Physics 199 Physics of Music

Lecture Notes Week II
[Chapter I — Acoustical Foundations of Music]

<u>3 Fundamental Physical Quantities</u>:

n.b. We use the System International/Metric System Units: kilograms – meters – seconds

<u>Length</u> — meter (m): 1m = 39.37 inches = 3.28 ft
1 ft = 0.3048 m

1 cm = 1/100 m (centi-meter)
1 mm = 1/1000 m (milli-meter)
1 μm = 1/1,000,000 m (micro-meter)

<u>Mass</u>: — kilogram (kg)
1 kg = 1000 grams
1 gm = 1/1000 kg

<u>Time:</u> — second (s) (or sec)
1 day = 24 hours = 24 ∗ 60 minutes = 1440 minutes
= 24 ∗ 60 ∗ 60 seconds = 86,400 seconds

<u>Additional physical quantities we will need in this course</u>:

<u>Velocity</u> = time <u>rate</u> of <u>change</u> of position, <u>and</u> in which <u>direction</u> the change of position is occurring.

<u>Speed</u> = time rate of change of position

Thus <u>Velocity</u> = speed in a given direction, e.g. in east direction, or up, or down, etc.

Speed = magnitude of the velocity. (i.e. "length" of velocity)

Speed, $v = \dfrac{\text{distance, } d}{\text{travel time, } t}$ $\boxed{\boldsymbol{v = \dfrac{d}{t}}}$ (meters per second, i.e. m/s)

Distance traveled, d = (speed, v) ∗ (travel time, t) $\boxed{\boldsymbol{d = v * t}}$ (meters, i.e. m)

Travel time, t = (distance d)/(speed, v) $\boxed{\boldsymbol{t = d / v}}$ (seconds, i.e. s, or sec)

Acceleration = time rate of change of velocity, and a direction (up, down, east, west, etc.)
(units = meters per second squared, i.e. m/s^2)

Speed increasing with time — accelerating

Speed decreasing with time — decelerating

a = magnitude (size) of acceleration

$$a = \frac{\text{speed, } v}{\text{time interval, } t} \qquad \boxed{a = v/t} \qquad \boxed{t = v/a} \qquad \boxed{v = at}$$

Actual formula(s) for motion of an object in one dimension with constant acceleration:

$$\boxed{x(t) = \underbrace{x_o}_{\substack{\text{Initial}\\ \text{position}}} + \underbrace{v_o}_{\substack{\text{Initial speed}\\ \text{in } x\text{-direction}}} t + \tfrac{1}{2} at^2} \qquad \boxed{v(t) = \underbrace{v_o}_{\substack{\text{Initial speed}\\ \text{in } x\text{-direction}}} + at} \qquad \boxed{a(t) = a = \text{constant}}$$

Force: — (units = Newtons = kg-m/s^2)

Newton's 2nd Law of motion: Force = (mass, m) ∗ (acceleration, a)

$$\boxed{F = \underbrace{m}_{kg}\underbrace{a}_{m/(\text{sec})^2}} \quad \text{[metric units of force = Newtons]}$$

1 Newton of force = 1 kg -$m/(sec)^2$

Weight, W = (mass, m) * (gravitational acceleration, g) = Force

$g = 9.81\ \text{m}/(\text{sec})^2$ (at sea level) $\quad g = \dfrac{G_N * M_{\text{earth}}}{(R_{\text{earth}})^2}$

$$\boxed{\boldsymbol{W = mg}}$$

Pressure: — Pressure = Force per unit area, A

$P = F/A$ (Newtons/(meter)^2

Metric units of pressure ≡ Pascal, Pa (1 Pascal = 1 Newton/m^2)

Work & Energy: — Work = Force, $F * $ Distance, d

energy $\boxed{\boldsymbol{W = F * d}}$ = energy required to e.g. move an object weighing Weight, $W = mg$ a distance, d

Metric units of work & energy = Joule = Newton-meter

(Total) Energy is (always) conserved

Energy required to move an object electrical, gravitational, wind, chemical, etc.

Power: Power = time rate of change of energy (units = Watts)

$$\{\text{Average}\}\ \text{Power, } P = \frac{\text{energy expended, } E}{\text{time interval, } t}$$

$$\boxed{P = E/t}$$

Watts = Joules per second

Watts = Joules/sec

1 kilowatt = 1000 watts

1 megawatt = 1 million watts

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