

Physics 199 Physics of Music

Lecture Notes Week II

[Chapter I — Acoustical Foundations of Music]

3 Fundamental Physical Quantities:

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

Length — meter (m): 1 m = 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 μ m = 1/1,000,000 m (micro-meter)

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

Time: — second (s) (or sec)
1 day = 24 hours = 24 * 60 minutes = 1440 minutes
= 24 * 60 * 60 seconds = 86,400 seconds

Additional physical quantities we will need in this course:

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

Speed = time rate of change of position

Thus Velocity = 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)

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

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

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

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

$$a = \frac{\text{speed, } v}{\text{time interval, } t}$$

$$a = v/t$$

$$t = v/a$$

$$v = at$$

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

$$x(t) = x_0 + v_0 t + \frac{1}{2} a t^2$$

↑ Initial position
↑ Initial speed in x-direction

$$v(t) = v_0 + at$$

↑ Initial speed in x-direction

$$a(t) = a = \text{constant}$$

Force: — (units = Newtons = $kg \cdot m/s^2$)

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

$$F = ma$$

↑ kg
↑ $m/(sec)^2$

[metric units of force = Newtons]

1 Newton of force = $1 \text{ kg} \cdot m/(sec)^2$

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

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

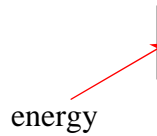
$$W = mg$$

Pressure: — Pressure = Force per unit area, A

$$P = F/A \quad (\text{Newtons}/(\text{meter})^2)$$

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

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

 $W = F * d$ = 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)

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

$P = E/t$ Watts = Joules per second
Watts = Joules/sec

1 kilowatt = 1000 watts

1 megawatt = 1 million watts

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