PHYSICS 534

ANSWERS

EXERCISE-10 **Systems at Rest**

Albert Michelson received the Nobel prize for physics in 1907 for his work on precision meteorogical investigations.

MICHELSON

For convenience, we divide mechanics into three parts:

Statics is the branch of mechanics that studies forces ***at rest***. In statics, the resultant force always equals zero. That is, in statics the vectorial ***sum*** of all the forces acting on a system is always ***zero***, and the system is said to be in "equilibrium".

Dynamics is the branch of mechanics that studies forces causing motion. In dynamics, the resultant force ***does not equal zero*** and the system is always ***accelerating*** (going faster and faster) in the direction of the resultant force.

An important task in the study of mechanics is finding the resultant force. The resultant force tells us whether or not a system is ***at rest*** or ***in motion***. In analyzing a mechanical system, therefore, the first thing we do is identify all the forces acting on the system. Next, we determine the sum (resultant) of the forces. If the sum of the forces is ***zero***, we know the system is ***at rest***. If the sum of the forces is not zero, the system is ***accelerating*** in the direction of the resultant force.

- **THE CONCEPT OF "AT REST"**

When we say "at rest" in everyday language, we interpret it as "not moving at all." However, in physics, the term "at rest" has a different meaning. It is important to note this difference so as not to be confused.

In mechanics, "at rest" means ***constant velocity***. Since velocity is a vector, it has both a magnitude and a direction. If the velocity is to be constant (not changing), then ***both*** the magnitude ***and*** the direction cannot change. There is only one way to have **constant velocity**: to go at the same speed ***and*** in the same direction. This means going in a ***straight line***. Any object not going in a straight line is changing direction and is, therefore, not going at constant velocity. As a result, in physics, any object not going in a straight line **is not at rest**.

HISTORICAL NOTE

When Albert Einstein came out with his Theory of Relativity, he did so in two parts. The first part, which he called the Special Theory of Relativity and published in 1905, dealt with **Statics**. The second part, which he called the General Theory of Relativity and published in 1915, dealt with **Dynamics**.

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1. Which of Newton's Laws of Motion do the following branches of ***mechanics*** deal with:

a) **STATICS** **First law of motion (Law of Inertia)**

b) **DYNAMICS** **Second law of motion (Law of Acceleration)**

2. Define ***acceleration***.

The change in velocity per unit time.

3. Define ***equilibrium***.

The state in which the net or resultant force equals zero (all forces cancel out).

4. Explain the difference between ***distance*** and ***displacement***.

Distance is a scalar (has no direction), displacement is a vector (has direction).

5. What is meant in physics by the term ***at rest***?

At "rest" in statics means that the system is in equilibrium.

6. State ***three*** conditions necessary for a system to be in ***equilibrium***.

① **$F_R = 0$**

② **Velocity is constant**

③ **Acceleration = 0**

7. The resultant force is also known as the ***sum*** or net force. Is it possible for a system to have more than one resultant force? Explain.

No. Just as any set of numbers has only one sum,
any system of forces has only one resultant force.

8. What two conditions must be valid for a system to be going at ***constant velocity***?

① **Maintain the same magnitude (size).**

② **Maintain the same direction (straight line).**

9. Tell whether or not each of the systems described below is ***at rest*** (in equilibrium).

a) Yes A book resting on a table.

b) No A book falling to the floor.

c) No A car traveling at constant speed around a circular road.

d) No A car speeding up on a highway.

e) Yes A train going at the same speed on a (level) track.

f) No A bus coming to a stop.

g) No A rock thrown into the air.

h) No A pendulum swinging to-and-fro.

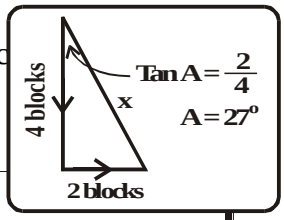
i) No A child on a merry-go-round.

j) Yes A plane cruising at constant speed in a (level) line.

10. A train is traveling at a ***constant velocity*** of 80 km/h. If the windows are kept closed so that it is impossible to look outside, what experiment can the people inside the train perform to indicate to them that they are moving?

There is no experiment they can perform to indicate that they are moving.

11. Calculate the ***distance*** and the magnitude of the ***displacement*** for each of the following:



a) Susan walks four blocks south and two blocks east.

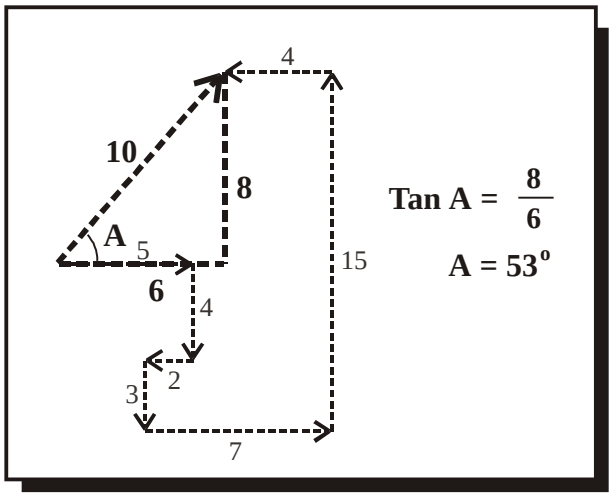
Distance = 4 blocks + 2 blocks = 6 blocks

Displacement: $x^2 = 4^2 + 2^2$ Thus, x = 4.5 blocks 27^o E of S

b) Riding his bike, Peter goes two kilometers to a store and then returns home.

Zero

12. Illustrated below is the route of a car as it travels from point-A to point-B. Determine both its distance and displacement. (Note that distances are in kilometers).



Distance = 40 km **Displacement = 10 km at 53° N of E**

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