III. RATE OF LENGTH CHANGE

Now that you understand the difference between distance and displacement, let us study motion. The world is full of examples of **motion**. We will first study the rate at which distance changes with respect to time, then we will observe the rate at which displacement changes with respect to time. The first produces a derived scalar quantity called **speed** and the latter, a derived vector quantity called **velocity**. The layman uses these terms interchangeably, but the scientist insists on distinguishing between them. We will begin with ideas on motion from the ancients like Aristotle, proceed to concepts developed by Galileo, and conclude with the expressions used in the study of **kinematics** today.

SECTION OBJECTIVES

Review these objectives. When you have completed this section, you should be able to:

9. Distinguish between speed (a scalar) and velocity.
10. Calculate problems involving speed and velocity.
11. Distinguish between average speed and average velocity.
12. Calculate problems involving average speed and average velocity.

VOCABULARY

Study these words to enhance your learning success in this section.

average speed	law of inertia	velocity
average velocity	motion	
kinematics	speed	

SPEED

Speed is a derived scalar defined as a change in distance (traveled) divided by a change in time (the time required to travel the distance). This relationship can be symbolized:

$$S \text{ (speed)} = \frac{\Delta d}{\Delta t} \text{ in meters per second } (^m/_{sec})$$

The symbol Δ is the Greek letter *delta*, which means *change in*; and the units are in meters per second (metric). Over two thousand years ago, the Greek philosopher, Aristotle, believed that **motion** was a property of matter and that what he termed "violent motion" was the result of objects being pushed or pulled (forced). "Natural motion," however, was the result of objects moving to reach their natural, proper place (like a rock falling off a cliff to rest at the bottom.)

Galileo differed with Aristotle in that he believed that an object in motion will keep moving and that an object at rest will remain at rest unless an external push or pull (force) acts on the object.

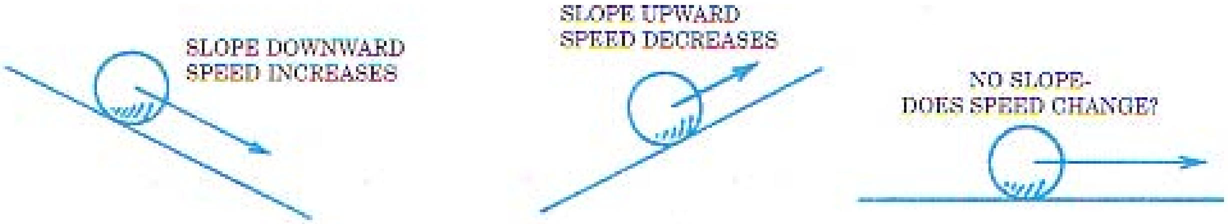

FIGURE 4: GALILEO'S MODEL OF MOTION

3.11 Calculate the change in temperature of 20 kg of water if 30 kg of aluminum is dropped in the water and the aluminum changes temperature by 20° C (hint, use the principle of conservation of energy).

3.12 If 10 calories of energy are added to 2 grams of ice at -30° C, calculate the final temperature of the ice. (Notice that ice has a specific heat different from that of water.)

LATENT HEAT

Between a substance's phase boundaries, a given heat increase (or decrease) produces a given increase (or decrease) in temperature. Across phase boundaries, however, no such temperature change occurs. All heat that is added during a phase change goes toward altering the bonds that hold molecule to molecule. An investigation of water yields the following results.

Latent heat of fusion. If 1 gram of water is at 10° C, removing 1 calorie changes the temperature by 1 Celsius degree to 9° C. Removal of 9 more calories drops the temperature to 0° C. At this point, however, removal of any more heat does not change the temperature at all; but now ice begins to form. In fact, 80 calories of heat must be removed for each gram of water (80 kilocalories from 1 kilogram) in order for the water to freeze at 0° C! The $80^{cal}/_{gm}$ (or $80^{kcal}/_{kg}$ is called the **latent** (or hidden) **heat of fusion** (L_f). The term *latent* is used because no change in temperature results, and the heat seems to be "hidden"!

If a substance is in the solid phase (such as ice) the amount of heat needed to change it to a liquid is found through the equation:

heat = (m)(C)(Δt) the heat needed to raise it to the melting point
+ (m)(L_f) the heat needed to melt it
+ (m)(C)(Δt) the heat needed to raise it to its final temperature in the liquid phase

Solid Substance	Melting Point (°C)	Latent Heat of Fusion $^{kcal}/_{kg}$
ice	0	80
oxygen	-219	3.3
aluminum	660	93
copper	1,083	51
iron	1,539	65
tungsten	3,400	44
lead	330	6
mercury	-39	2.8
zinc	420	24
alcohol (ethyl)	-114	25

LATENT HEATS OF FUSION

Example

How much heat is needed to raise 2 g of ice (C_{solid} =0.5) at -15° C to water (C_{liquid} = 1) at 35° C?

heat = (2 g)(0.5)(15°C) + (2 g)(80 $^{cal}/_{g}$) + (2 g)(1)(35° C)
= 15 cal + 160 cal + 70 cal
heat = 245 cal

The first term accounts for the change in temperature to raise the ice from -15° C to the melting point (0° C). The second term accounts for the phase change. The third term accounts for the change in temperature of the melted ice (0° C) to its final temperature of 35° C.

Complete these sentences (each answer, 3 points).

2.01 Resistance is inversely proportional to ________.

2.02 Resistance is inversely proportional to the ________ of the conductor.

2.03 The unit of resistance is the ________.

2.04 The unit of resistivity is the ________.

2.05 Resistance is directly proportional to the a. ________ and b. ________ of the conductor.

2.06 The proportionality constant that relates resistance with length and area is the quantity called ________.

2.07 The conductivity of water can be increased by adding ________.

2.08 Materials with resistivities between those of good conductors and those of insulators are called ________.

2.09 Across a resistor, voltage ________.

2.010 Another name for voltage is ________.

Answer *true* **or** *false* (each answer, 1 point).

2.011 ________ Voltage drops across sources of emf.

2.012 ________ A battery converts mechanical energy to chemical energy.

2.013 ________ The electrical analogy to height in a fluid flow system is potential.

2.014 ________ Current and resistance have an inverse relationship.

2.015 ________ Conductance is directly proportional to the length of a conductor.

Complete these activities (each answer, 5 points).

2.016 Compute the resistance of a 90-cm length of copper wire with a 0.02 -cm^2 cross-sectional area ($\rho = 1.8 \cdot 10^{-6}$ ohm-cm).

2.017 Compute the conductance of a length of silver wire whose resistance is $4.0 \cdot 10^{-4}$ ohms.

2.018 Compute the conductivity of a conductor with a length of 2 cm and a cross sectional area of 0.06 cm^2, whose conductance is $3.5 \cdot 10^3$ mhos.

40/50

Score ________
Adult check ________
Initial **Date**

SCIENCE 1210

LIFEPAC TEST

105/131

Name ______________________

Date ______________________

Score ______________________

SCIENCE 1210: LIFEPAC TEST

These data may be useful.

Particle	Mass (amu)
proton	1.007593
neutron	1 .008982
deuteron	2.014186
triton	3.016448
helium 3	3.015779
helium 4	4.003873

$1 \text{ ev} = 1.6 \cdot 10^{-19} \text{ j}$

$1 \text{ emu} = 931 \text{ Mev}$

$1 \text{ angstrom } (\text{Å}) = 10^{-10} \text{ m}$

$h = 6.63 \cdot 10^{-34} \text{ j-sec.}$

Match these items (each answer, 2 points).

1. _____ length
2. _____ current
3. _____ acceleration
4. _____ force
5. _____ mass
6. _____ charge
7. _____ frequency
8. _____ atomic unit of energy
9. _____ atomic unit of mass
10. _____ electric potential

a. ampere
b. coulomb
c. volt
d. hertz
e. electron volt
f. meter
g. newton
h. faraday
i. atomic mass unit
j. kilogram
k. meter/sec./sec.