University of Science and Technology
Faculty of Engineering
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physics (1)

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Lec (3)

The Motion

1-MOTION IN ASTRAIGHT LINE :

VELOCITY – SPEED – ACCELERATION -the formulas for motion

2-MOTION IN AVERTICAL PLANE :

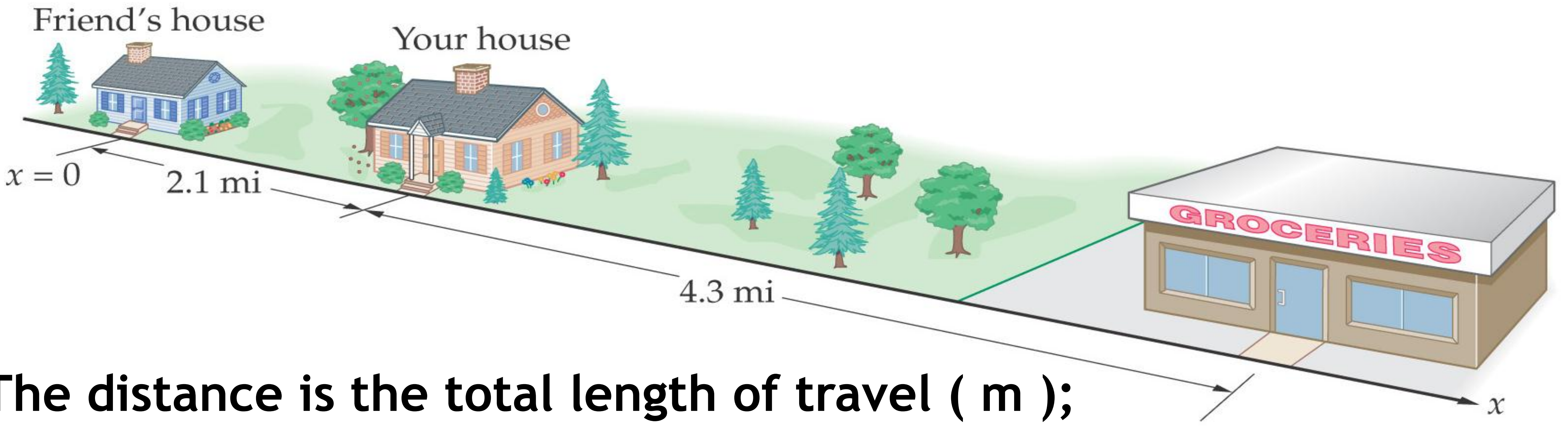
ACCELERATION OF GRAVITY

3- LAWS OF MOTION :

MASS – WEIGHT

4- STATIC AND KINETIC FRICTION

POSITION, DISTANCE, AND DISPLACEMENT



The distance is the total length of travel (m);

Displacement is the change in position.

Definition: Displacement, Δx

displacement = change in position = final position − initial position

$$\text{displacement} = \Delta x = x_f - x_i$$

SI unit: meter, m

1-Motion in aStraight Line

VELOCITY :

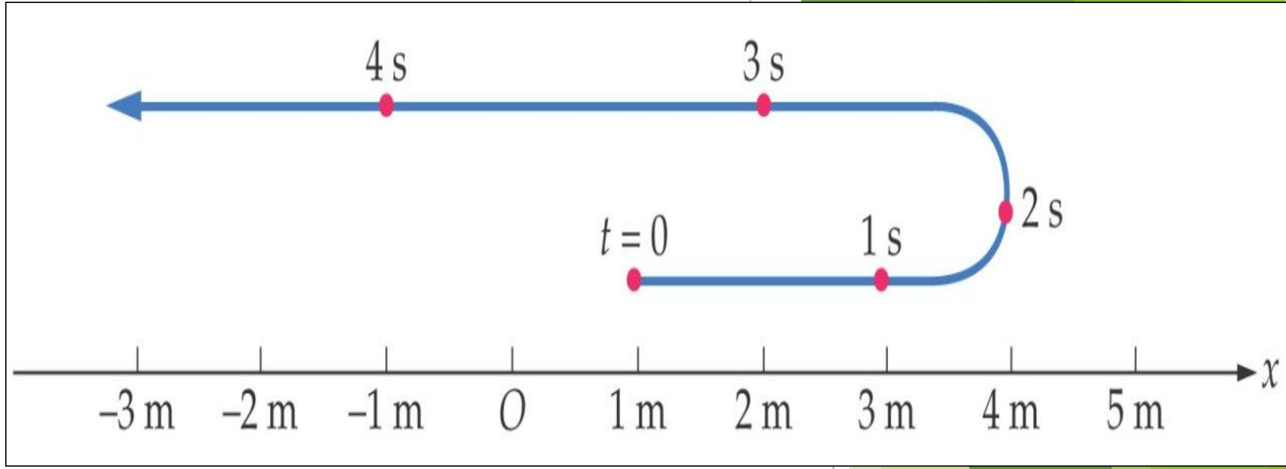
The *velocity* of a body is a vector quantity that describes both how fast it is moving and the direction in which it
is headed. The magnitude of a velocity is sometimes called *speed*.

SPEED is a scalar quantity.

VELOCITY is a vector quantity.

$$\textit{Average speed} = \frac{\text{total distance traveled}}{\text{time taken}}$$

$$v_{av} = \frac{l}{t}$$



$$\textit{Average velocity} = \frac{\text{vector displacement}}{\text{time taken}}$$

$$\vec{\mathbf{v}}_{av} = \frac{\vec{\mathbf{s}}}{t}$$

The units of velocity (and speed) are those of distance divided by time, such as m/s or km/h.

SOLVED PROBLEM (1) :

A runner makes one lap around a 200-m track in a time of 25 s. What were the runner's (*a*) average speed and (*b*) average velocity?

(*a*) From the definition,

$$\text{Average speed} = \frac{\text{distance traveled}}{\text{time taken}} = \frac{200\ \text{m}}{25\ \text{s}} = 8.0\ \text{m/s}$$

(*b*) Because the run ended at the starting point, the displacement vector from starting pont to end point has zero length. Since $\vec{\mathbf{v}}_{av} = \vec{\mathbf{s}}/t$,

$$|\vec{\mathbf{v}}_{av}| = \frac{0\ \text{m}}{25\ \text{s}} = 0\ \text{m/s}$$

ACCELERATION :

Abody whose velocity is changing is accelerated.Abody is accelerated when its velocity is increasing,decreasing, or changing in direction.

$$Average\ acceleration = \frac{\text{change in velocity vector}}{\text{time taken}}$$

$$\vec{\mathbf{a}}_{av} = \frac{\vec{\mathbf{v}}_f - \vec{\mathbf{v}}_i}{t}$$

The units of acceleration are those of velocity divided by time.(m/s)/s (or m/s^2)

THE FORMULAS FOR MOTION UNDER CONSTANT ACCELERATION:

- $v_f = v_i + at$
- $v_{avg} = (v_i + v_f)/2$
- $d = v_i t + \frac{1}{2} at^2$
- $v_f^2 = v_i^2 + 2ad$
- $a = \Delta v/t$
- $v = d/t$

SOLVED PROBLEM (2) :

An object starts from rest with a constant acceleration of 8.00 m/s^2 along a straight line. Find (*a*) the speed at the end of 5.00 s, (*b*) the average speed for the 5-s interval, and (*c*) the distance traveled in the 5.00 s.

We are interested in the motion for the first 5.00 s. Take the direction of motion to be the +*x*-direction (that is, $s = x$). We know that $v_i = 0$, $t = 5.00$ s, and $a = 8.00\ m/s^2$. Because the motion is uniformly accelerated, the five motion equations apply.

(*a*) $$v_{fx} = v_{ix} + at = 0 + (8.00\ \mathrm{m/s^2})(5.00\ \mathrm{s}) = 40.0\ \mathrm{m/s}$$

(*b*) $$v_{av} = \frac{v_{ix} + v_{fx}}{2} = \frac{0 + 40.0}{2}\ \mathrm{m/s} = 20.0\ \mathrm{m/s}$$

(*c*) $$x = v_{ix}t + \tfrac{1}{2}at^2 = 0 + \tfrac{1}{2}(8.00\ \mathrm{m/s^2})(5.00\ \mathrm{s})^2 = 100\ \mathrm{m} \quad \text{or} \quad x = v_{av}t = (20.0\ \mathrm{m/s})(5.00\ \mathrm{s}) = 100\ \mathrm{m}$$

2-Motion in aVertical Plane

ACCELERATION OF GRAVITY :

All bodies in free fall near the earth's surface have the same downward acceleration of

$$g = 9.8 \text{ m/s}^2$$

SOLVED PROBLEM (3) :

A stone dropped from a bridge strikes the water 2.5 s later. (*a*) What is its final velocity in meters per second? (*b*) How high is the bridge?

(*a*) $$v = gt = (9.8 \text{ m/s}^2)(2.5 \text{ s}) = 24.5 \text{ m/s}$$

(*b*) $$h = \tfrac{1}{2}gt^2 = \left(\tfrac{1}{2}\right)(9.8 \text{ m/s}^2)(2.5 \text{ s})^2 = 30.6 \text{ m}$$

FORCE AND LAWS OF MOTION

<u>3- Laws of Motion</u>

NEWTON'S FIRST LAW :

states that an object at rest will remain at rest and an object in motion will remain in motion with a constant velocity unless acted on by a net external force.

*** Can conclude that any isolated object is either at rest or moving at a constant velocity**

*** The First Law also allows the <u>definition</u> of *force as that which causes a change in the motion of an object.***

*** The tendency of an object to resist any attempt to change its velocity is called *inertia*.**

* **Mass is that property of an object that specifies how much resistance an object exhibits to changes in its velocity.**

* **Mass is a scalar quantity.** **The SI unit of mass is kg.**

Mass and weight are two different quantities.

* **Weight is equal to the magnitude of the gravitational force exerted on the object.**

Weight will vary with location.

$m_{earth} = 3\ kg; \quad m_{moon} = 3\ kg$

$w_{earth} = 30\ N;\ w_{moon} \simeq 6\ N$

NEWTON'S SECOND LAW :

states that the acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass. .

$$F = ma$$

$$\text{Net force} = (\text{mass})(\text{acceleration})$$

the unit for force is the *newton* (N)

WEIGHT :

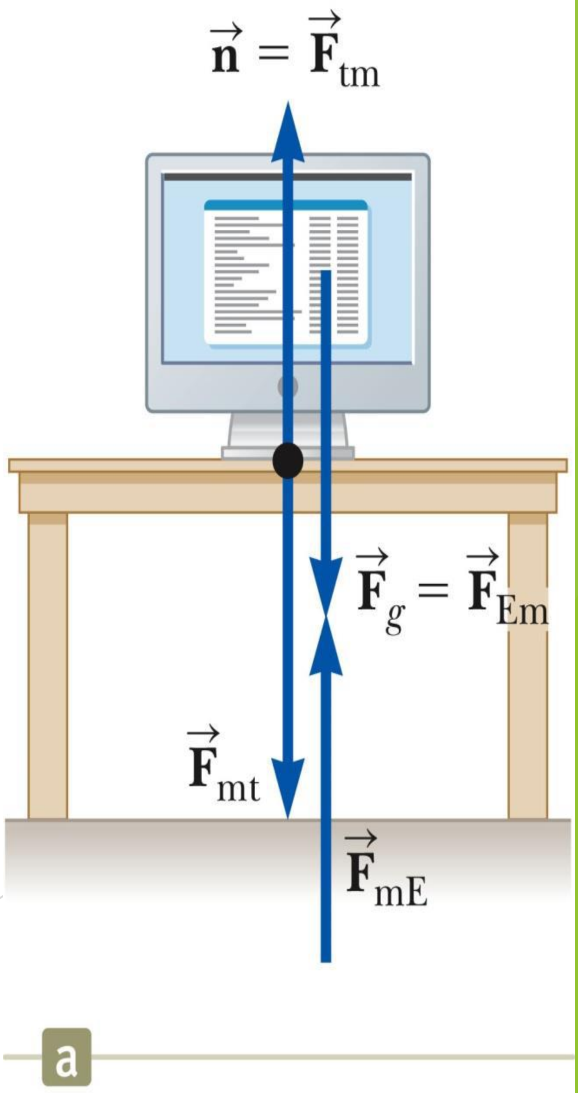
The *weight* of a body is the gravitational force with which the earth attracts the body.

$$w = mg$$

Weight = (mass)(acceleration of gravity)

NEWTON'S THIRD LAW :

The action force is equal in magnitude to the reaction force and opposite in direction.



SOLVED PROBLEM (4) :

A 10-kg body has an acceleration of 5 m/s^2. What is the net force acting on it?

$$F = ma = (10\ \text{kg})(5\ \text{m/s}^2) = 50\ \text{N}$$

SOLVED PROBLEM (5) :

A force of 3000 N is applied to a 1500-kg car at rest. (*a*) What is its acceleration? (*b*) What will its velocity be 5 s later?

(*a*) $$a = \frac{F}{m} = \frac{3000\ \text{N}}{1500\ \text{kg}} = 2\ \text{m/s}^2$$

(*b*) $$v = at = (2\ \text{m/s}^2)(5\ \text{s}) = 110\ \text{m/s}$$

SOLVED PROBLEM (6) :

(*a*) What is the weight of an object whose mass is 5 kg? (*b*) What is its acceleration when a net force of 100 N acts on it?

(*a*) $$w = mg = (5\ \text{kg})(9.8\ \text{m/s}^2) = 49\ \text{N}$$

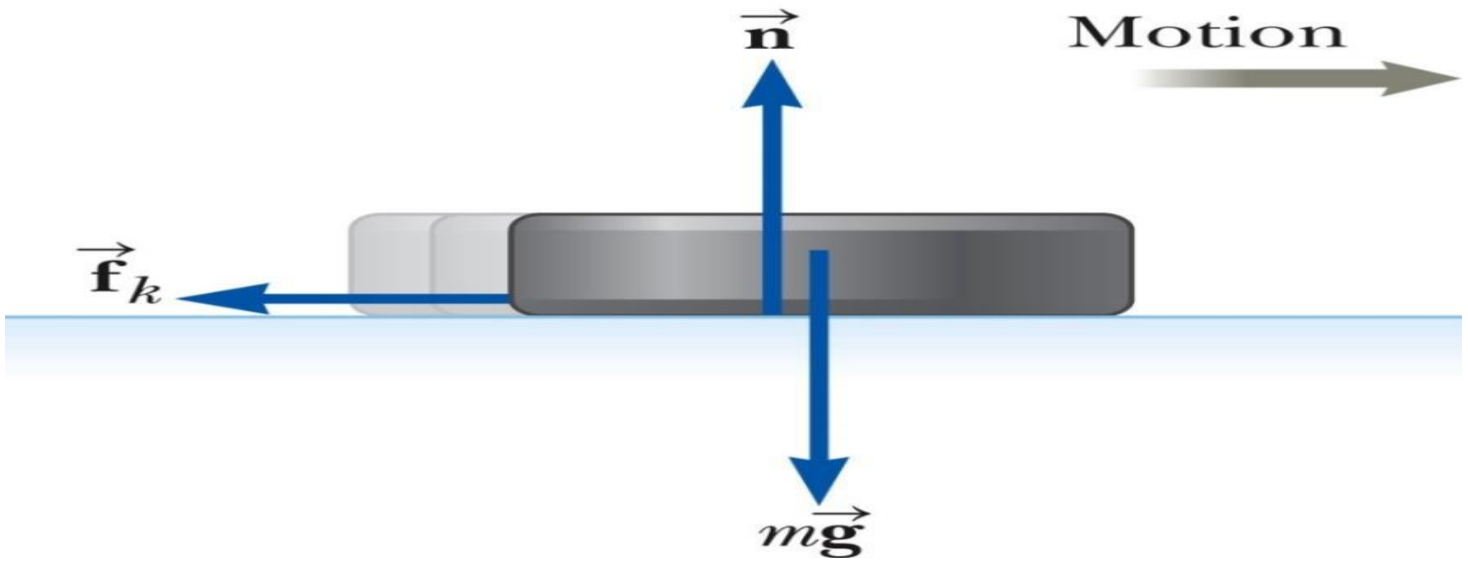
(*b*) From the second law of motion $F = ma$, we have

$$a = \frac{F}{m} = \frac{100\ \text{N}}{5\ \text{kg}} = 20\ \text{m/s}^2$$

4- STATIC AND KINETIC FRICTION :

Frictional forces act to oppose relative motion between surfaces that are in contact.

$$F = F_f = \mu_k N = \mu_k mg$$



SOLVED PROBLEM (7) :

How much force is needed to keep a 1200-kg car moving at constant velocity on a level concrete road? Assume that the car is moving too slowly for air resistance to be important, and use $\mu_k = 0.04$ for the coefficient of rolling friction.

The normal force here is the car's weight mg, because weight is a force that acts vertically downward. Hence

$$F = F_f = \mu_k N = \mu_k mg = (0.04)(1200\ \text{kg})(9.8\ \text{m/s}^2) = 470\ \text{N}$$

Multiple-Choice Questions

1. In which of the following examples is the motion of the car not accelerated?

   (*a*) A car turns a corner at the constant velocity of 20 km/h.
   (*b*) A car climbs a steep hill at the constant velocity of 20 mi/h.
   (*c*) A car climbs a steep hill with its velocity dropping from 60 km/h at the bottom to 20 km/h at the top.
   (*d*) A car climbs a steep hill and goes over the top and then down on the other side, all at the same velocity of 40 km/h.

2. A snail travels 45 cm in 20 min. Its average velocity is

   (*a*) 2.25 cm/h
   (*b*) 15 cm/h
   (*c*) 90 cm/h
   (*d*) 135 cm/h

3. Ball A is dropped from a roof at the same time as ball B is thrown horizontally from the roof. Ball A

   (*a*) reaches the ground first
   (*b*) reaches the ground last
   (*c*) has the greater velocity when it reaches the ground
   (*d*) has the smaller velocity when it reaches the ground

4. A jumper of weight w presses down on the floor with a force of magnitude F, and the jumper leaves the floor as a result. The force the floor exerted on the jumper must have had a magnitude

(*a*) equal to w and less than F
(*b*) equal to w and equal to F
(*c*) more than w and equal to F
(*d*) more than w and more than F

5. A force of 1.0 N acts on a 1.0-kg object that can move freely. The object's acceleration is

(*a*) 0.102 m/s^2 (*c*) 1.0 m/s^2
(*b*) 0.5 m/s^2 (*d*) 9.8 m/s^2

.6. The coefficient of static friction for wood on concrete is 0.6. The force needed to set a 40-kg crate in motion on a concrete floor is

(*a*) 2.4 N (*c*) 235 N
(*b*) 24 N (*d*) 653 N