Class 12 - Force and Motion II

Chapter 6 - Monday September 19th

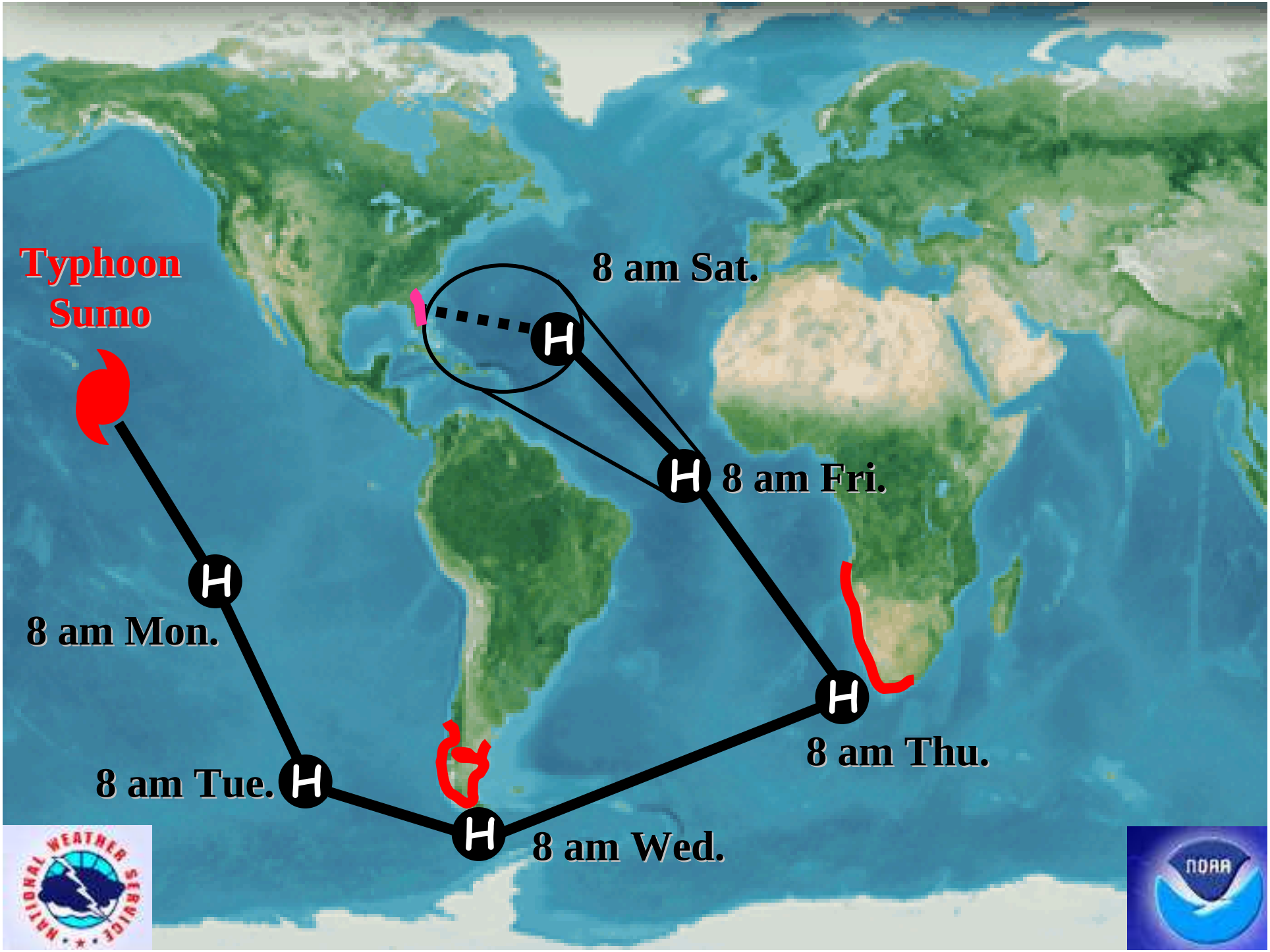
- Review
- Chapter 5 sample problems
- Friction
- Sample problems

Reading: pages 116 thru 122 (chapter 6) in HRW

Read and understand the sample problems

Assigned problems from chapter 6:

8, 18, 20, 28, 30, 32, 40, 50, 52, 68, 84, 102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Review

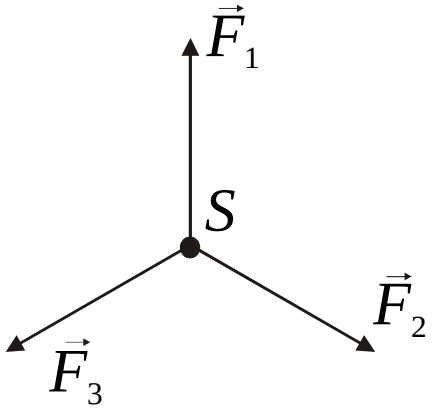
Newton's 1st law: If no force acts on a body, then the body's velocity cannot change; that is, it cannot accelerate.

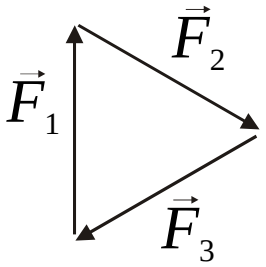
1 Newton is that force required to accelerate our standardized mass (1 Kg) at a rate of 1 $m.s^{-2}$.

Mass is simply the characteristic of a body that relates a force on the body to the resulting acceleration

Newton's 2nd law: $\vec{F}_{net} = m\vec{a}$

Free-body diagrams





$$\sum \vec{F} = 0 = \vec{a}$$

Newton's 3rd law

When two bodies interact, the forces on the bodies from each other are always equal in magnitude and opposite in direction.

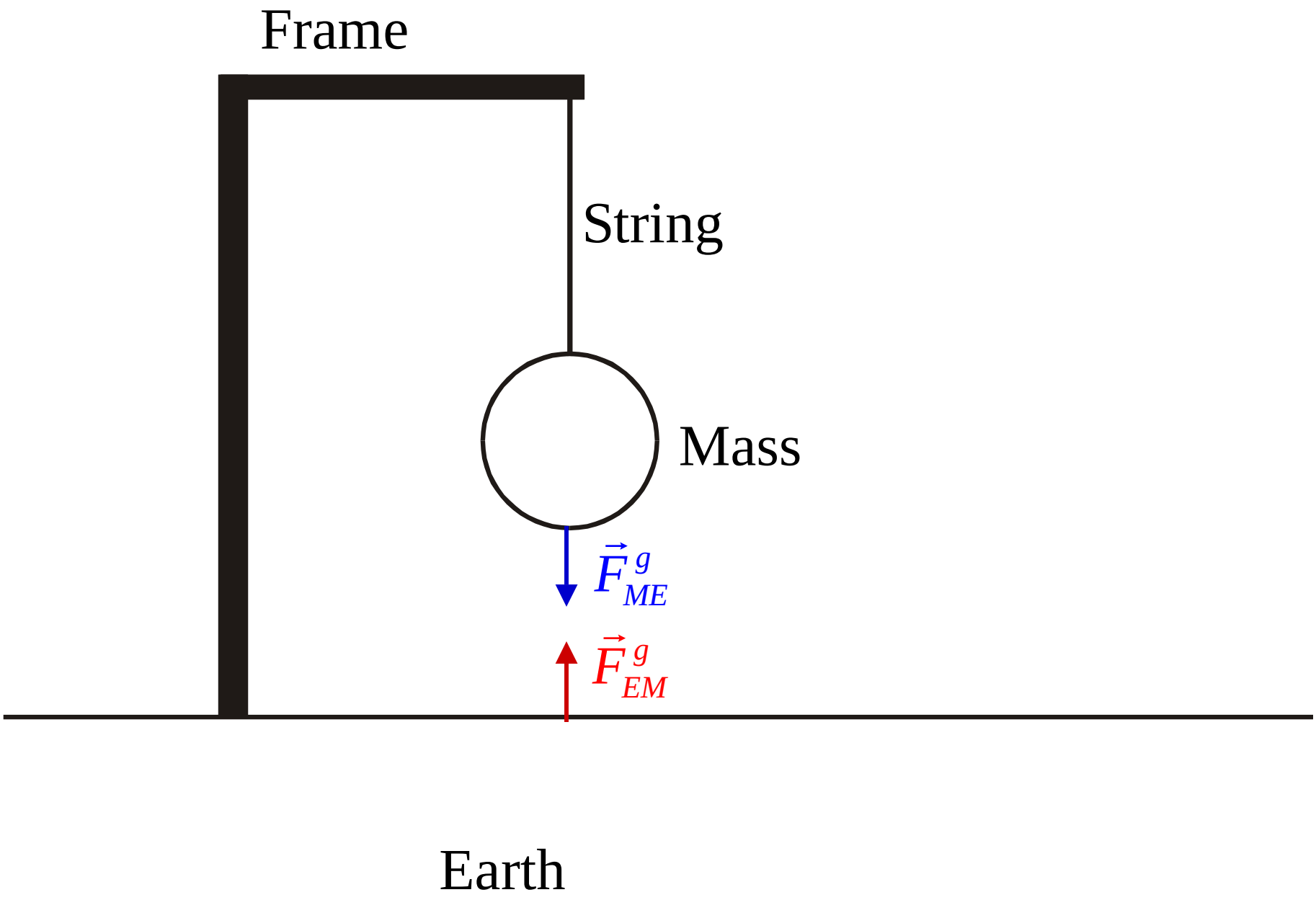
For every **"action"** force, there is always an equal and opposite **"reaction"** force; we call these a **"third-law force pair."**

- When a table supports an object against the force of gravity, the internal forces within the table supply an upward **normal force**, which is **normal to the surface**.

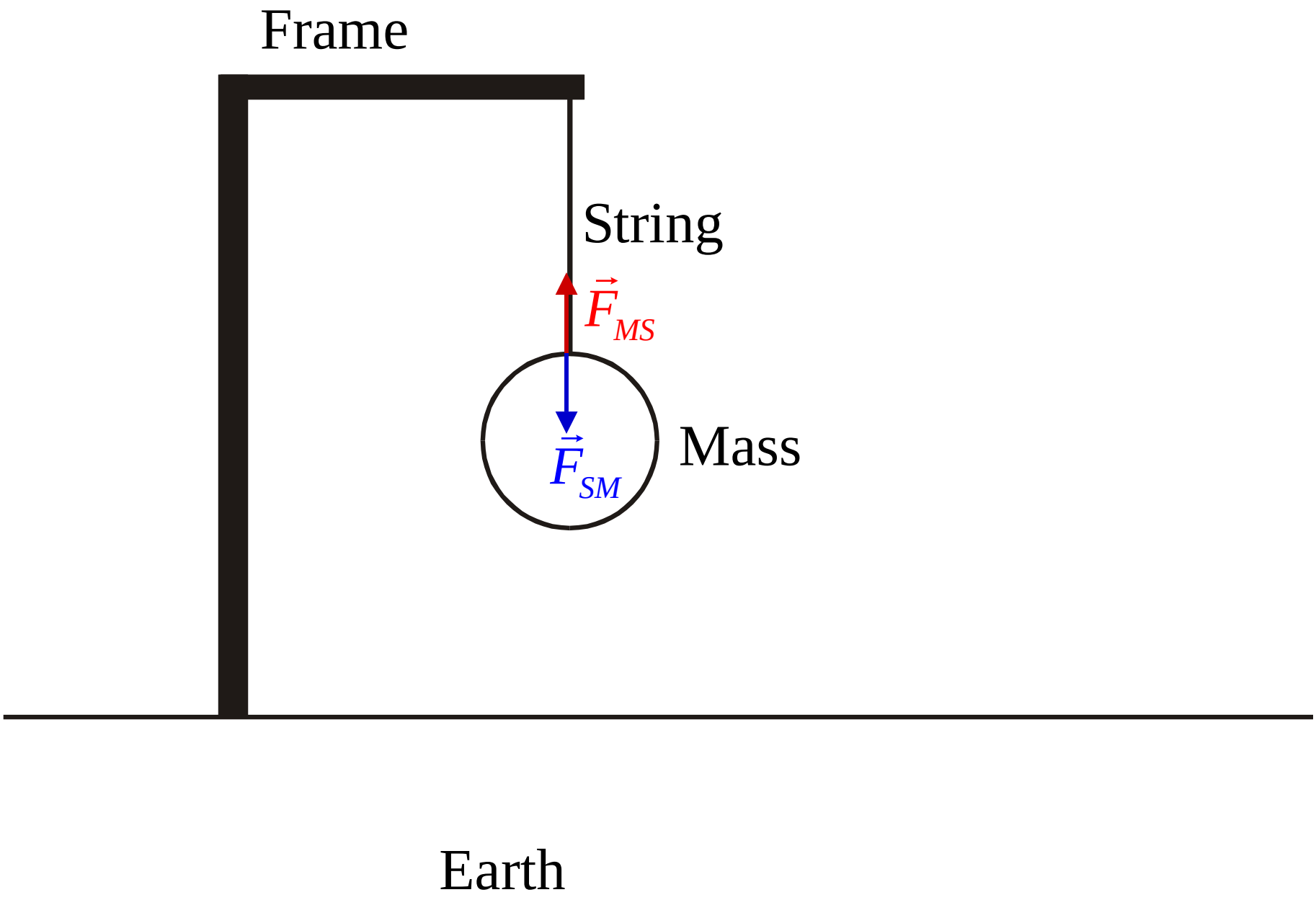
- If we hold the mass in a stationary state, we must supply the normal force. This is the sensation of weight, i.e.

$$W = F_g = mg \text{ Newtons}$$

Newton's 3rd law and force pairs



Newton's 3rd law and force pairs



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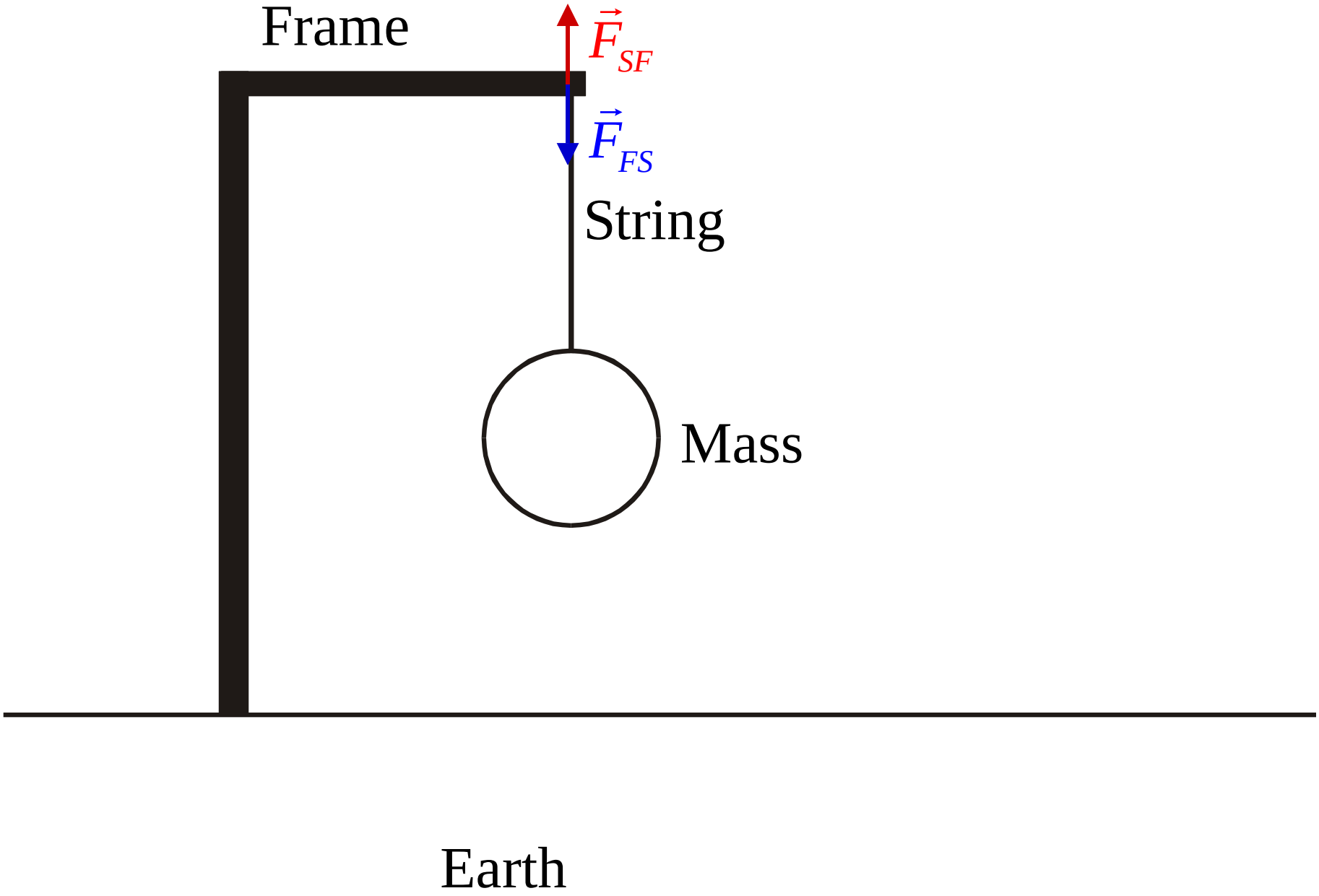

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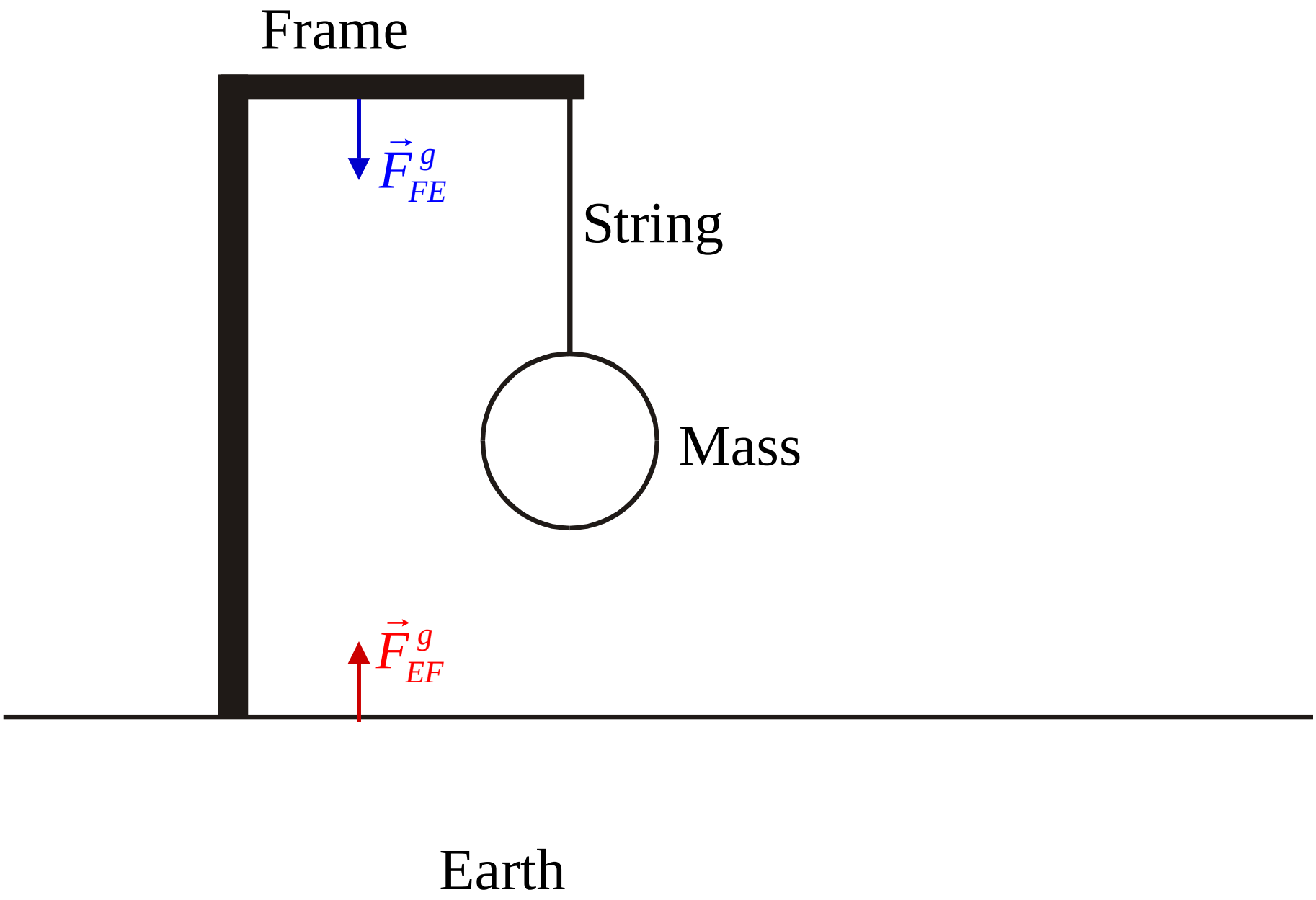
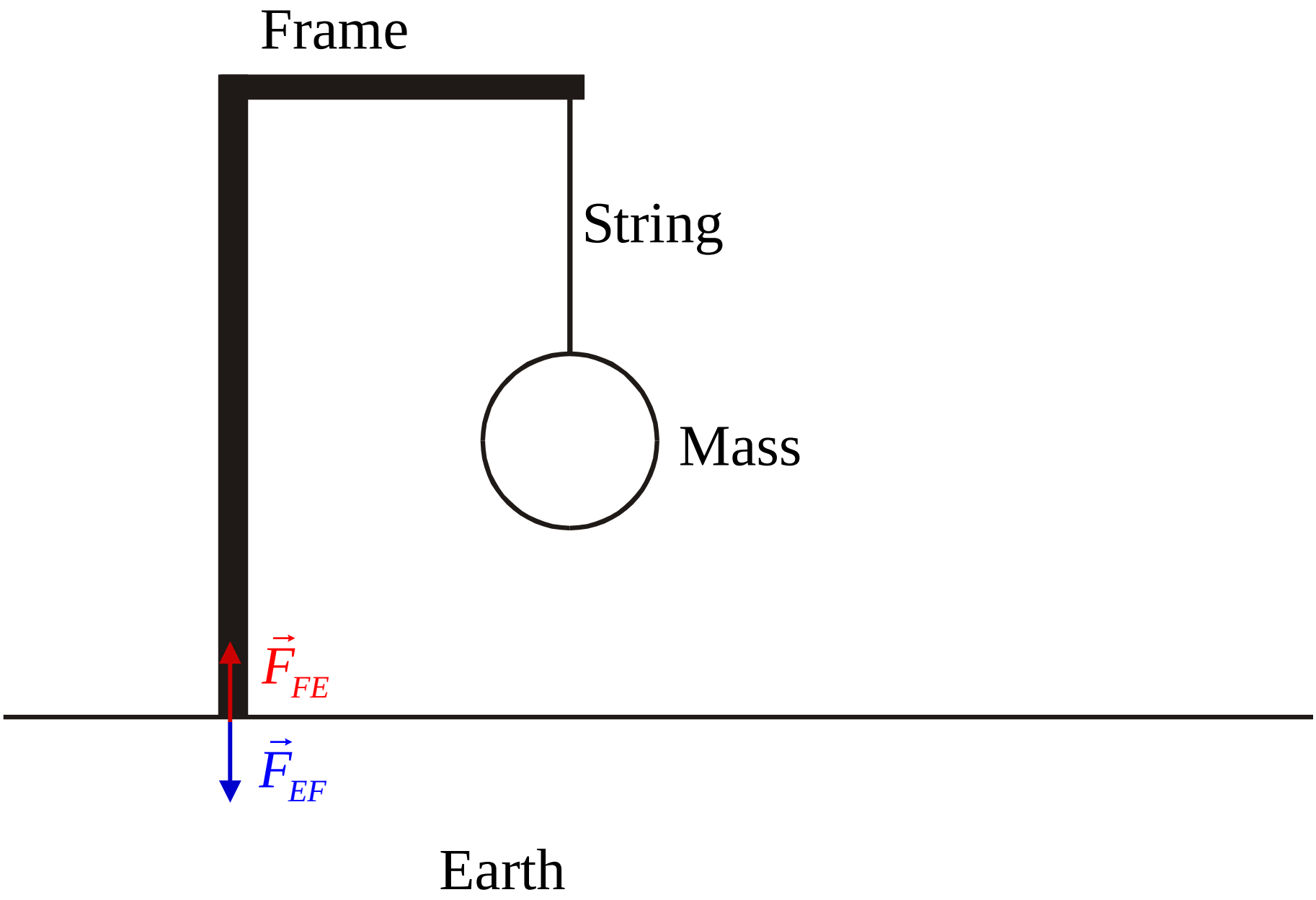


Newton's 3rd law and force pairs



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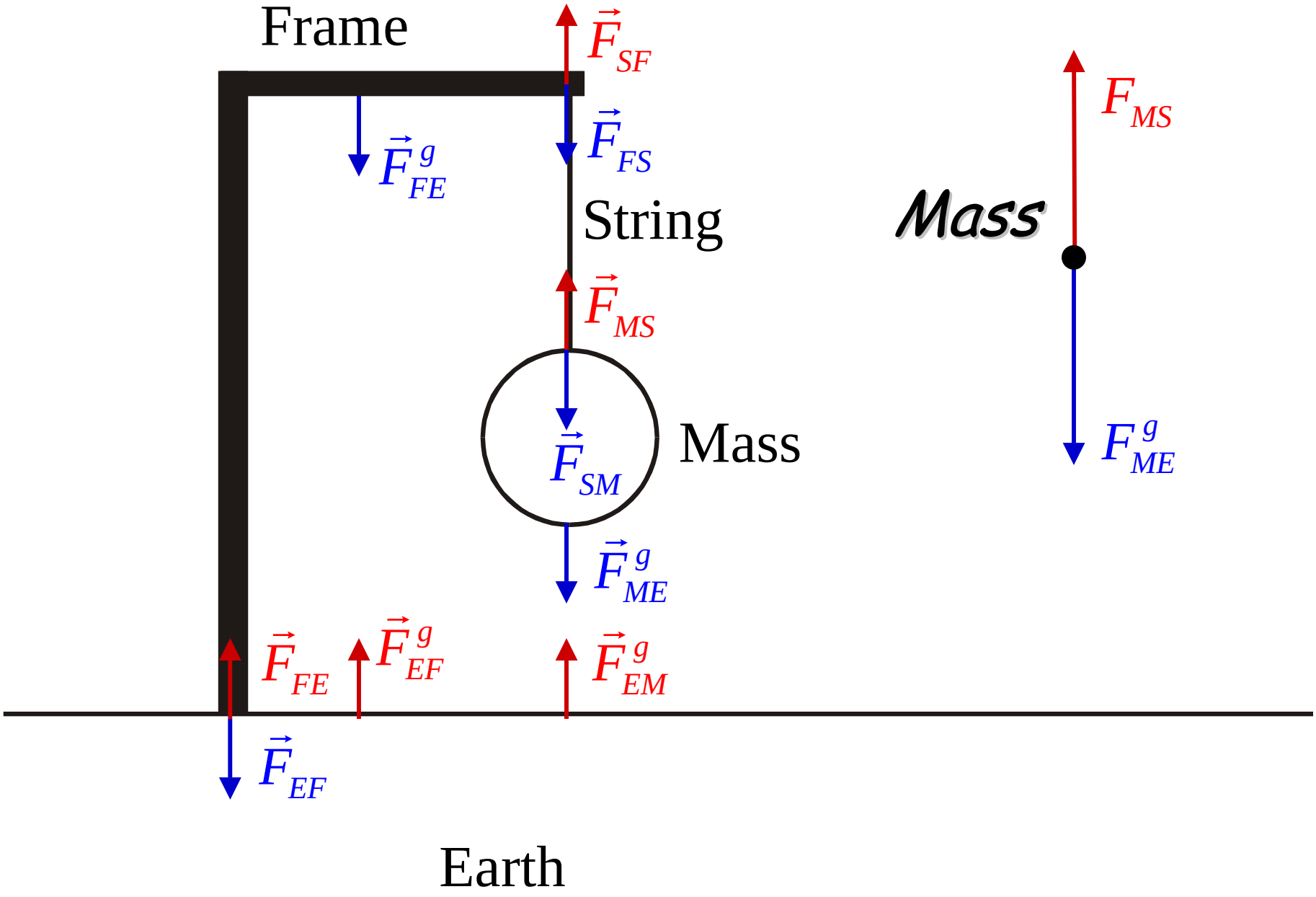
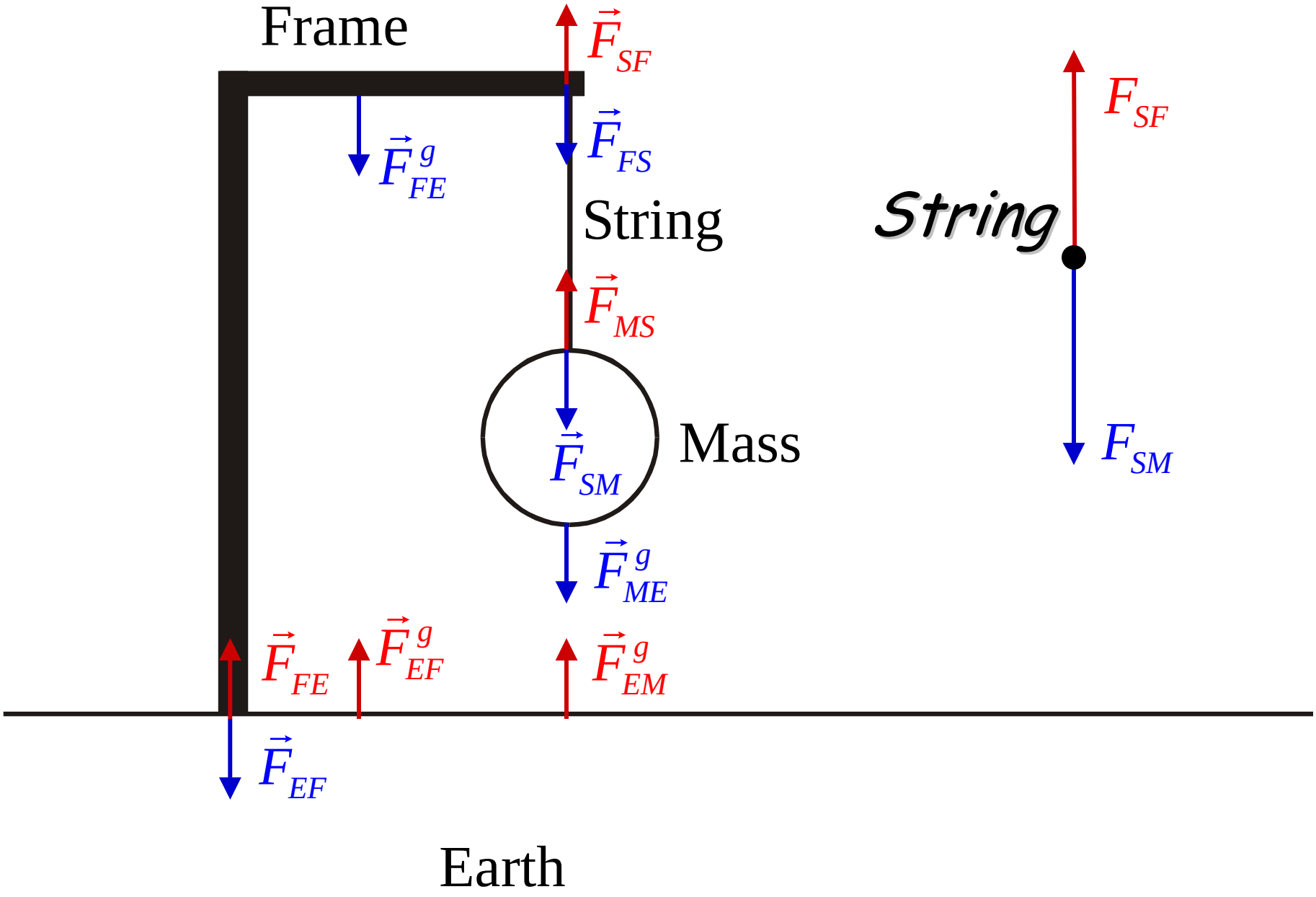
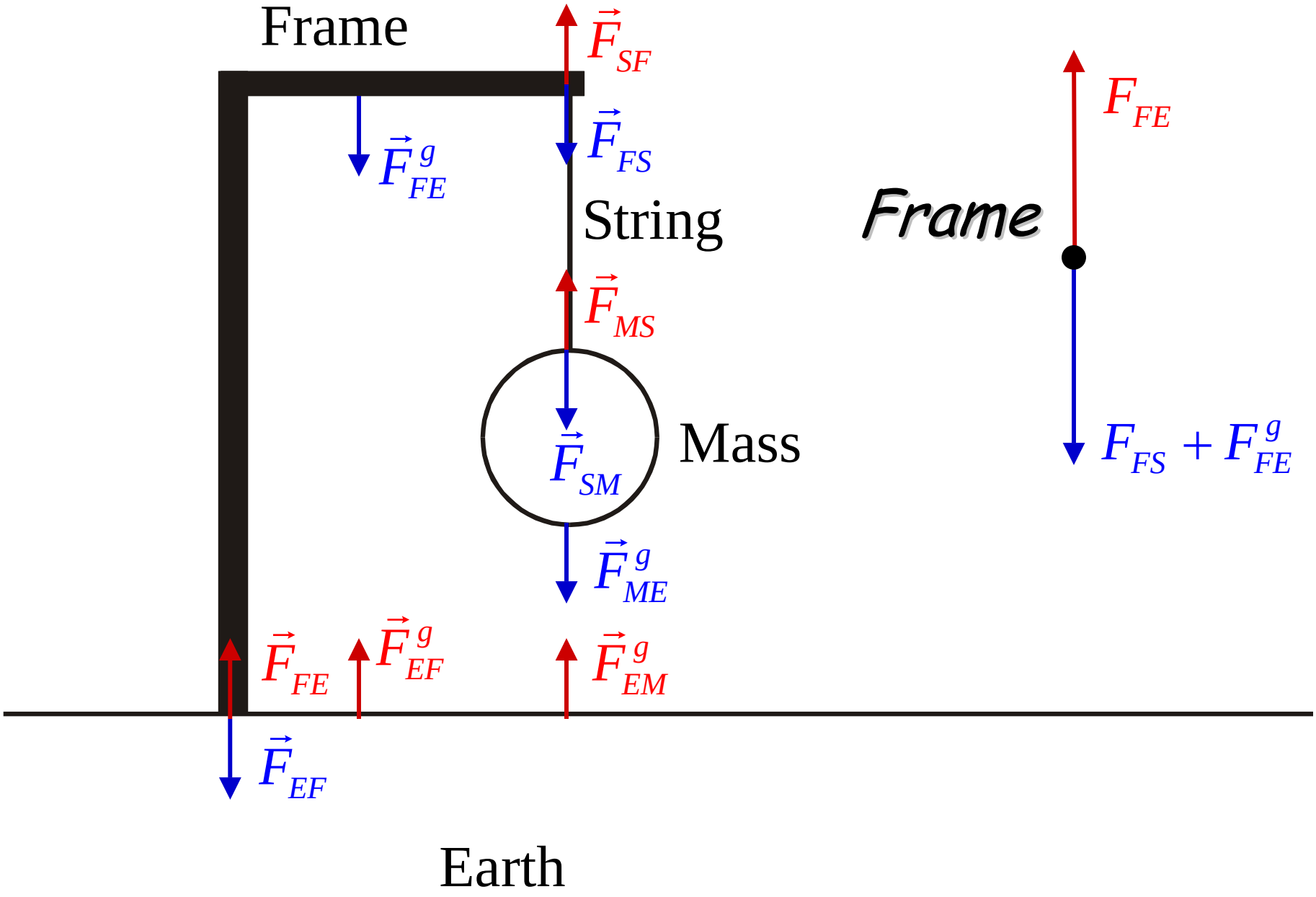


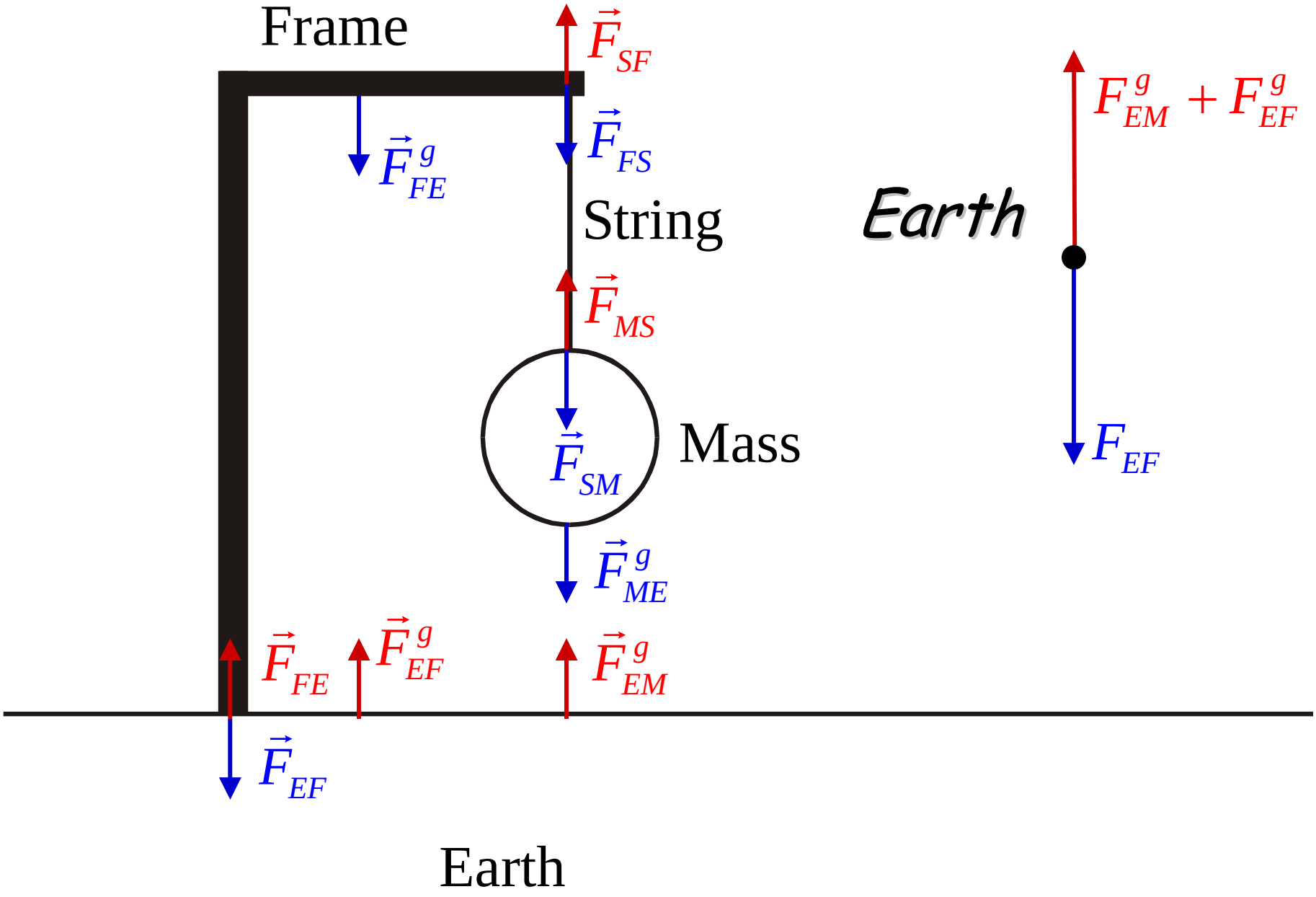
Newton's 3rd law and force pairs



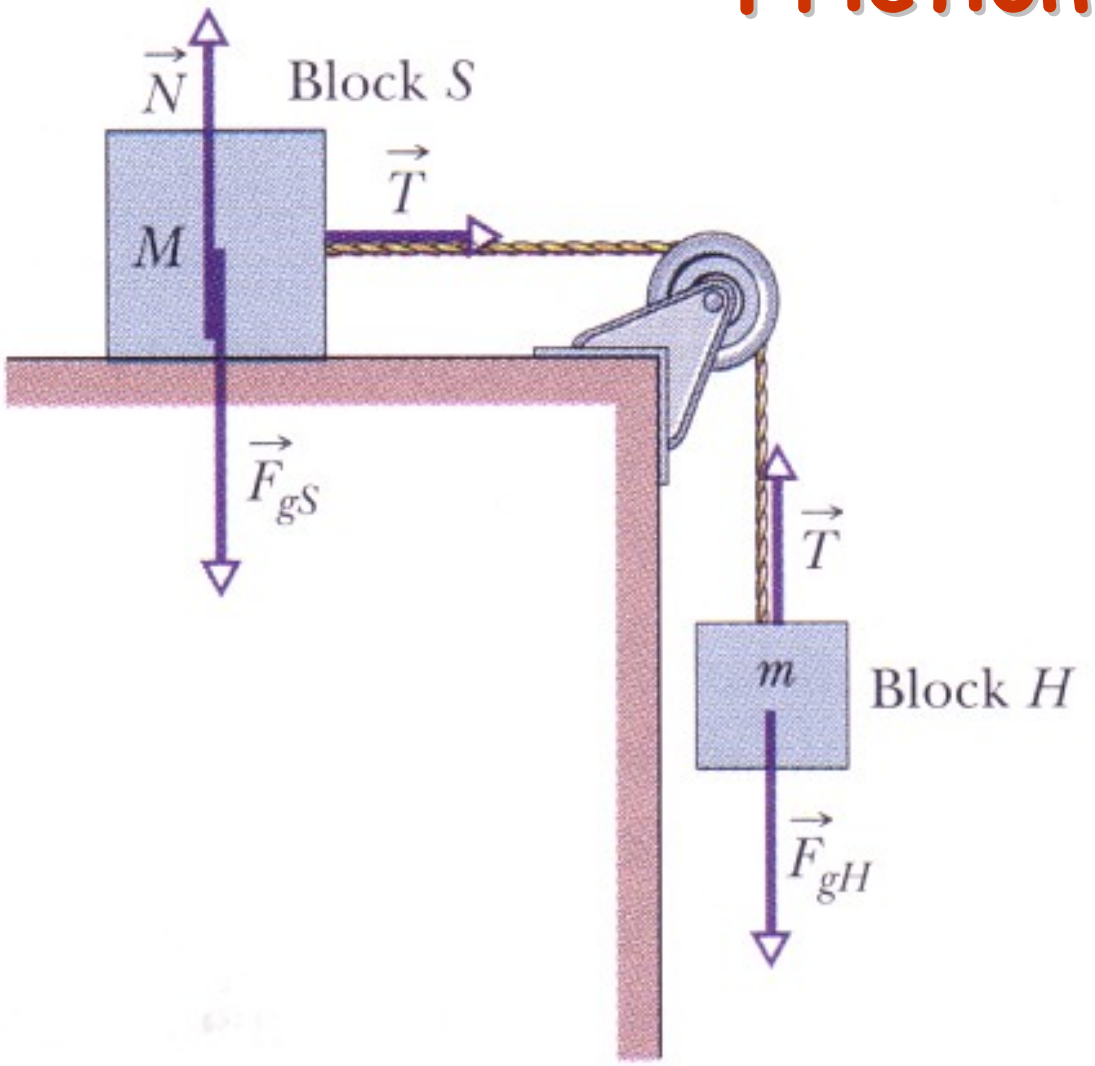
Newton's 3rd law and force pairs



Newton's 3rd law and force pairs



Friction



$$a = \frac{m}{m+M} g$$

- Experience might lead you to believe that if M was very large, say 2000 Kg, m would not budge. This is where **friction** comes in.

Characteristics of Friction

1. When you set an object in motion on a typical surface, it slows down and stops if you do not continue to push.
2. Even if you continue to push with the same force, the object does not accelerate.
3. If you try to push an extremely heavy object, it does not move, no matter whether you push hard or lightly.
4. If you really push with all of your might, it eventually gives way and begins to slide.

1 and 2, along with Newton's second law, tell us that there must be an unseen force - **friction** - in operation which opposes the motion. In 1, this frictional force is the only force on the object, and it causes a deceleration. In 2, the frictional force is equal and opposite to the pushing force.

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•3 tells us that, in static cases, the force due to friction adjusts so as to exactly oppose the applied force.

•4 tells us that there is a maximum magnitude for the frictional force; when you exceed this, the object slides.

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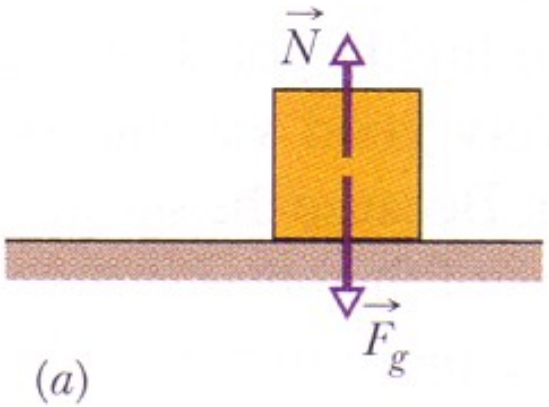
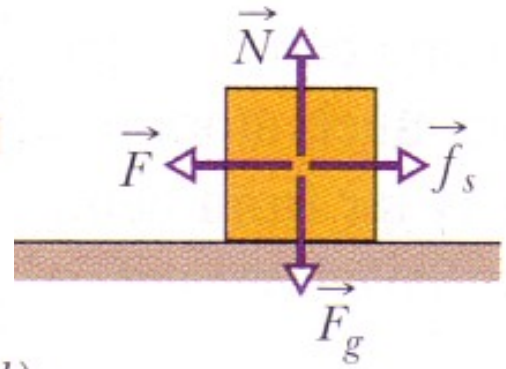
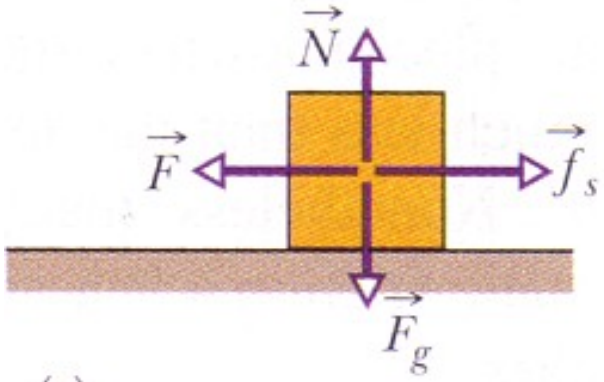
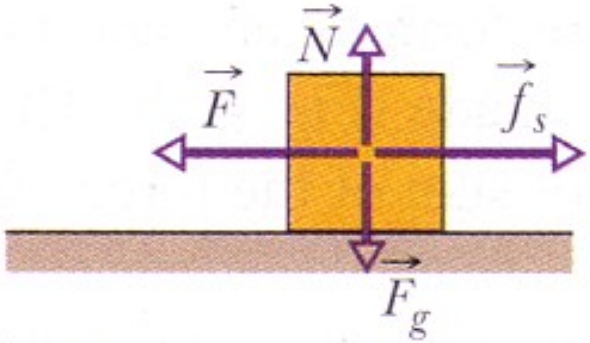
•3 and 4 tell us that the frictional force is greater for heavier objects.



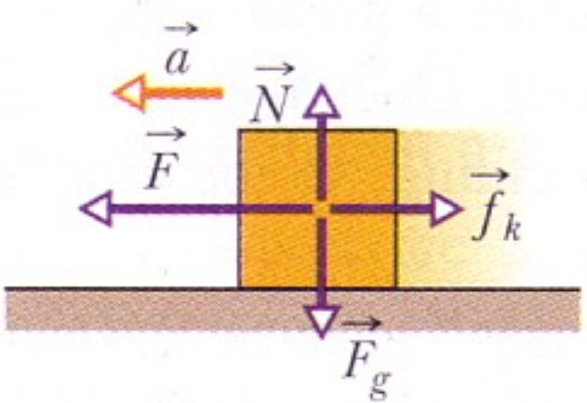


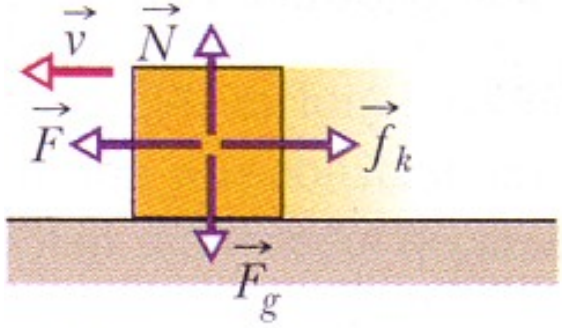


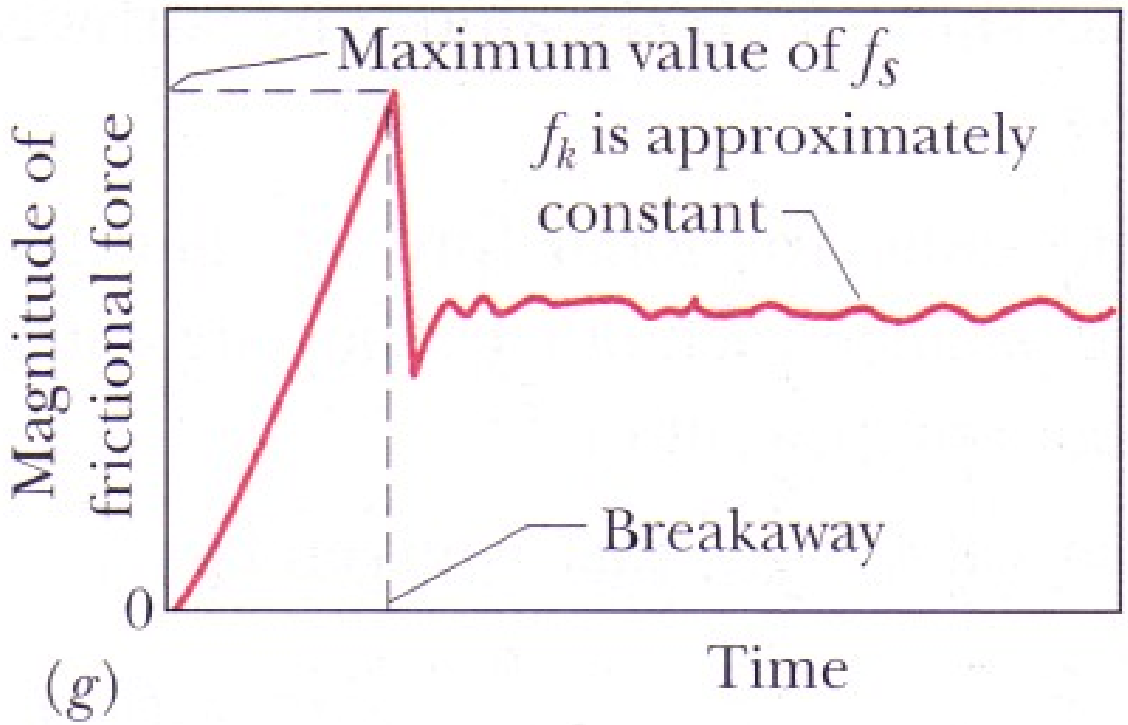


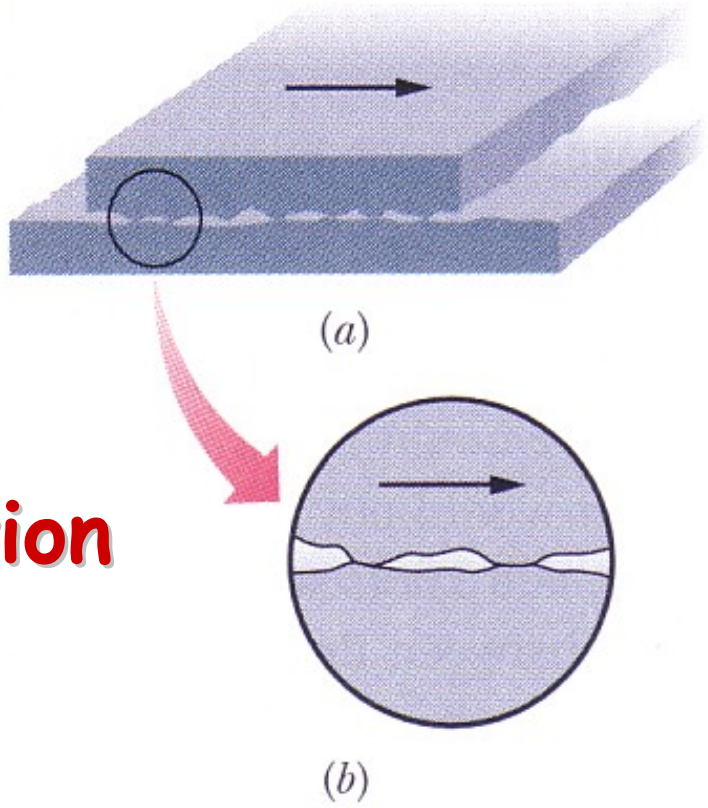
f_s is called the coefficient of static friction

f_k is called the coefficient of kinetic friction









Microscopic origin of friction

Properties of Friction

1. In static situations, the static frictional force exactly cancels the component of the applied force parallel to the surface.
2. The heavier an object, the more difficult it is to make it slide. Evidently, the maximum frictional force depends on the normal force between the surface and the object, i.e.

$$f_{s,\max} = \mu_s N$$

where μ_s is the **coefficient of static friction** and N is the magnitude of the normal force. μ_s is a parameter that depends on both surfaces. Once the force component parallel to the surface exceeds $f_{s,max}$, then the body begins to slide along the surface.

Properties of Friction

3. If a body begins to slide along the surface, the magnitude of the frictional force instantly decreases to a value f_k given by

$$f_k = \mu_k N$$

where μ_k is the **coefficient of kinetic friction** and N is the magnitude of the normal force. Therefore, during the sliding, a kinetic frictional force of magnitude f_k opposes the motion.

4. When several agents push in different directions on an object, the frictional force opposes the component of the net force on the object which is parallel to the surface.