**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.

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…

Ex

Two masses are suspended from a lightweight rope over a frictionless pulley as shown.

What will their acceleration be once released?

8.0kg

5.0 kg

**NOTE:** When calculating the acceleration we use the \_\_\_\_\_\_\_\_\_\_\_\_\_ because the Fnet is accelerating the entire system (both masses)!

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

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…

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

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 \_\_\_\_\_\_\_\_\_\_\_.

**The Hanging Mass:** One mass hanging, one horizontal

Ex: (Frictionless system)

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

8.0 kg

6.0 kg

Because one tricky concept is never enough, I give you…

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...

m2 = 6.0 kg

m1 =

4.0 kg

30o

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.

even more adorable sheep

28 kg

adorable monkey

24 kg

40o

**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 mtotal
4. Choose either body and examine it separately to determine the tension in the rope