Phys 111 2023

Lecture 38

Mon: HW by 5pm

Ex 339, 342, 344, 345, 346, 347, 349, 350

Weds: Warm Up 15 (D2L)

Oscillatory motion

Periodic or oscillatory motion is that where the system repeats a basic pattern over and over.

DEMO: * Mass/Spring

* Pendulum

* Tacoma Narrows bridge.

Examples of such motion are:

1) vibrations in matter
2) atom + molecular systems
3) electric oscillations in circuits
4) musical instruments.

DEMO: PhET Normal Modes – Two Dimensions

– set up lattice + show vibrations

We will provide a language for describing oscillatory motion. This will also be useful for

1) wave phenomena
2) modern/quantum physics.

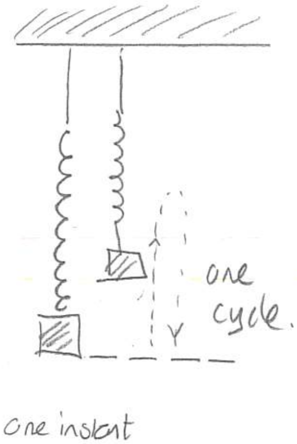
Basic features of oscillatory motion

In oscillatory motion, the same basic pattern repeats. A single instance of this is called a cycle of oscillation.

> One cycle is the segment of motion from one instant with a particular state of motion to the next instant with the same state of motion

DEMO: PhET Spring and Mass - Bounce tab

~~* Place differ same masses on springs~~



There are two aspects to this motion:

1) spatial ~ distances traveled / locations
2) temporal ~ related to motion as time passes.

DEMO: PhET M+Sp - Bounce Tab

* Same masses on different springs → larger amplitude
→ smaller "

The spatial aspect is described by:

> The amplitude of oscillation is the maximum displacement from equilibrium. Spring: measured in meters

The temporal aspects concern the rate at which motion occurs.

DEMO: PhET M+Sp - Bounce Tab

- Spring 1 100g
- Spring 2 250g

→ different time evolution

These can be described by two related quantities:

The period of oscillation, T, is the time taken to complete one cycle.

units: seconds
s

and

The frequency of oscillation is $f = \frac{1}{T}$

units: Hertz $Hz = s^{-1}$

The frequency is roughly the number of cycles completed each second.

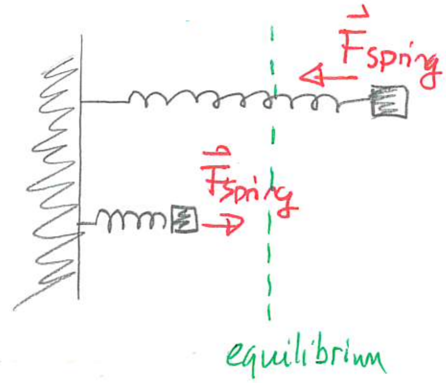
Quiz 1 70% - 90%

Quiz 2

The frequency of oscillation depends on physical characteristics of the system. Typical ranges are:

mass/spring	$0.10\,Hz \to 10\,Hz$
audible sound	$20\,Hz \to 10\,000\,Hz$
radio waves	$10^8\,Hz$
light waves	$10^{14}\,Hz$.

Simple harmonic motion



Oscillations arise in mechanical systems when

1) there is a force that tends to restore equilibrium
2) the restoring force is proportional to the displacement from equilibrium.

In a given system, such as a spring and mass, one can apply Newton's laws to analyze the system motion. These are often recast into a calculus form and the resulting equations give:

1) the graph of position versus time will be a sinusoidal function.

DEMO: MIT Tech TV Spray Paint Oscillator

2) the frequency and period of oscillation are independent of the amplitude.

Quiz 3 70%

The frequency of oscillation emerges after applying Newton's Laws. For

1) spring and mass

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

k → spring constant
m → mass

2) pendulum (small oscillations)

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{L}}$$

g → (local) acceleration due to gravity
L → length of pendulum

348 Pendulum and Earth's gravity

The acceleration due to Earth's gravity varies with distance from Earth's center. At a particular location on Earth a pendulum with length 0.800 m swings with a period of 1.797 s. Determine the acceleration due to Earth's gravity at this location. *(111F2023)*

Answer:

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{L}}$$ means need f.

$$f = \frac{1}{T}$$

$$f = \frac{1}{1.797\,s} = 0.5565\,Hz.$$

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{L}} \Rightarrow 2\pi f = \sqrt{\frac{g}{L}}$$

$$\Rightarrow (2\pi f)^2 = \frac{g}{L}$$

$$\Rightarrow 4\pi^2 f^2 = \frac{g}{L}$$

$$\Rightarrow g = 4\pi^2 f^2 L$$

$$= 9.78\,m/s^2$$