FORCES

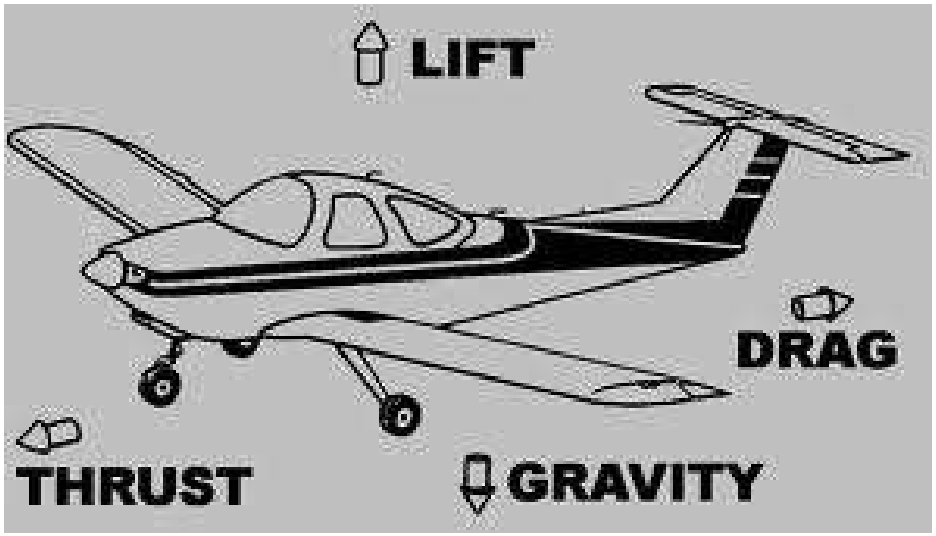
Chapter 4

Standards for this Unit:

- **SP1. Students will analyze the relationships between force, mass, gravity, and the motion of objects.**
  - d. Measure and calculate the magnitude of frictional forces and Newton's three Laws of Motion.
  - h. Determine the conditions required to maintain a body in a state of static equilibrium.

What is a Force?

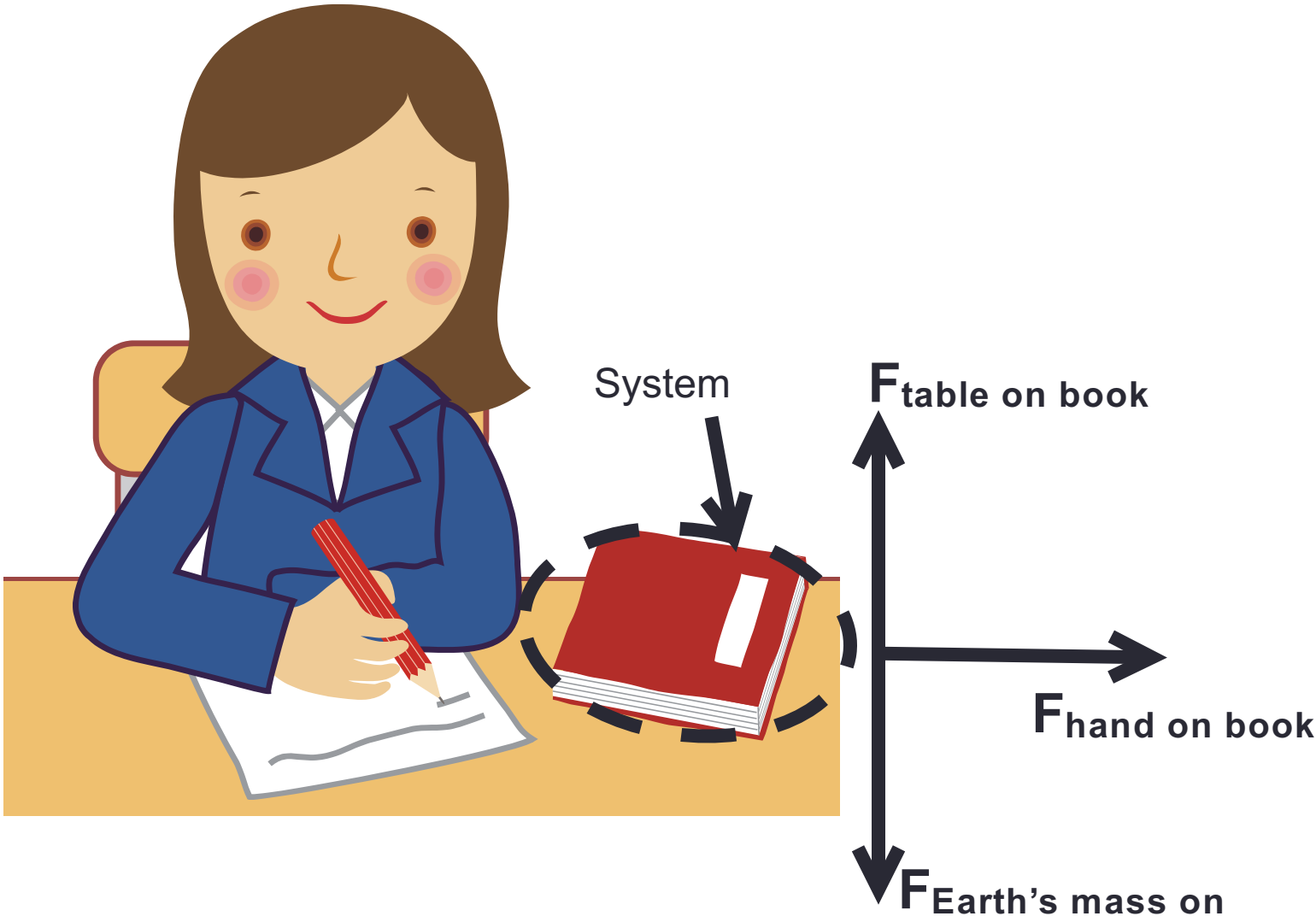
- A **force** is a push or a pull exerted on an object
- Whenever there is an *interaction* between two objects, there is a force upon each of the objects.
  - When the *interaction* ceases, the two objects no longer experience the force. Forces only exist as a result of an interaction.
- Forces can cause objects to speed up, slow down, or change directions.



Think About a Book on a Table

- If you wanted it to move, you could push or pull it.
- These are both forces you would exert on the book.
- If you push harder, that is a greater force
  - This would result in having a greater effect on the motion of the textbook.
- The direction of your push is the direction the book moves.
- In this case, we call the book a “system”
- A system is the object of interest.
  - Everything around the system which exert forces on it is called the external world.
- Your hand and gravity are part of the external world.

A system


System
$F_{\text{table on book}}$
$F_{\text{hand on book}}$
$F_{\text{Earth's mass on}}$

Representing Forces

- Forces have both magnitude and direction.
  - So they are ___.
- The symbol **F** represents a vector.
  - Ex. $F_{gravity}$
- Since forces are vectors, we represent them just like any other vector
  - Use an arrow pointing in the same direction as the vector
- We can also add forces together the same way we added vectors in the last unit
  - Tip to Tail
  - Pythagorean Theorem
  - Other Trig functions ☺

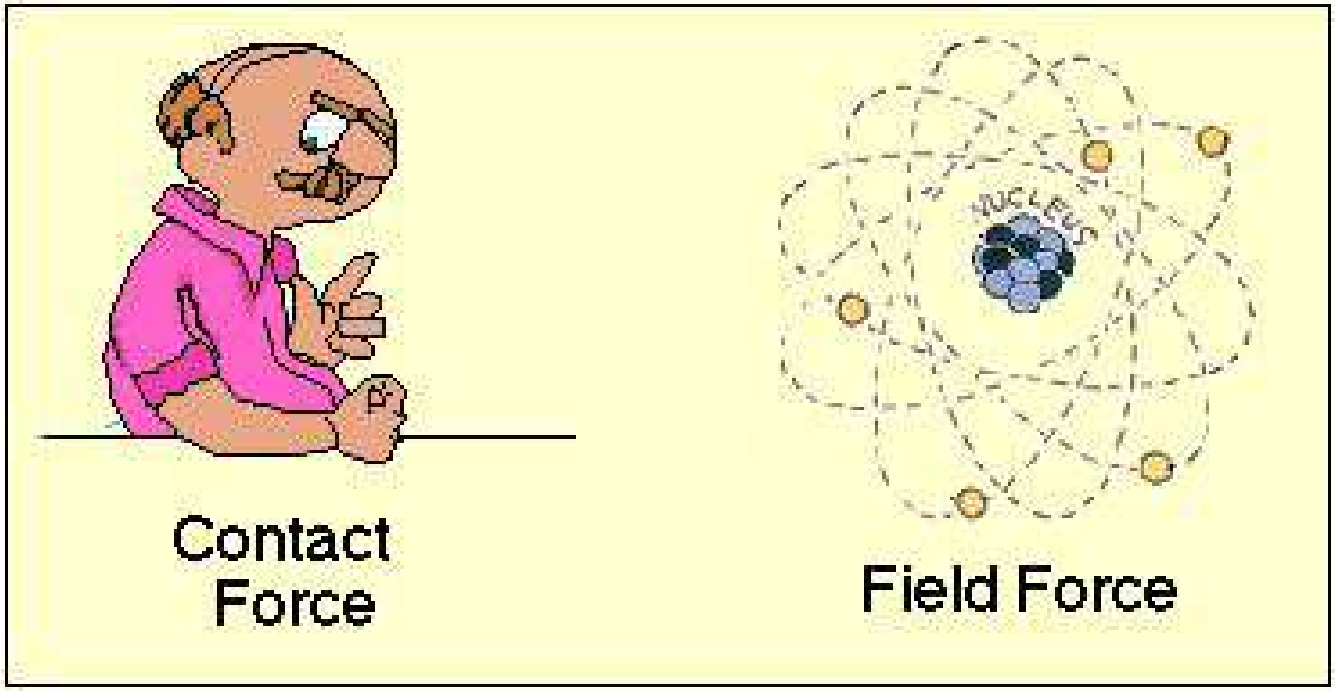
Units of Force

- Forces depend on mass and acceleration
- Standard unit for mass = kg
- Standard unit for acceleration = m/s/s
- So forces are measured in kg*m/s/s
- These are called Newtons
  - Abbreviated **N**
- 1 lb = 4.448 N
- 1 N = 0.225 lb

$$1\ \text{Newton} = 1\ \text{kg}^* \frac{\text{m}}{\text{s}^2}$$

Types of Forces

- There are two main types of forces
  - Contact
  - Field



Contact Force

- Contact Force
  - Exists when an object from the external world touches a system and exerts a force on it
- Think About the Book on the Table
  - If you push it, you are exerting a contact force
  - If you put it down, no longer interacting… so no more force from you
  - But table is touching it- table is now exerting a force

Field Force

- An object can move without something directly touching it
- What if you dropped the book?
  - It falls due to gravity
- Gravitational Force is a field force.
  - They affect movement without being in physical contact
- Can you think of other field forces?
  - Magnetic fields
  - Electric Forces
  - Nuclear Forces

Interactions

- Forces result from interactions
  - Each force has a cause called the **agent**
- You have to determine the agent exerting the force as well as the system it is being exerted on.
- What about when you push a book on a table?
  - Agent= your hand
  - CAUSES a contact force on the…
  - System= the book
- When you drop your book?
  - Agent= the mass of the earth
  - CAUSES the gravitational force acting on the
  - System= the book

More Types of Forces

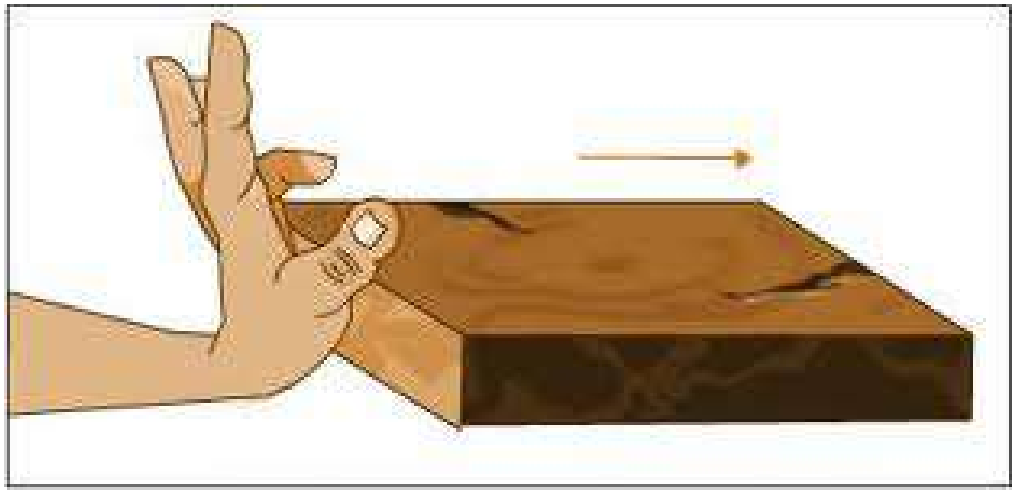
- The two main types of forces (field and contact) can be further divided into specific forces

Gravity Force (also known as Weight) F_{grav}

- The force of gravity is the force with which the earth, moon, or other massively large object attracts another object towards itself.
- By definition, this is the weight of the object.
- All objects upon earth experience a force of gravity that is directed "downward" towards the center of the earth. The force of gravity on earth is always equal to the weight of the object

Applied Force - F_{app}

- An applied force is a force that is applied to an object by a person or another object.
- If a person is pushing a desk across the room, then there is an applied force acting upon the object.
- The applied force is the force exerted on the desk by the person.



Normal Force - F_{norm}

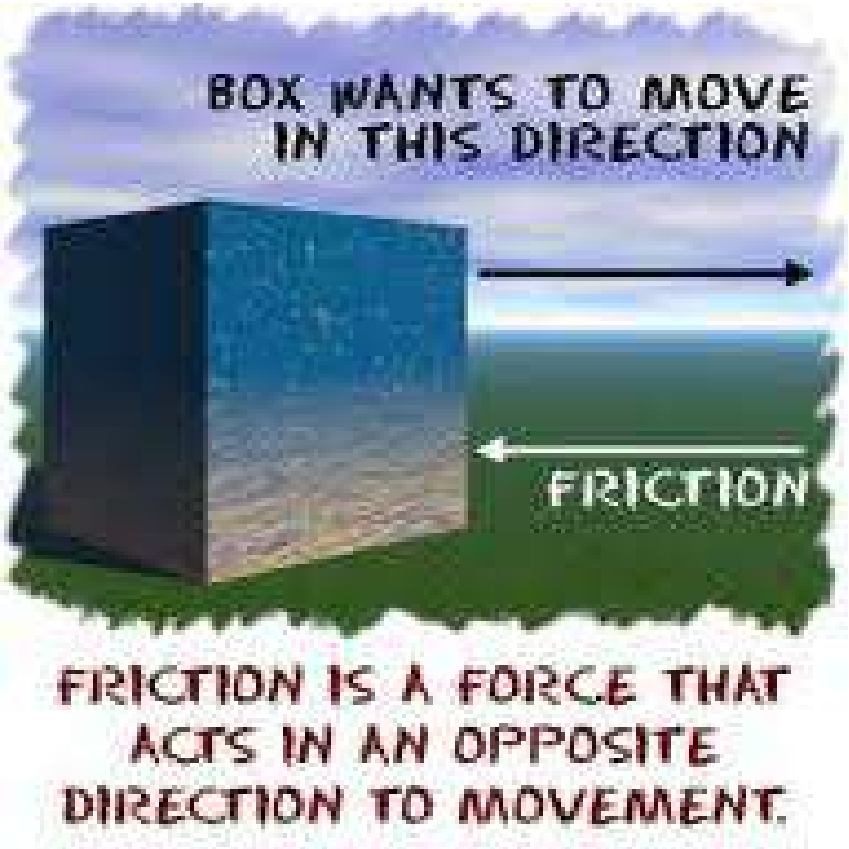
- The normal force is the support force exerted upon an object that is in contact with another stable object.
- For example, if a book is resting upon a surface, then the surface is exerting an upward force upon the book in order to support the weight of the book.
- On occasions, a normal force is exerted horizontally between two objects that are in contact with each other.
  - For instance, if a person leans against a wall, the wall pushes horizontally on the person.

Normal Force

Friction Force - F_{frict}

- The friction force is the force exerted by a surface as an object moves across it or makes an effort to move across it.
- There are at least two types of friction force –
  - Sliding
  - static.
- Thought it is not always the case, the friction force often opposes the motion of an object.
- For example, if a book slides across the surface of a desk, then the desk exerts a friction force in the opposite direction of its motion.
- More on friction later…

Friction


BOX WANTS TO MOVE
IN THIS DIRECTION
FRICTION
FRICTION IS A FORCE THAT
ACTS IN AN OPPOSITE
DIRECTION TO MOVEMENT.

Air Resistance Force - F_{air}

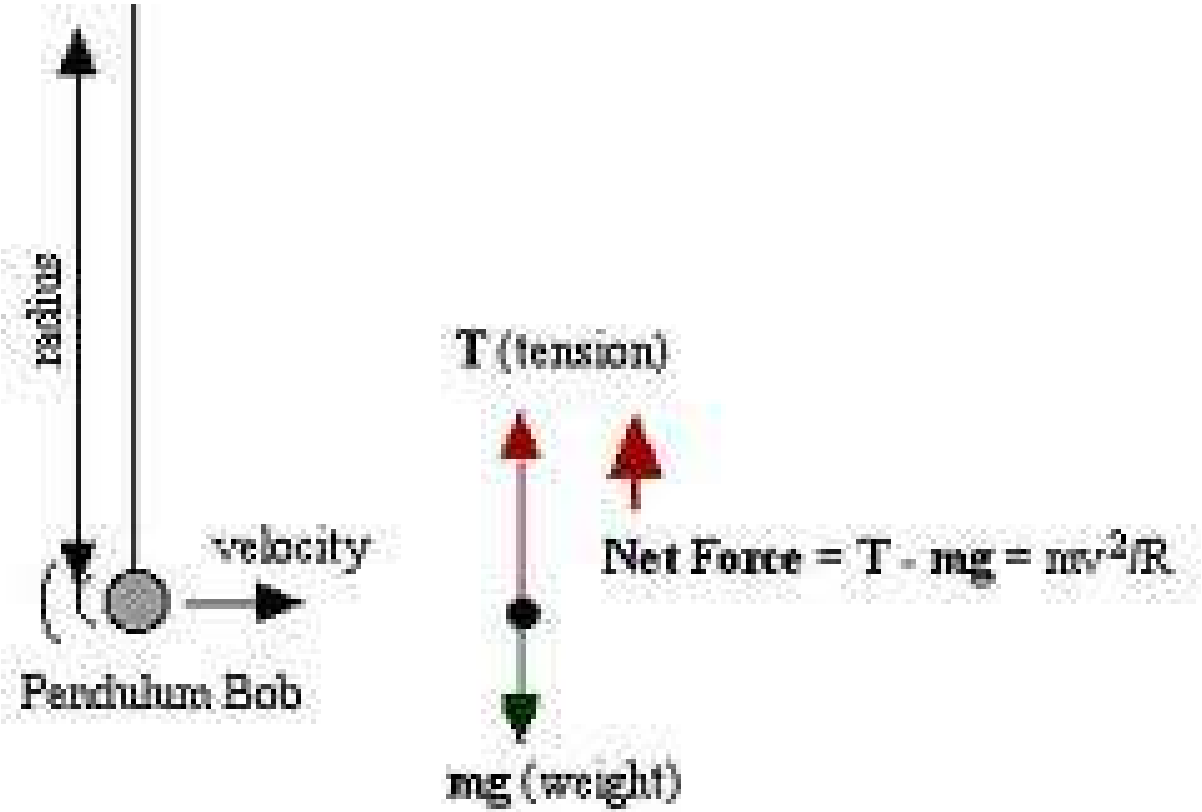
- The air resistance is a special type of frictional force that acts upon objects as they travel through the air.
- The force of air resistance is often observed to oppose the motion of an object.
- This force will frequently be neglected due to its negligible magnitude (and due to the fact that it is mathematically difficult to predict its value).
- It is most noticeable for objects that travel at high speeds (e.g., a skydiver or a downhill skier) or for objects with large surface areas.

Air Resistance

Tension Force - F_{tens}

- The tension force is the force that is transmitted through a string, rope, cable or wire when it is pulled tight by forces acting from opposite ends.
- The tension force is directed along the length of the wire and pulls equally on the objects on the opposite ends of the wire.
- The tension force is always directed *along the length* of the thing doing the pulling (string, rope, chain).

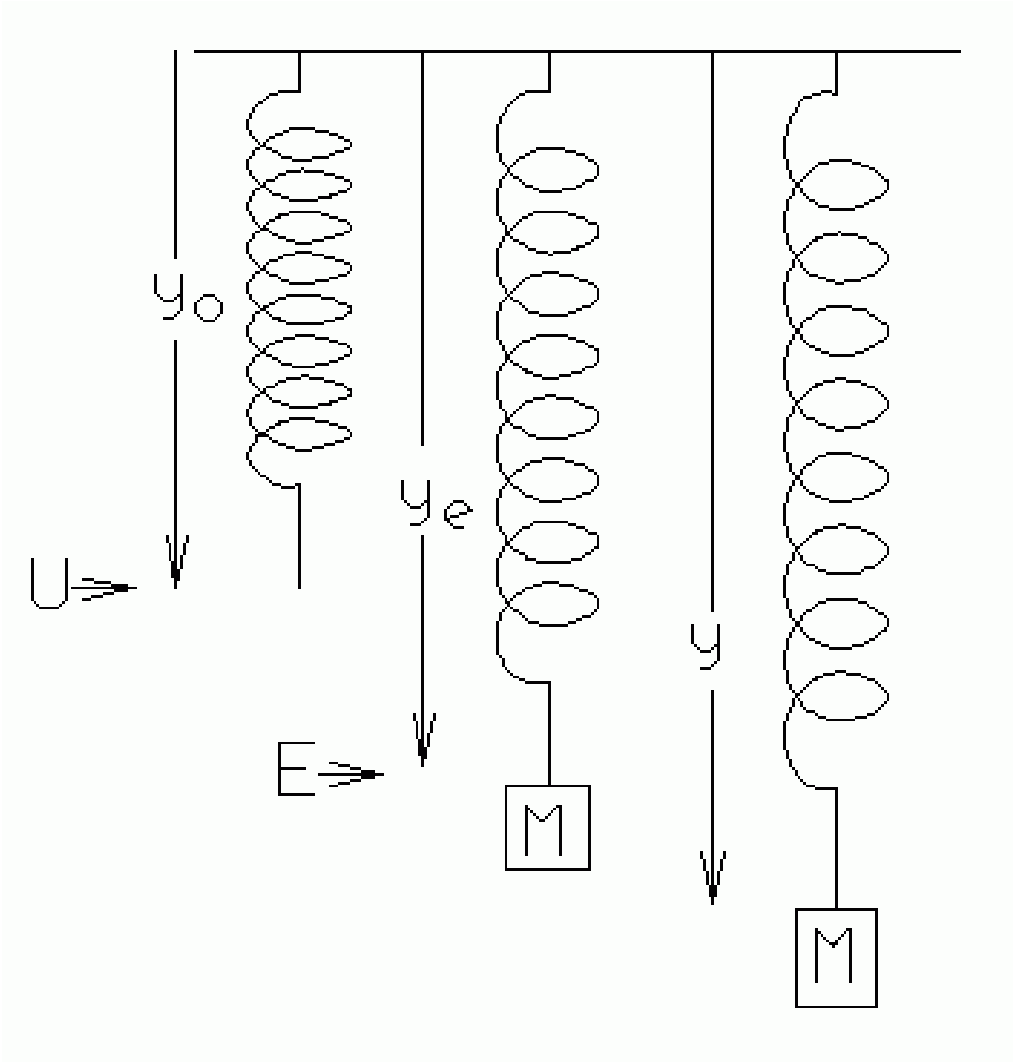
Tension


radius
velocity
Pendulum Bob
T (tension)
Net Force = T - mg = mv²/R
mg (weight)

Spring Force - F_{spring}

- The spring force is the force exerted by a compressed or stretched spring upon any object that is attached to it.
- An object that compresses or stretches a spring is always acted upon by a force that restores the object to its rest or equilibrium position.
- For most springs, the magnitude of the force is directly proportional to the amount of stretch or compression of the spring.
- The force F_{spring} of the spring acts upward on the suspended mass. The downward force on the mass is its weight (due to the force of gravity)

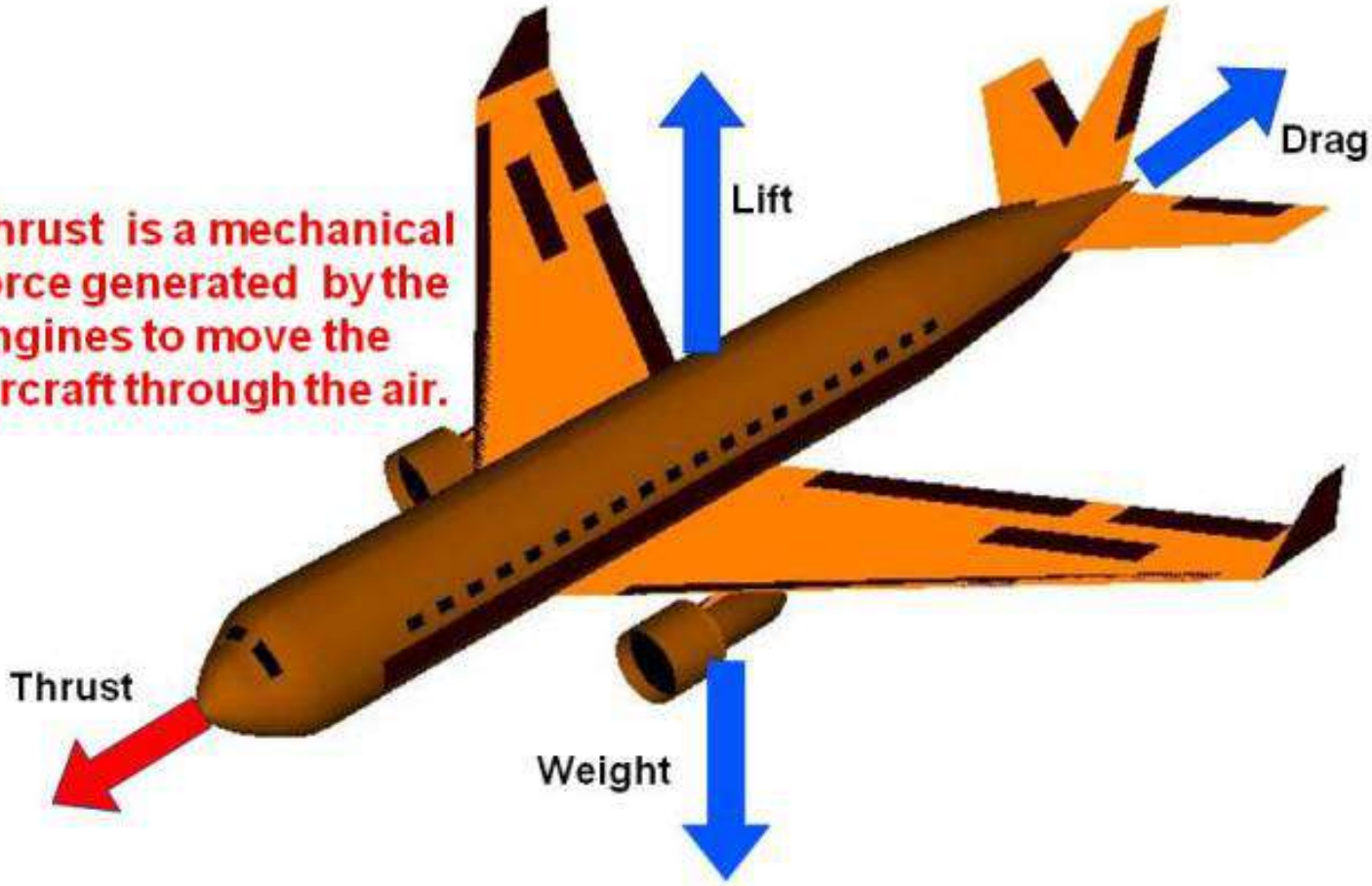
Spring Force



Thrust Force - F_{thrust}

- A general term for the forces that move objects
- Typically associated with rockets
- Thrust is a mechanical force, so the propulsion system must be in physical contact with a **working fluid** to produce thrust.
- When a system expels, or accelerates, mass in one direction the accelerated mass will cause a force of equal magnitude but opposite direction on that system.

What is Thrust ?



PRACTICE

Identify the following…

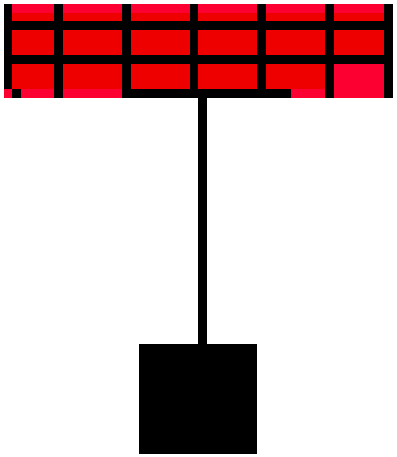
- … as either
  - Contact force
  - Field Force
  - Not a Force

- Weight
- Mass
- Push of a hand
- Thrust
- Resistance
- Air resistance
- Spring force
- acceleration

- Field force
- Not a force
- Contact force
- Contact force
- Field force
- Contact force
- Contact force
- Not a force

What forces are present?

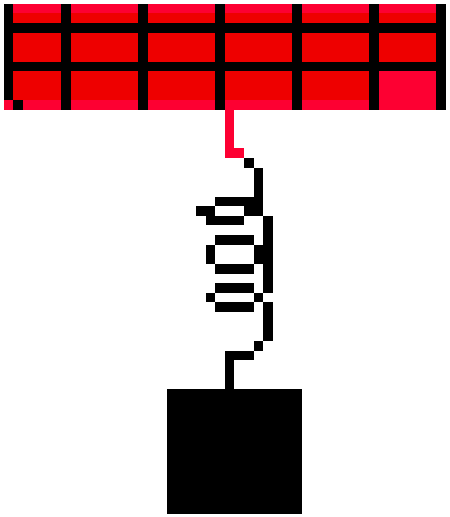
- A block hangs at rest from the ceiling by a piece of rope. Consider the forces acting on the block.



Gravity and Tension

What forces are present?

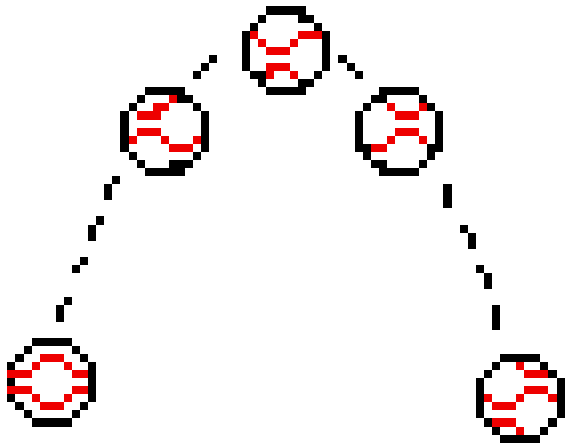
- A block hangs from the ceiling by a spring. Consider the forces acting on the block when it is at rest.



Gravity and Spring

What forces are present?

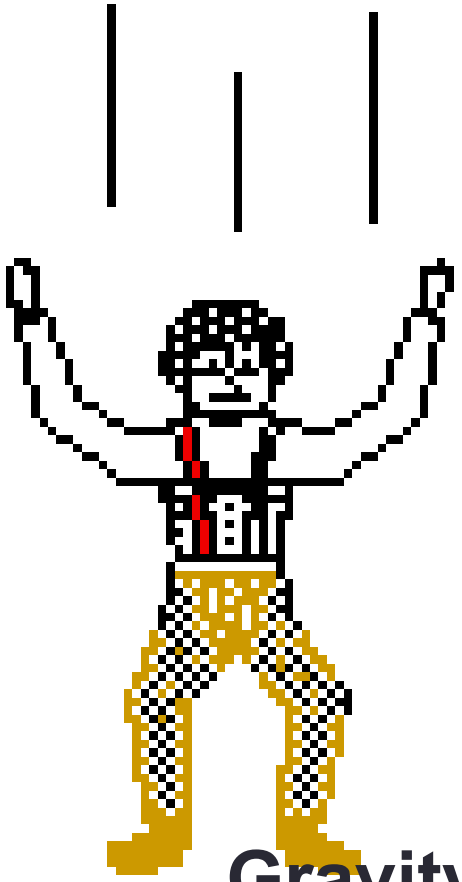
- A ball is shot into the air with a spring-loaded cannon. Consider the forces acting on the ball while it is in the air.



Gravity and Air Resistance

What forces are present?

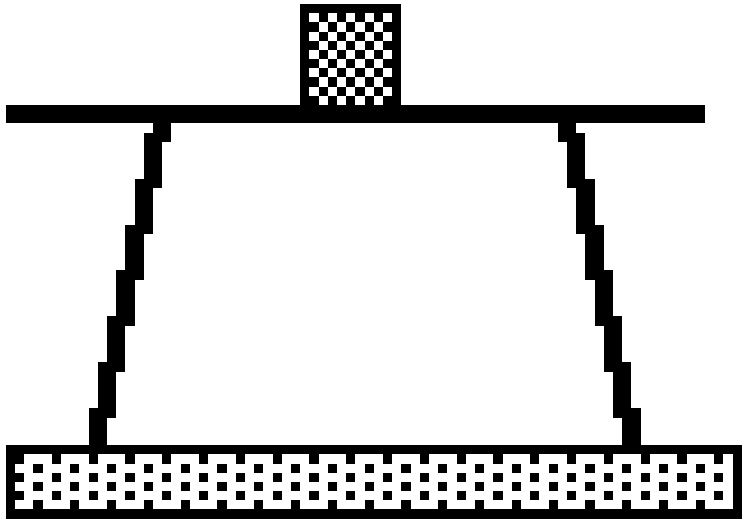
- A skydiver (who hasn't opened his parachute yet) falls at terminal velocity. Consider the forces acting on the skydiver.



Gravity and Air Resistance

What forces are present?

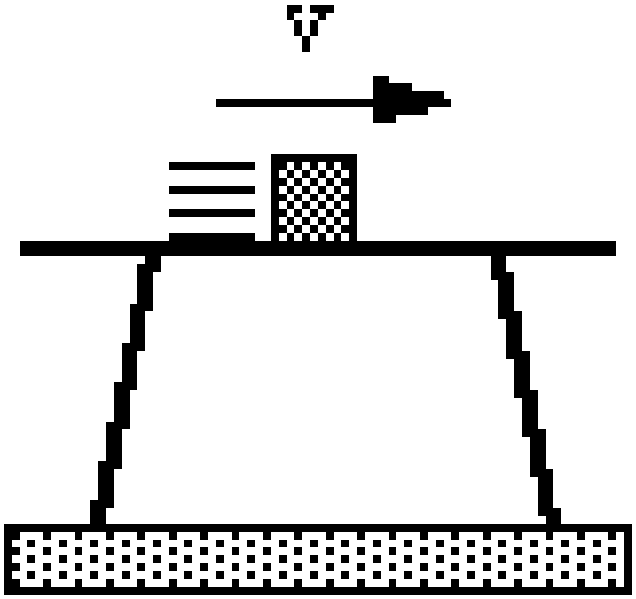
- A block rests on top of a table. Consider only the forces acting upon the block.



Gravity and Normal

What forces are present?

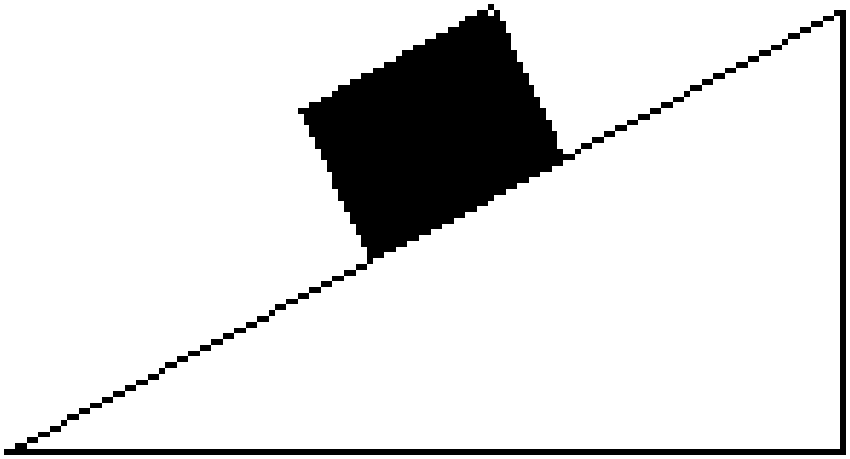
- A block slides across the top of a table. Consider only the forces acting upon the block.



Gravity, Normal, Friction and Air Resistance

What forces are present?

- A block rests on an incline plane without sliding. Consider the forces acting on the block.



Gravity, Normal, Friction