THE NATURE OF FORCE

- You experience a force when you push, pull or hold an object. This force can be of different magnitudes and can have different directions. That is why force is a vector quantity.

- The unit of force is NEWTON (symbol: N). One newton is equal to one kilogram-meter per second squared (1 kg×m/s^2). One newton is a force needed to move a 1kg object with acceleration of 1m/s^2.
- Direction of the force must be always described using reference coordinate system.

- There are many types of forces. When one object is in contact with another, they have a common surface of contact. For now, we are going to consider the following:

  - Gravitational force F_g [always down ☺]
  - Normal force F_N [always perpendicular to the surface of contact]
  - Force of friction F_f [always parallel to the surface of contact and always opposing the motion]
  - Applied force F_{app} [direction varies]
  - Net force F_{net} [direction varies] this is a vector sum of all the forces acting simultaneously on an object
  - T=Tension force F_T [direction varies] this is a force acting on an object at the point where a rope or a cable is attached to the object. In this course, we make the following assumptions: the mass of the rope is negligible, the rope has a negligible thickness, and the rope is taut and does not stretch. These assumptions guarantee that the force of tension is uniform throughout the entire length of the rope, it acts parallel with the rope and is directed away from the object, and that the object attached to this rope has the same acceleration as the rope itself.

Drawing a FREE-BODY DIAGRAM (FBD) is a convenient and clear way to describe and analyze situations involving forces.

Example #1: An object is pulled up on a rope. This object is experiencing a force of gravity

F_g of 50 N[down] and the force of tension is F_T is 100 N[up]. Draw and label a FBD.

Example #2: A person is pushing a stroller on a flat sidewalk with a force of 150 N[forward], the force of friction is opposing the motion of the stroller and has a magnitude of 50 N. The force of gravity on the person pushing the stroller is 600 N [down], the magnitude of the force of gravity on the stroller is 250 N. Draw and label a FBD describing all forces acting on the stroller.

REPRESENTING FORCES USING FREE-BODY DIAGRAMS (FBD)

Identify the object for the free-body diagram

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Sketch the object in isolation with a dot at its centre

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Identify all the forces acting on the object

Ignore forces acting on other objects!

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Choose appropriate reference coordinates and include which directions are positive

x, y

N, S, E, W

up, down, forward, backward

↓

If possible, choose an appropriate scale

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Include the forces in the free-body diagram.

Draw forces proportionally extending out from the dot at the center of the object.

Whenever you are given magnitude and direction of the forces add appropriate labels to the FBD (numbers with units and angles)

Draw a FBD of a book lying on a slanted shelf. The shelf is slanted 10°up. Gravitational and normal forces, as well as friction are acting on this book. The book is at rest.

A car experiencing a gravitational force F_g of 10 000 N [down] is coasting on a level road. The car expriences a normal force F_N of 10 000 N [up], a force of air resistance F_{air} of 2 500 N[backward], and a force of friciton F_f excerted by the road on the tires of 500 N [backward]. Draw a FBD of this situation.

Note: the car is coasting so there is no forward force acting on it.

Consider the car coasting down a 25° hill. It still experiences a gravitational froce F_g of 10 000N [down], the force of air resistance F_{air} of 2500 N [backward], the force of friction F_f of 500 N[bakward]. But the normal force F_N is 9 063 N

Draw the FBD of this situation.

What is the magnitude and direction of the component of the gravitational force that is parallel with the road. Show this component in the diagram.