THEORY AND EXERCISES ON FRICTION FORCE

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Tolentino Tuition, Year 10 *Physics*

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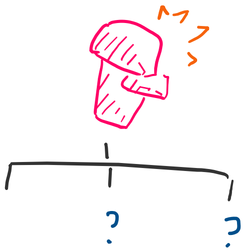
CONTENTS

REVISION

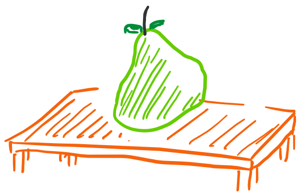
Last lesson, we reviewed:

- Three further ways that we can categorise 'contact forces'

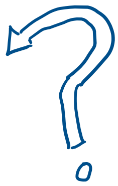


- That 'normal force' ($\overrightarrow{F_N}$) is a type of contact force

- The definition of normal force



- That $\overrightarrow{F_N}$ is a vector:

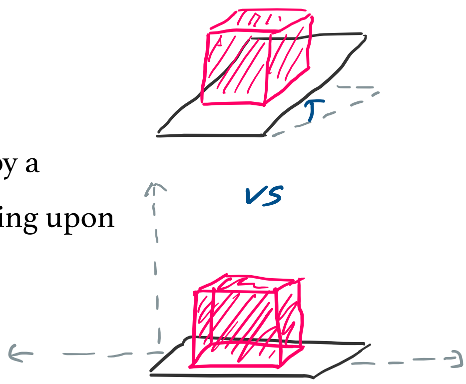


    - The direction of $\overrightarrow{F_N}$

    - The equation giving the magnitude of $\overrightarrow{F_N}$ exerted by an inclined surface on an object

$$\left|\overrightarrow{F_N}\right| =$$

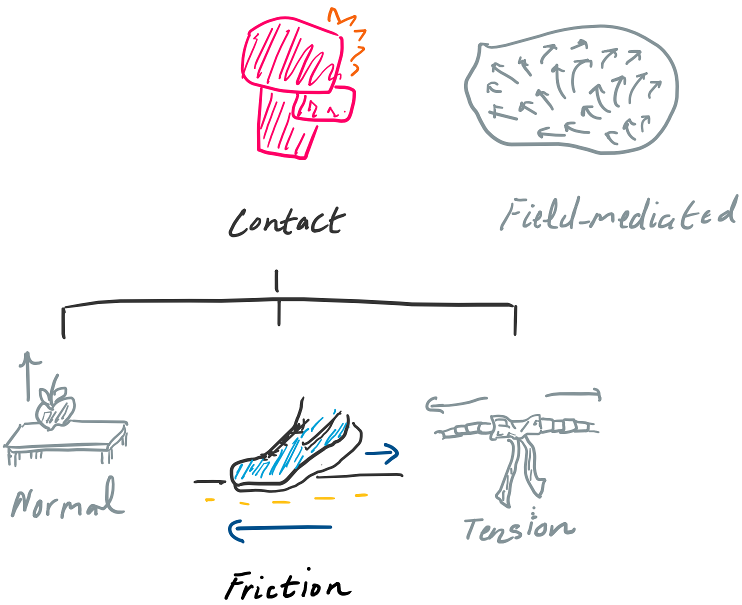
- A geometric intuition/interpretation for the equation giving the magnitude of $\overrightarrow{F_N}$ exerted by an inclined surface on an object



- What the magnitude of $\overrightarrow{F_N}$ is, when exerted by a horizontally flat surface on a static object sitting upon it

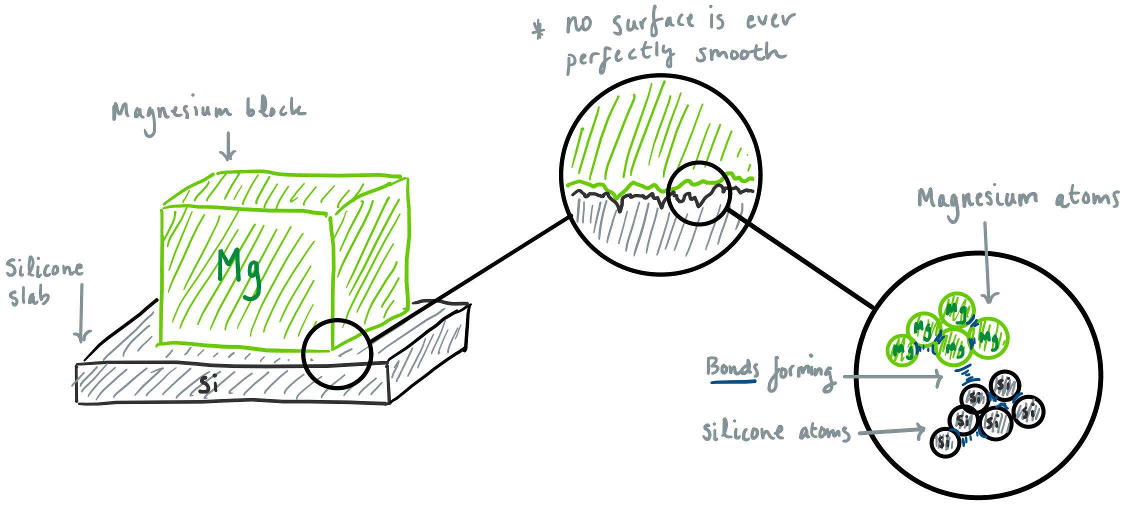
EXERCISE 1

A second category of 'contact force' is 'friction force':



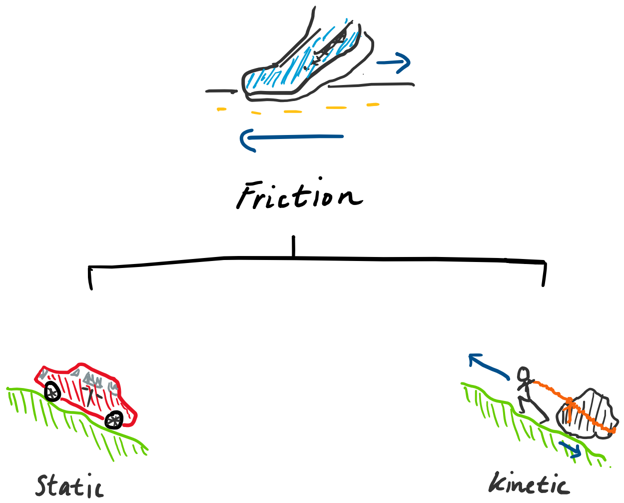
1. Friction is a force that *resists* or *opposes* the sliding or rolling of one solid object over another. Depending on the circumstances, friction between solid objects may be beneficial or detrimental. Can you think of an example of beneficial friction and detrimental friction respectively?

2. Based on the below diagram, (1) why do you think that friction force occurs in nature? (2) Why might friction generate heat?



EXERCISE 2

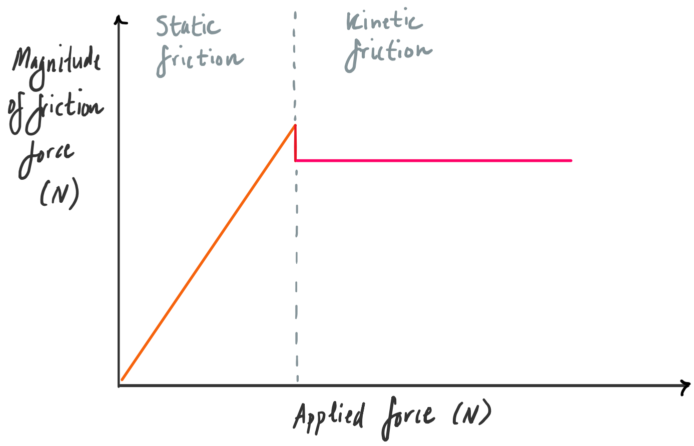
Friction force can be further classified in two ways:



1. What might be the difference between static and kinetic friction?

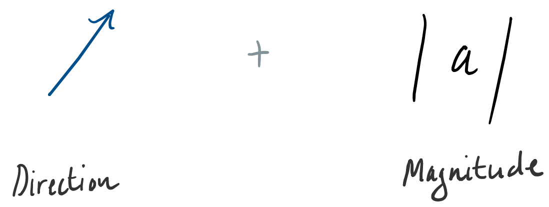
2. For a solid object at rest upon another solid surface object, we say that static friction must be 'overcome' to get the object to move. Once the object has begun moving across the surface, kinetic friction occurs. The strength/magnitude of kinetic friction remains relatively constant and is lower than the magnitude of static friction.

   Can you interpret the below graph with reference to the aforementioned information?



EXERCISE 3

As static and kinetic friction are 'contact forces' and hence vectors, to describe them we need to specify a



1. We can indicate the direction of static and kinetic friction using an arrow that is parallel to the solid objects/surfaces in contact.

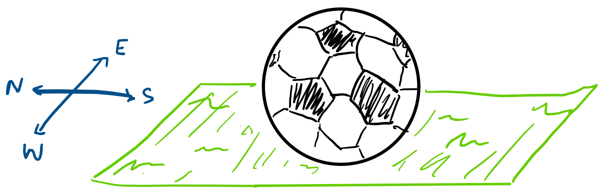


Figure 1

The ball sitting on the grass above is static, and a breeze is blowing east at $1.18\ N$.

A. Is friction force present in Figure 1, and if so, is it static or kinetic, and why?

B. Based on your answer to (A), please draw an arrow to indicate the direction of the friction force in Figure 1.

C. Can you infer a general way in which we would describe the direction of a static friction vector and a kinetic friction vector respectively?

D. *What might be the magnitude of the friction force depicted in Figure 1, and why?

EXERCISE 4

The *magnitude* of the friction force exerted by a surface on a solid object is related to the *normal* force acting on the solid object.

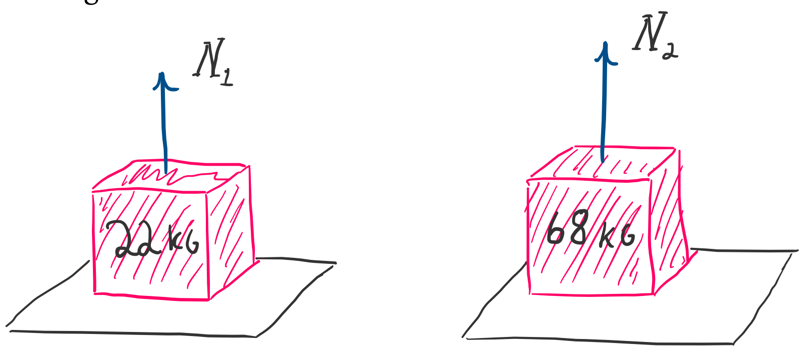
The *magnitude* of friction force is given by the following equation:

$$f = \mu N$$

magnitude of Normal force

'mu', the coefficient of friction

The normal force (N) dictates how strongly two surfaces are pressed together:



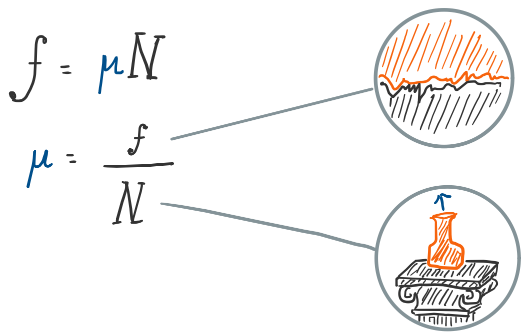
A. Given that the two boxes above are both sitting static on a horizontally flat platform, please calculate N_1 and N_2

B. Given your answers to (A), why might normal force dictate how strongly two surfaces are pressed together?

C. Given your answer to (B) and referring to the diagram from **Exercise 1 Question 2,** why might the magnitude of the normal force exerted by a surface on an object be directly proportional to the magnitude of the friction force exerted by the surface on that same object?

EXERCISE 5

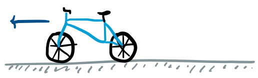
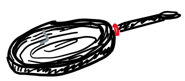
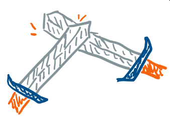
The coefficient of friction (μ) represents the *ratio* of the force of friction between two solid objects to the normal force that presses them together.



1. Given that $\mu = \frac{f}{N}$, please interpret the meaning of

   A. $\mu \approx 0$
   B. $\mu \approx 1$
   C. $\mu > 1$
   D. $\mu = 0$ (is this possible theoretically/practically?)

2. Please match the following surface interactions with the appropriate friction coefficient(s) and justify your answers. (if μ_s is the static friction coefficient, what might μ_k represent?)

A. Rubber on dry concrete 	$\mu_k \approx 0.04$
B. Teflon on steel (*Teflon is used on non-stick pans*) 	$\mu_s \approx 0.74,\ \mu_k \approx 0.57$
C. Steel on steel (dry) 	$\mu_k \approx 0.4$
D. Glass on glass 	$\mu_s \approx 1.0,\ \mu_k \approx 0.8$