THEORY AND EXERCISES ON NORMAL FORCE

BY

M.A. TOLENTINO

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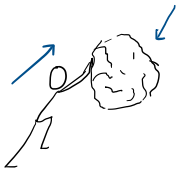
REVISION

Last lesson, we reviewed:

- What a 'force' is (definition)



- Two broad categories of forces

- What a 'field' is (its components)

- What a 'vector' is

- What 'gravitational force' or 'weight force' is

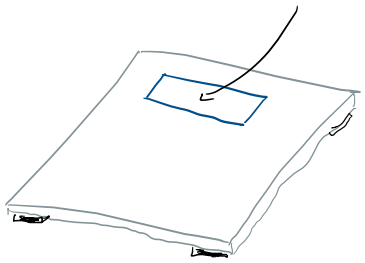
- The weight force equation (magnitude)
  The direction of weight force

$F_{weight} = ?$

- The difference between 'weight' and 'mass'

- Whether a bathroom scale measures weight or mass, and why

weight or mass ?



EXERCISE 1

We can further categorise 'contact forces' in the following manner:

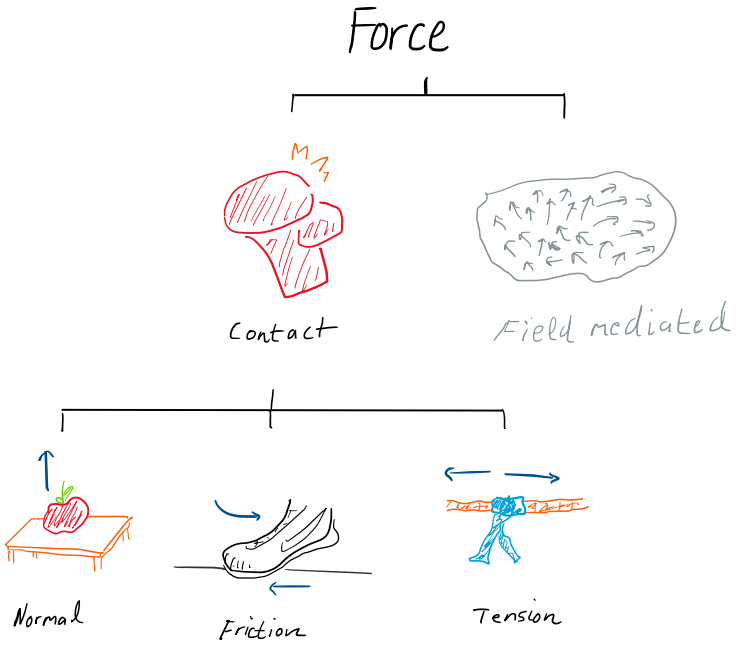


Figure 1. *Types of contact forces*

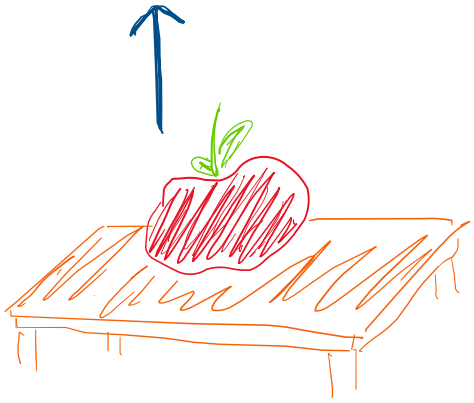
1. Based on the illustrations in Figure 1, can you guess what is meant by,

   A. Normal force?
   B. Friction force?
   C. Tension force?

2. Why do you think that the three aforementioned forces are not categorised as 'field mediated'?

EXERCISE 2

1. A 'normal force' is a type of contact force which is exerted by a surface on an object in contact with it.



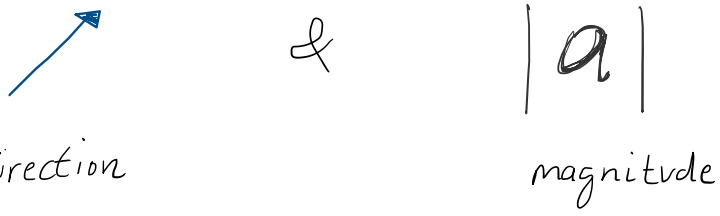
When investigating a force, we are generally investigating a relationship between two objects:

one which exerts the force, and one which is impacted by the force.

A. What kind of object might exert a normal force?

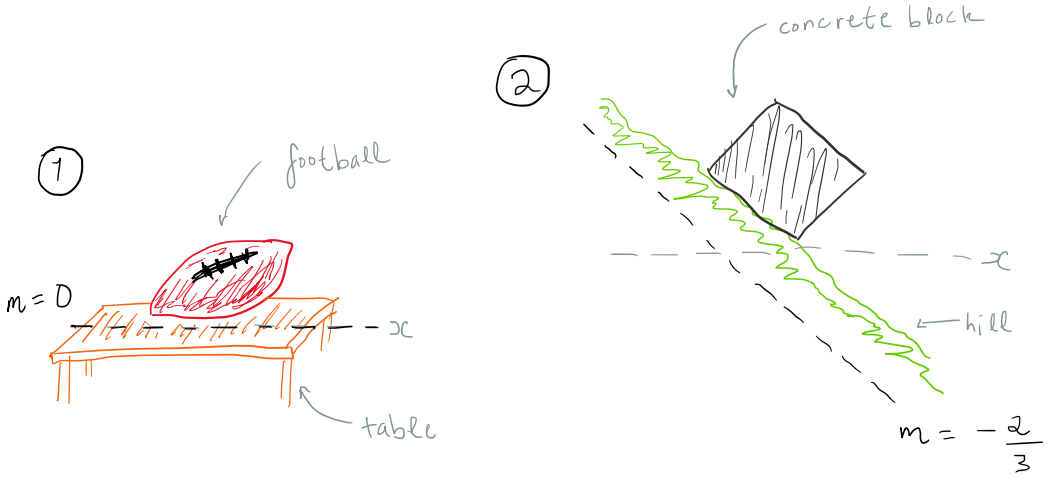
B. What kind of object could be acted upon by a normal force?

2. Because normal force is a vector, we need two things in order to describe it:



3. The direction of the normal force is always *perpendicular* to the slope (m) of the surface exerting it.

   Please consider each scenario below:



A. Please draw an arrow to indicate the direction of the normal force

B. Which object exerts the normal force?

C. Which object is acted upon by the normal force?

D. What is the slope of the arrow pointing in the direction of the normal force?

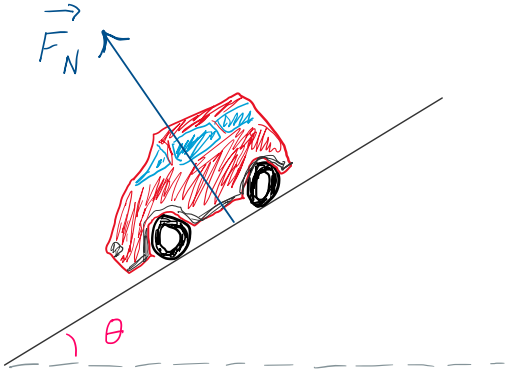
E. In Scenario 2, the hill is inclined at an angle of 135° counterclockwise from the positive x axis.
   What angle does the arrow pointing in the direction of the normal force make, counterclockwise from the positive x axis?

EXERCISE 3

The magnitude (~strength) of a normal force exerted by an inclined surface on an object is given by the following equation:

$$F_N = mg\cos\theta$$

θ: angle of the slope with the horizontal axis



1. What do you think that m and g refer to in the normal force equation?

2. Are there any other equations, which we have previously examined, that also contain mg ?

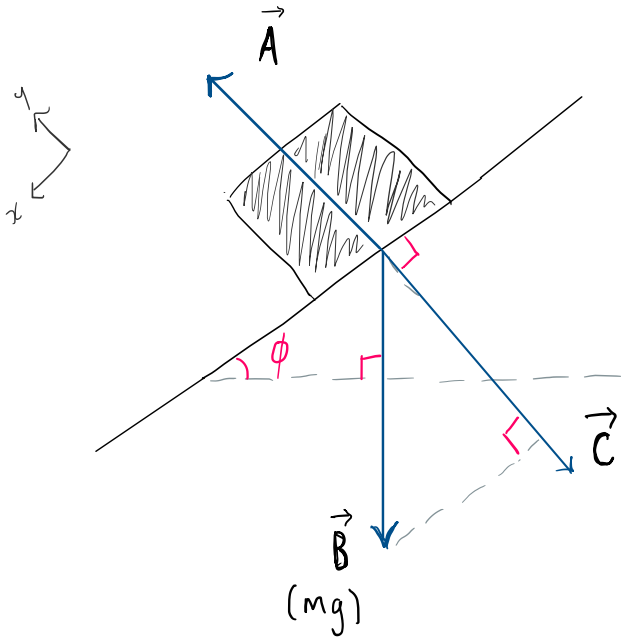
   A. Given your answer to (2), can you describe what we are doing algebraically when we calculate normal force using $F_N = mg\cos\theta$?

3. *Geometrically, why might $\cos\theta$ be present in the normal force equation?

   (see **Exercise 4** for hints)

EXERCISE 4

A concrete block is sitting static on a bitumen ramp.



1. Which object exerts the normal force, and which object is acted upon by the normal force?

2. Of the vectors $\vec{A}$, $\vec{B}$ and $\vec{C}$, which one represents the normal force exerted by the object in your answer to (A), and why?

3. Given that the magnitude of $\vec{B}$ is mg, what force does $\vec{B}$ represent? (recall the force that we investigated last lesson).

4. *Despite being acted upon by the normal force, the concrete block is static – meaning that it is not accelerating upwards or downwards in the y direction.

   An object will be static in the y direction if, you get zero when you add up the magnitude of all of the forces acting on that object in the y direction.

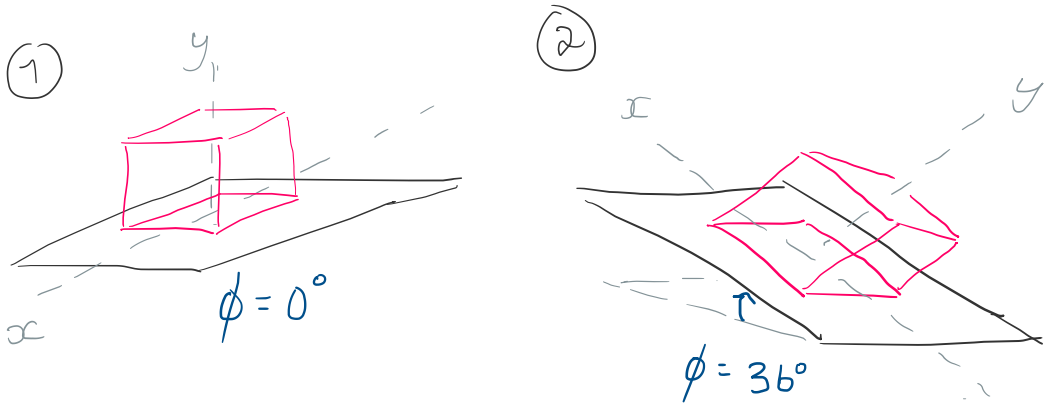
   Given this information, and using the above diagram, why do you think/**can you prove** that $F_N = mg\cos\emptyset$?

EXERCISE 5

The concrete block depicted below has a mass of $47kg$.

- In Scenario 1, the block is sitting static on a horizontally flat platform (on Earth).

- In Scenario 2, the platform has been inclined by the angle shown, and the concrete block remains static.



1. For each scenario,

   A. Please draw an arrow indicating the direction of the normal force.

   B. Please calculate the magnitude of the weight force (F_W) exerted by the concrete block.

      i. Can you draw an arrow to indicate the direction of the weight force?

   C. Please calculate the magnitude of the normal force (F_N) in *Newtons*.

2. Can you draw any general conclusions from your answers to 1.B. and 1.C. for Scenario 1?