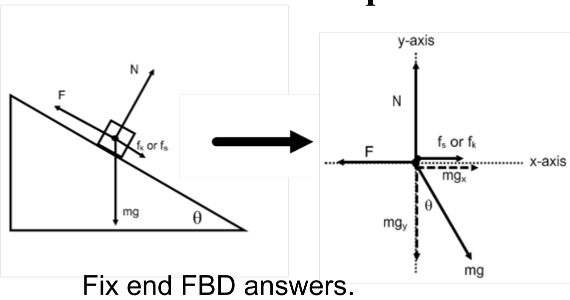
4.4 – Free-Body Diagrams & Translational Equilibrium



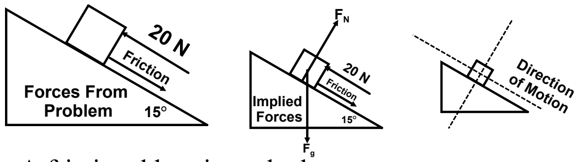
Fix end FBD answers.

Must reveal FBD's secret: Normal force is the one that has x and y components, not gravity.

FBD - Review

1. Make a sketch with all forces shown.

(1.b) If the object is on an incline, rotate your sketch so the direction of motion becomes the x-axis.

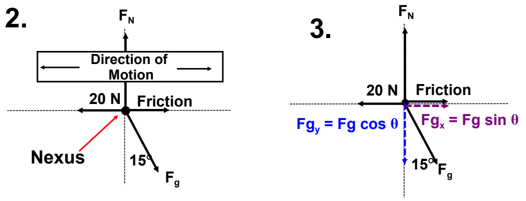


A frictional box is pushed up a 15° slope at constant velocity with a force of 20 N.

FBD - Review

2. Redraw oriented force vectors (with angles) on Cartesian axes with the 'Nexus' at the origin.

3. Decompose all forces not directed along the x or y-axis into x and y components.

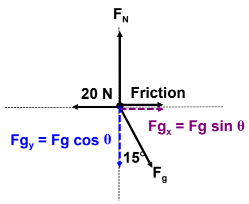


FBD Repercussions

The utility of FBDs is realized when comparing x and y forces separately.

Consider the nexus as an equal sign if forces balance **(constant velocity).**

From the review example:



x-axis:

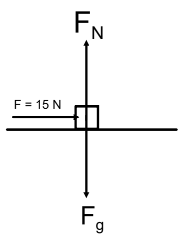
$$20\text{ N} = F_{friction} + F_{gx} = F_{friction} + F_g \sin\theta$$

y-axis:

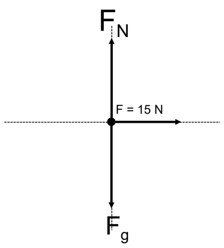
$$F_N = F_{gy} = F_g \cos\theta$$

1. FBD Example A

Make a sketch and FBD:
A frictionless box is pushed along a horizontal surface with a force of 15 N. Do we rotate the FBD?



Sketch

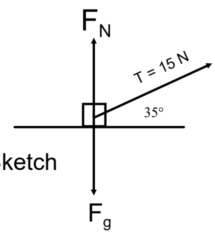


FBD

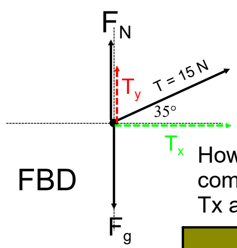
2. FBD Example B

Sketch and FBD the following: A frictionless box is pulled with a force of 15 N at a 35° angle along a horizontal surface. Does the FBD rotate?

Your FBD needs a decomposed tension vector.



Sketch

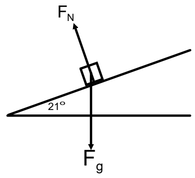


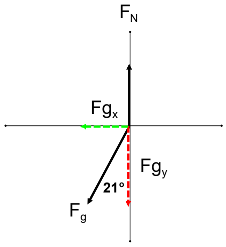
FBD

How to compute Tx and Ty?

3. Acceleration Example

A 14.0 kg frictionless box is released on a 21° slope. Determine the acceleration of the box.
Sketch and FBD first. Does the FBD rotate?
Show decomposed vectors.

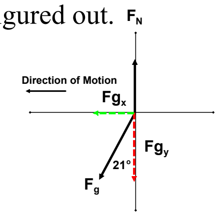




Example 3: Acceleration

Find acceleration using F = ma, once the force acting along the direction of motion is figured out.

The only force acting in the direction of motion is the x component of gravity.



Decompose that, apply it to F = ma, and you're done.

Example 3: Acceleration

Force:

$$F_x = m \bullet g \bullet \sin\theta$$

$$F_x = 14.0\,kg \bullet 9.81\,m/s^2 \sin 21^\circ = 49.2\,N$$

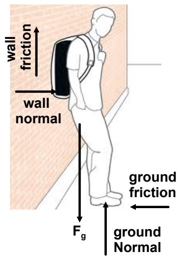
Acceleration: $a = \frac{F}{m} = \frac{49.2\,N}{14.0\,kg} = 3.52\,m/s^2$

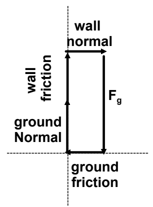
Translational Equilibrium (TE)

A vector sum of forces equaling zero: no acceleration!

If vectors emanating from the nexus of a system in TE are drawn to scale, they return to the original point when connected tip-to-tail.

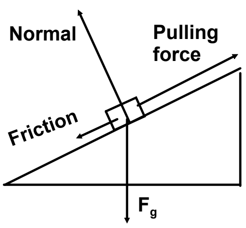
4. Draw a tip-to tail vector map of the dude leaning against the wall using the shown forces.

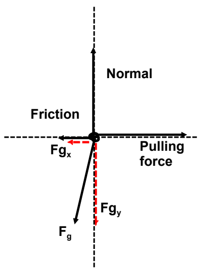




5. FBD Practice A

Make an FBD of this sketch, showing all forces. Decompose forces not in alignment with the direction of travel.

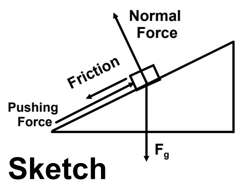




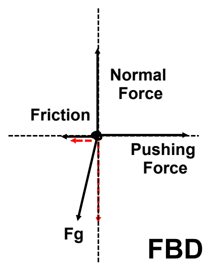
Which forces oppose each other?
On x-axis: The pulling force opposes friction and F_{gx}.
On y-Axis: The normal force opposes F_{gy}.

6. FBD Practice B

A box is pushed up an incline with friction. Sketch ALL the forces, then make an FBD of the situation.



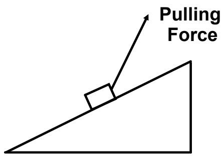
Sketch

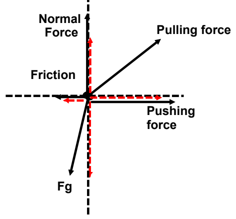


FBD

7. FBD Practice C

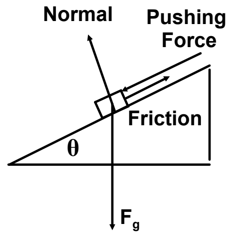
A box is pulled up an incline, at the angle shown. There is friction opposing the motion of the block. Sketch in the forces, then make an FBD, being sure to decompose vectors not in alignment with the direction of travel.

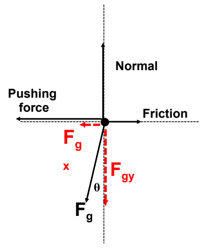




8. FBD Practice D

Make an FBD of this sketch, showing all forces.

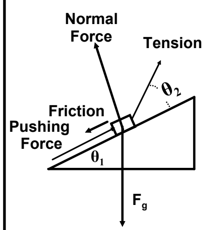


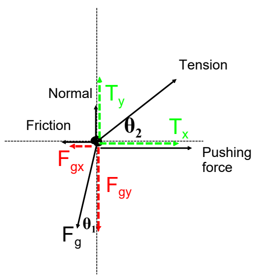


Which forces oppose each other?
On x-axis: The pushing force plus F_{gx} opposes friction.
On y-Axis: The normal force opposes F_{gy}.

9. FBD Practice E

Make an FBD of this sketch, showing all forces.





Which forces oppose each other?
On x-axis: The pushing force and T_x opposes friction and F_{gx}.
On y-Axis: The normal force and T_y opposes F_{gy}.

Homework

Preview 4.5

4.4 Problems in your Booklet
Due: Next Class