Optics and Waves

School of Physics and Astronomy
University of Birmingham

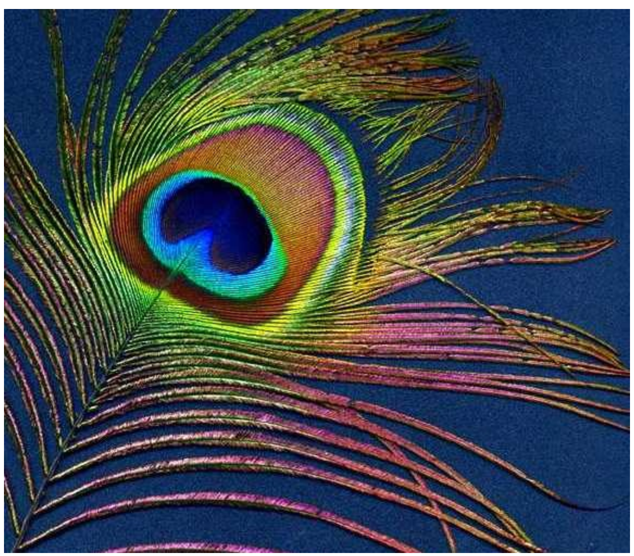
Why is the sky blue?

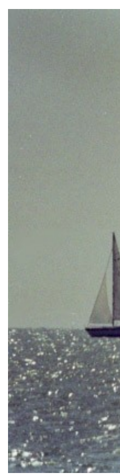
Why is the Sun red at sunrise/sunset?

Why does the Sun look squashed?

How does a rainbow form?

Why do rainbows come in pairs somet





What gives a peacock its pretty colour?

http://newt.phys.unsw.edu.au/jw/brassacoustics.html

Optics and Waves

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11.00 Tues. Law LT1
12.00 pm Weds. Arts Main

Canvas: Optics and Waves

22 lectures + 1 revision

Objectives

- Have a sound understanding of basic wave properties.
- Have a basic understanding of interference effects, including diffraction.
- Be able to use simple geometrical optics and understand the fundamentals of optical instruments.

Textbooks:

Young and Freedman, (University Physics)

Chapters: 15, 16,……33, 34,35,36 (Waves-Optics)

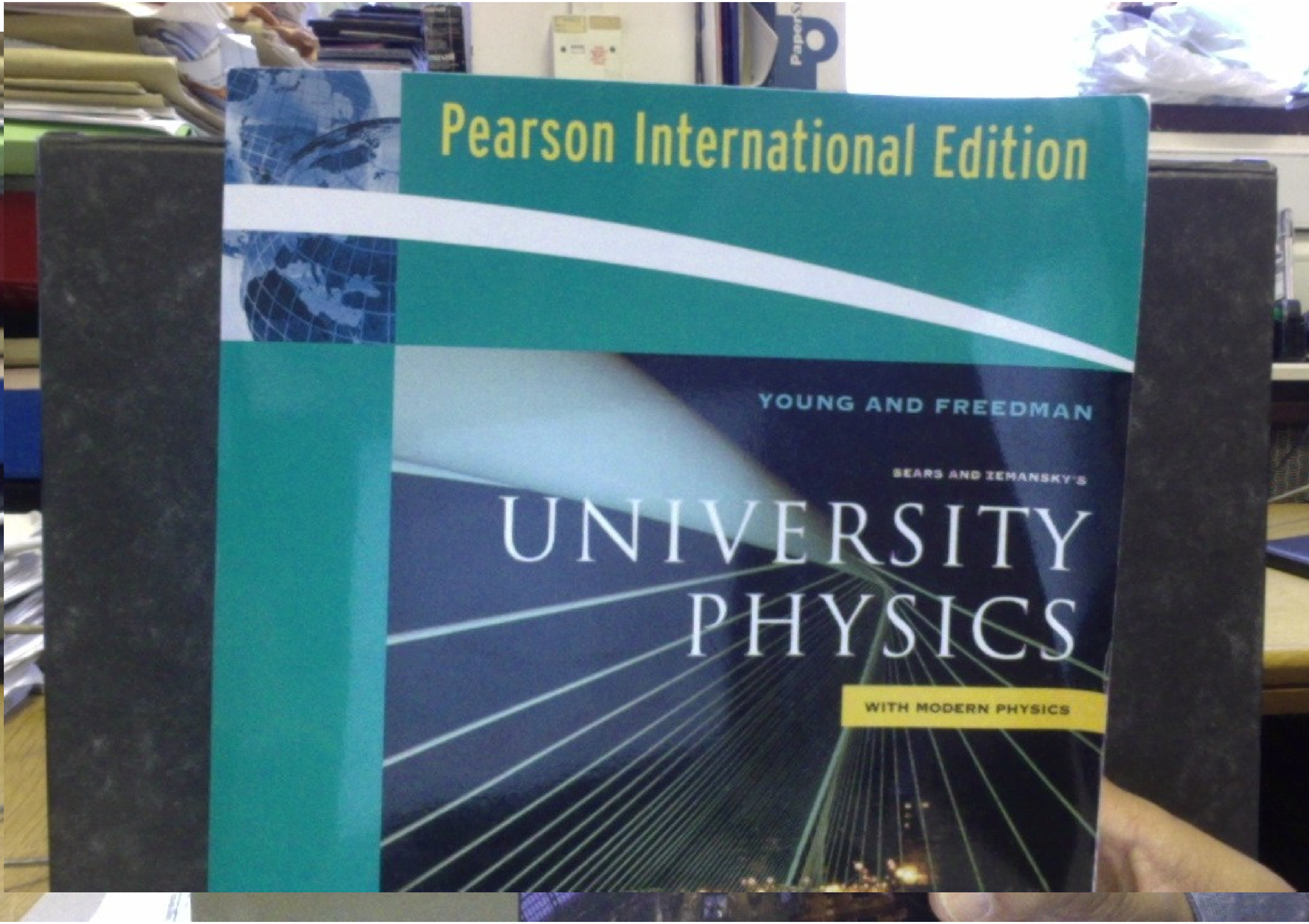
Knight (Physics for Scientists and Engineers) Chapters:

20, 21, ….. 22, 23, 24 (Waves – Optics)

Tipler and Mosca (5th Ed.)

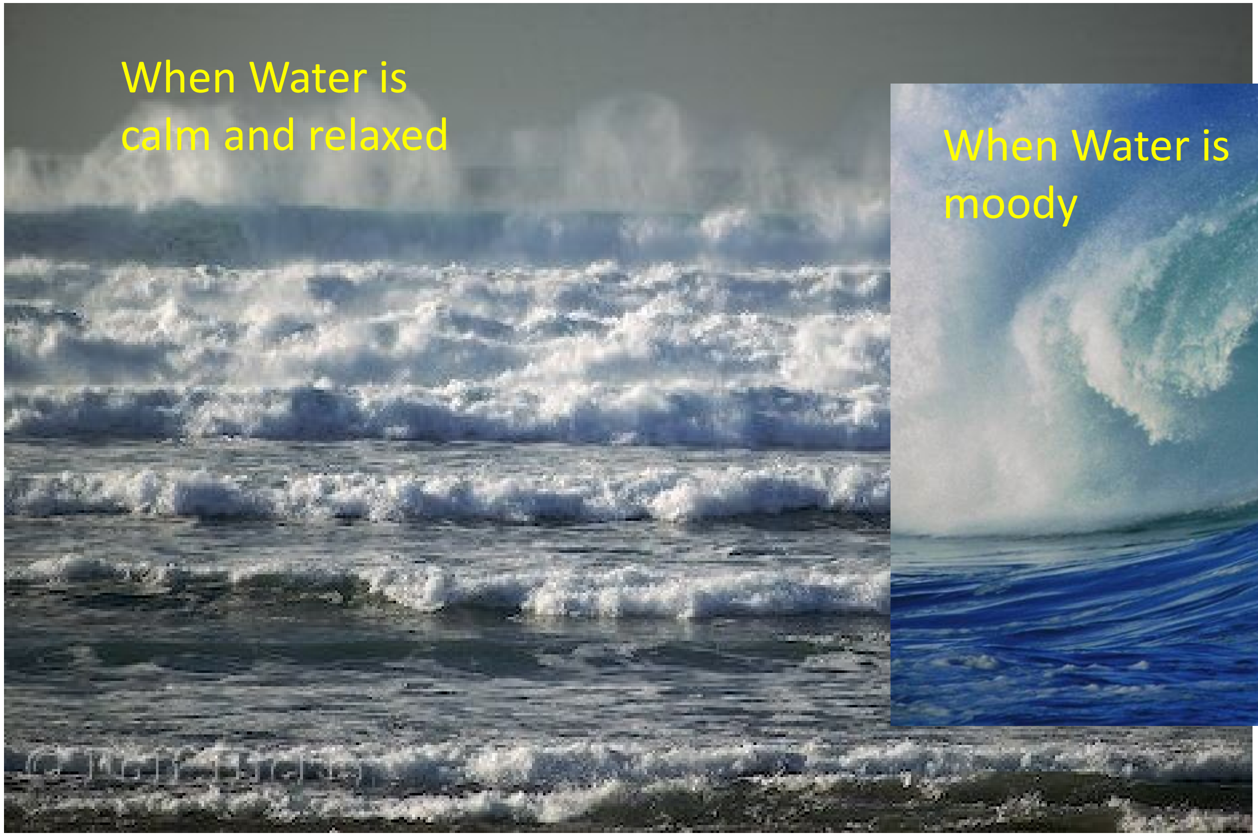
Chapters: 15, 16, ….. 31, 32, 33 (Waves – Optics)

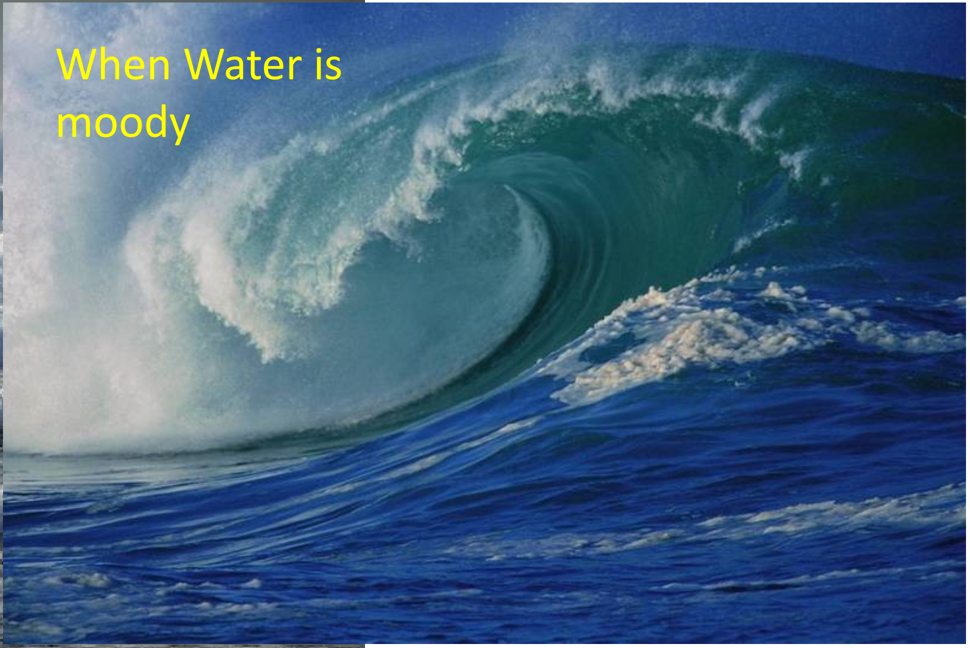
Jenkins and White - Fundamentals of Optics


Pearson International Edition
YOUNG AND FREEDMAN
SEARS AND ZEMANSKY'S
UNIVERSITY PHYSICS
WITH MODERN PHYSICS

Waves can occur whenever a system is disturbed from equilibrium and when the disturbance can travel from one region to another. Waves carry Energy (Earthquake is a kind of wave).

Familiar Waves https://www.shutterstock.com/video/clip-7510351-water-drop-making-ripple-shot-high-speed





There are many types of waves. Light is a particular type of wave.

Aim of this lecture module is to derive **BASIC EQUATIONS** for describing waves, and learn the physical properties of waves.

Mexican wave

Waves are closely linked to periodic motion.
In the following, we will briefly review periodic motion and see how this leads to the creation of waves.

Periodic motion (c

Periodic motion has the following characteristics:

It has a period T: the time for one cycle.

It has a frequency f: the number of cycles per unit time ($f=1/T$).

It has an amplitude A: the maximum displacement from the equilibrium point.

Q: What keeps the periodic motion going?

A: The restoring force. When the object is moved away from its equilibrium position, there is a restoring force trying to bring it back. When it returns to the equilibrium position, it has non zero speed, so it keeps on moving passing the equilibrium position. The process repeats, forever.

Energy

- In terms of energy, exchange of kinetic energy and potential energy.
- Total energy is conserved.

When the restoring force is directly proportional to the displacement from equilibrium

$F = -kx$, (why $-kx$, not just kx?)

The periodic motion becomes a

Simple harmonic motion.

A body undergoes simple harmonic motion is called a harmonic oscillator.

In one dimension, the displacement of a harmonic oscillator is described by:

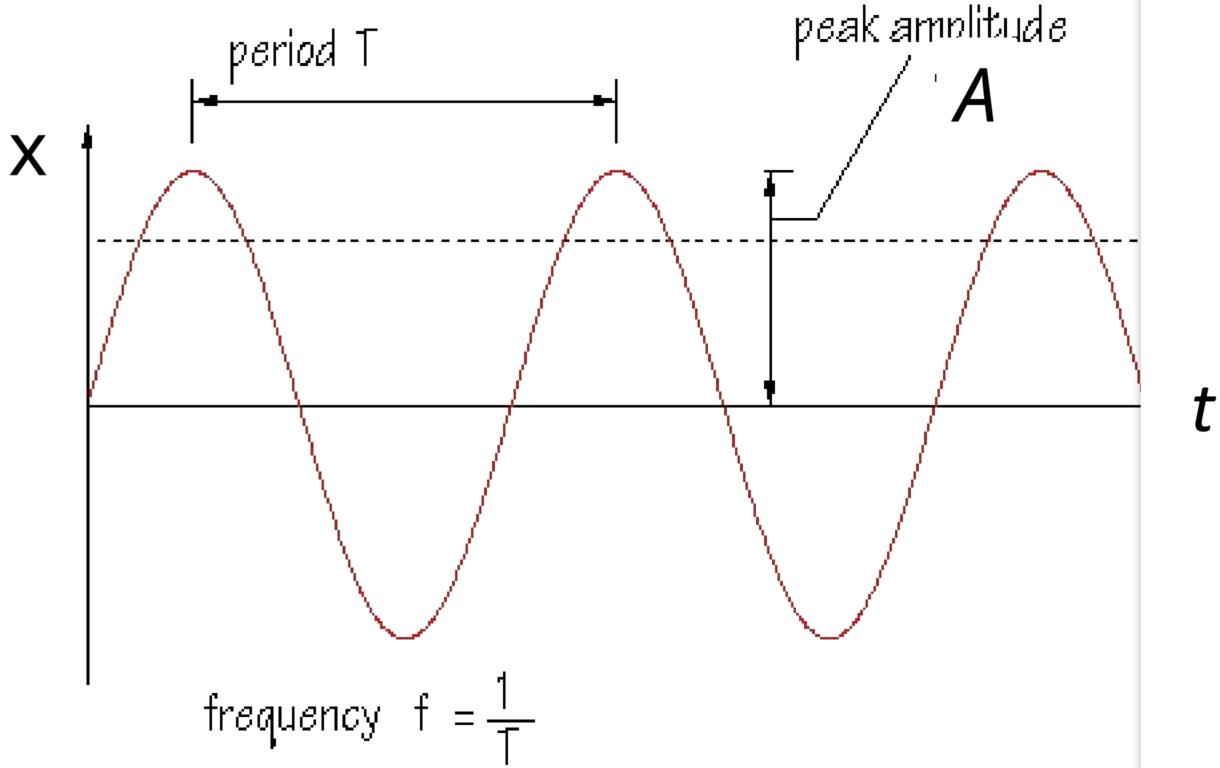
$$x = A\cos\,(\omega t + \phi)$$

Where $\omega = 2\pi f$ is the angular frequency, and ϕ is the phase angle.

$$x = A\cos\ (\omega t + \phi)$$

$$-kx = ma = m\frac{dv}{dt} = m\frac{d}{dt}(\frac{dx}{dt}) = m\frac{d^2x}{dt^2}$$

$$x = A\cos\ (\omega t + \phi)$$



SHM-t

Phase angle here is –90 degrees, an equivalent expression is :

$$x = A\sin\ \omega t$$

Velocity in SHM (simple harmonic oscillator):

$$v_x = \frac{dx}{dt} = -\omega A \sin(\omega t + \phi)$$

Acceleration in SHM:

$$a_x = \frac{dv_x}{dt} = \frac{d^2 x}{dt^2} = -\omega^2 A \cos\ (\omega t + \phi)$$

The signs are used to indicate the directions of velocity and acceleration. Both velocity and acceleration are **vectors**.

Energy in SHM:
With only the restoring force, the total energy is conserved. A swing slows down with time due to the presence of friction and air resistance.

The energy of the oscillator equals the kinetic energy when the object is at its peak speed: (PE+KE). At peak speed (KE), PE is zero.

$$v_x = \frac{dx}{dt} = -\omega A \sin\ (\omega t + \phi)$$

Peak speed in SHM: ωA

Energy in SHM: ½ $m(\omega A)^2$

Each wave can be described by a Wavefunction.

Next Lecture, Wavefunction.