

**Next
Step**
TEST PREP

Physics (waves)

Today's Info Session

- ▶ Welcome to this Info Session!
- ▶ Introduction
- ▶ Physics
 - ▶ Waves
 - ▶ Doppler effect
 - ▶ Standing waves
- ▶ How Can Next Step Help?
- ▶ Questions?

Next
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MCAT
Medical College
Admission Test

WHAT IS YOUR NEXT STEP?

Introduction

Next
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Hi, I'm Phil!

- ▶ **MCAT Content writer**
 - ▶ **Tutored and taught for 9+ years**
 - ▶ **Attended University of Nebraska Medical Center as an MD/PhD student.**
- ✓ **Next Step is a team of test prep and educational experts committed to excellence.**



Who Is Next Step?

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- Began in 2009 as a tutoring company
- Focus on graduate admissions tests only
- Team of educational experts
- First company to have materials built from ground up for 2015 MCAT format
- Now the first company to have new 2018 MCAT Interface

✓ We never stop improving our materials!



Waves

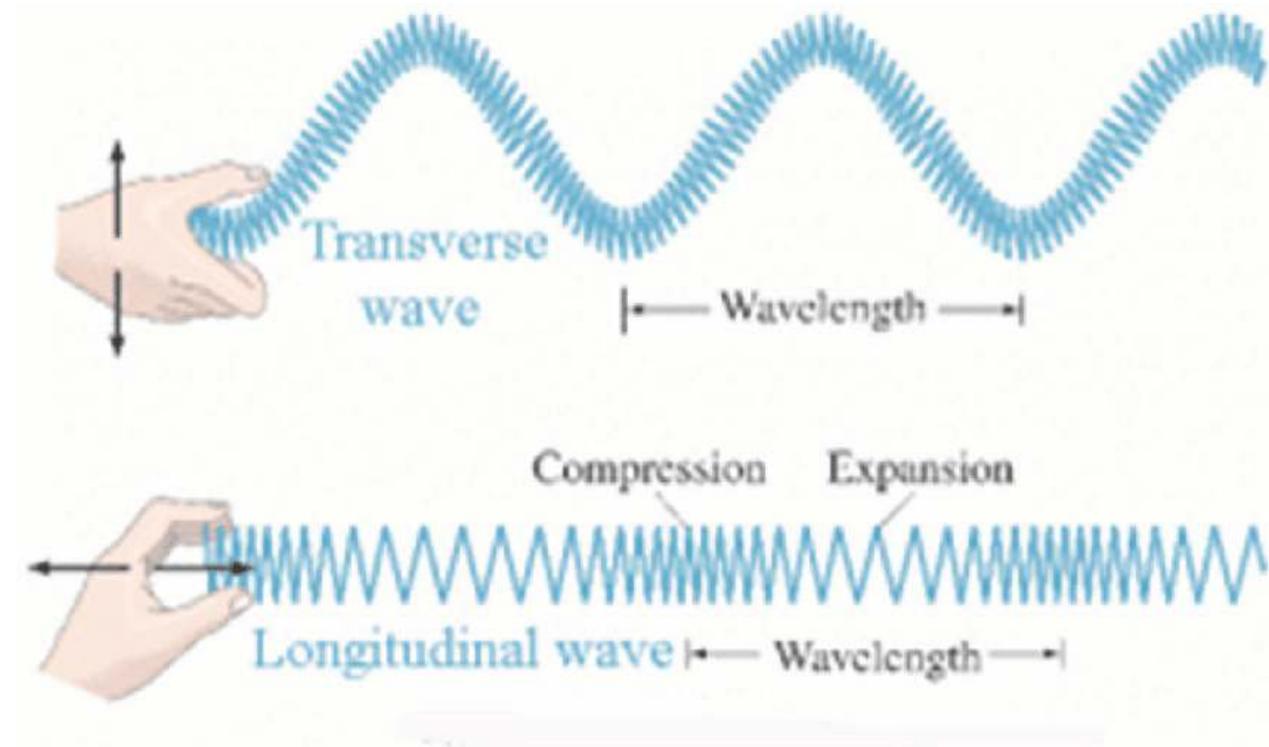
Two main types of waves tested on the MCAT:

Transverse and Longitudinal

Sound?

Light?

Ocean waves?



Waves

Equations!

$$\text{Velocity of a wave} = \lambda f$$

λ = wavelength

f = frequency

Period?

$$T = 1/f$$

How fast do light and sound waves go?

Speed of light:

$$C = 3 \times 10^8 \text{ m/s}$$

Speed of sound (in air)

$$v = 340 \text{ m/s}$$

Waves

Doppler effect

Imagine I have a water balloon gun that fires a water balloon every second. How often do you get hit if the balloons travel at a set speed and I am running towards you?

$$f' = f \left(\frac{v \pm v_o}{v \mp v_s} \right)$$

f' = perceived freq
 f = source freq
 v = speed of wave
 v_o = speed of observer
 v_s = speed of source

Waves

Doppler effect

There is a boombox playing the macarena and it was traveling towards you at twice the speed of sound. You will hear:

- A. The song at twice the pitch
- B. The song backwards
- C. The song at half speed
- D. The song played normally

$$f' = f \frac{v \pm v_o}{v \mp v_s}$$

What if it was traveling at the speed of sound?

Waves

Nodes occur any place you cross the center. (if it just hits the middle, then we count it as a half.

Antinodes occur when the wave hits the sides

Standing waves (double closed)

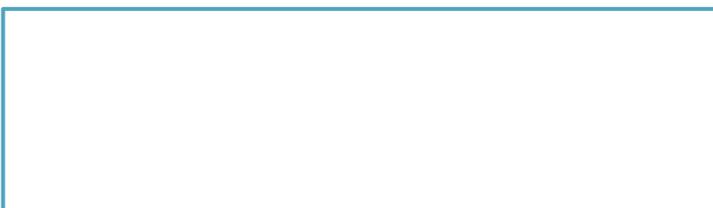
Crosses 1 time total = 1 node = first harmonic



2nd harmonic



3rd harmonic



$$\text{wavelength} = 2L/n$$

**n = number of nodes
and harmonic**

Waves

Nodes occur any place you cross the center. (if it just hits the middle, then we count it as a half.

Antinodes occur when the wave hits the sides

Standing waves (double open)

Crosses 1 time total = 1 node = first harmonic

2nd harmonic

3rd harmonic

wavelength = $2L/n$

n = number of nodes
and harmonic

Waves

Nodes occur any place you cross the center. (if it just hits the middle, then we count it as a half.

Antinodes occur when the wave hits the sides

Standing waves (half open half closed)

Crosses 1 time total = 1 node = first harmonic



3rd harmonic



5th harmonic



$$\text{wavelength} = 4L/n$$

**n = number of
harmonic
(MUST BE ODD!)**

Practice Passage

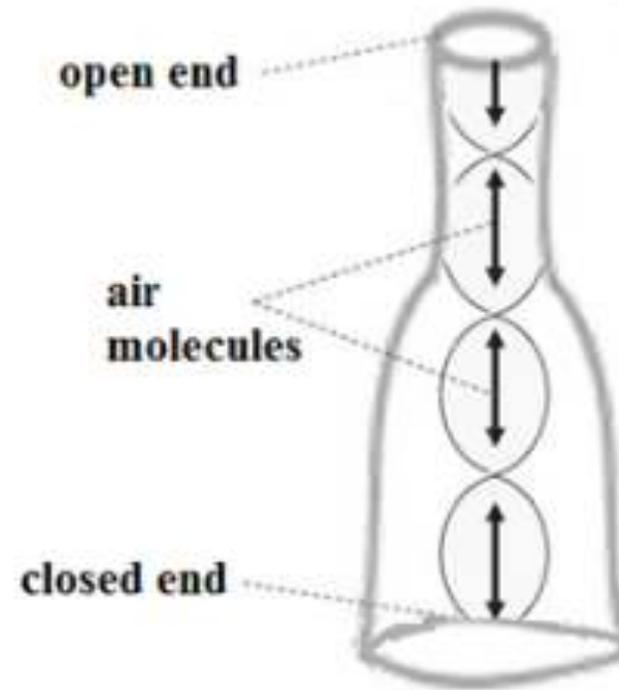
As air is forced out of the lungs, the vocal cords that are stretched over the opening in the larynx vibrate to create pressure waves. Muscles attached to the cords can adjust their tension, changing the frequencies of vibration. The body creates specific sound waves by changing the size and shape of its respiratory resonance cavities.

Each human voice has a unique timbre, produced by the shape of the individual's biological resonance chambers. Harmonics known as overtones also contribute to the timbre of the voice. Humans have a lung capacity of about 1200 cm³. The system is analogous to a closed tube with an average diameter of about 2 cm and a length of approximately 10 cm. Adult males have a fundamental frequency from 85 to 180 Hz while females range from 165 to 250 Hz. The amplitude of the overtones can be affected by manipulating the diameter of resonating chambers (i.e. the mouth).

The human vocal cords are similar to the operation of a bottle whistle, also known as a Helmholtz resonator. As air is blown over the opening of a bottle, it is forced into the empty bottle, creating a pressure gradient. The system responds like a spring, with air being pushed back out of the bottle, causing the pressure inside the bottle to decrease. Air from outside then rushes back into the bottle and the process is repeated. Thus, the air will oscillate in and out of the container at some natural frequency. If air is gently blown over the opening, the sound that is produced is primarily due to the fundamental frequency of the resonating cavity.

Practice Passage

Figure 1 Bottle whistle.



Blowing air more forcefully can result in the production of one or more overtones. The pitch of the fundamental frequency can be changed by adding water to the bottle. Equation 1 allows for the calculation of the fundamental frequency of a bottle.

$$f = \frac{v}{2\pi} \sqrt{\frac{A}{VL}}$$

Equation 1

Practice Pass

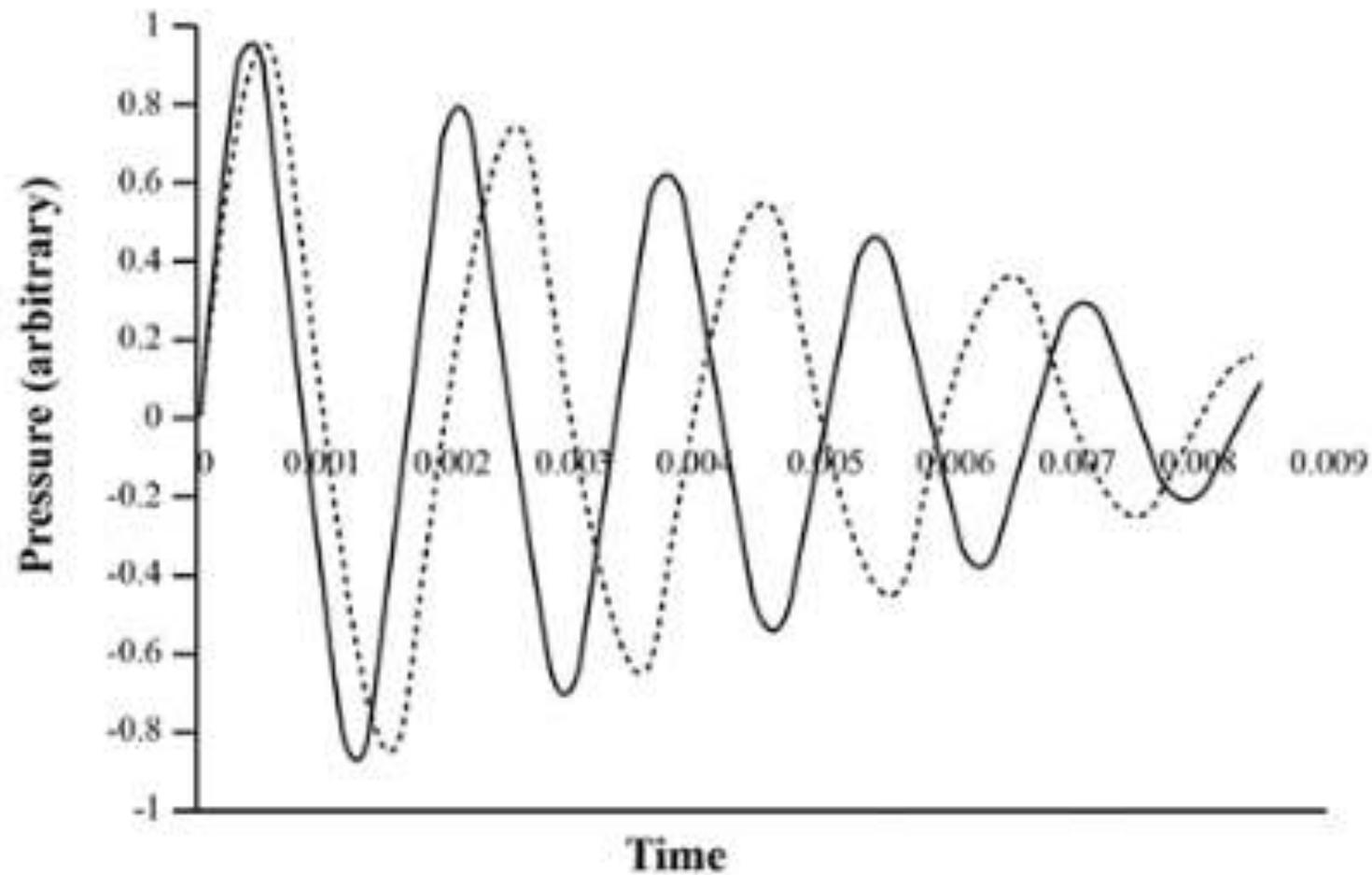


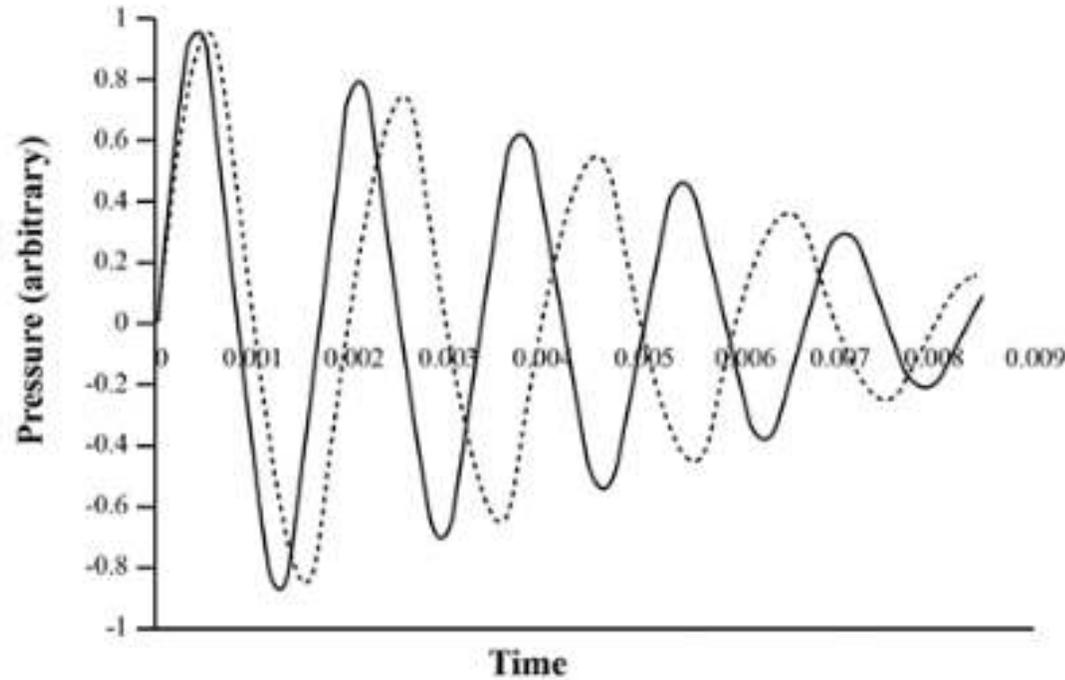
Figure 2 Pressure versus time for two bottles (F1 = solid line and F2 = dashed line)

(Note: Velocity of sound in air = 343 m/s)

Practice Passage

What is the frequency of the lowest pitched tone produced by the bottle whistle in Figure 2?

- A. 500 Hz
- B. 600 Hz
- C. 1000 Hz
- D. 1200 Hz



Practice Passage

According to the passage, what is the predicted fundamental wavelength of the average human vocal cords?

- A. 20 cm
- B. 40 cm
- C. 80 cm
- D. 100 cm

Practice Passage

Which of the following describe the number of nodes and antinodes for a closed tube resonator?

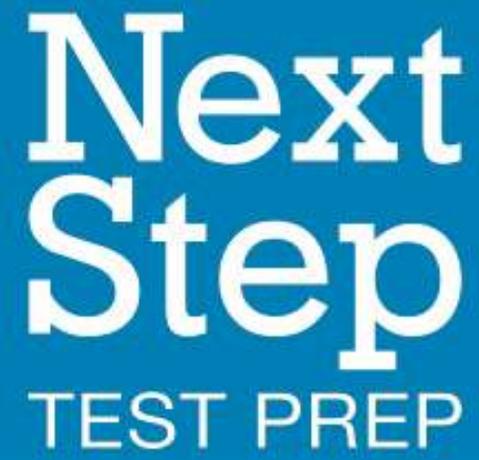
- I. For the fundamental, there is a single node and a single antinode.
 - II. For the third harmonic, there are two nodes and two antinodes.
 - III. For the fifth harmonic, there are three nodes and three antinodes. The pitches get higher and the loudness stays the same
-
- A. I only
 - B. I and III only
 - C. II and III only
 - D. I, II, and III

Practice Passage

Which of the expressions below correctly shows the relationship between the pressure inside and outside of the bottle when the person is blowing over the mouth of a bottle filled with air?

- A. Pressure inside $<$ Pressure outside
- B. $2(\text{Pressure inside}) = \text{Pressure outside}$
- C. Pressure inside $>$ Pressure outside
- D. Pressure inside $=$ Pressure outside

This is fluid dynamics!

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Q&A

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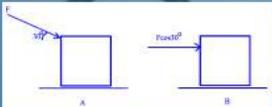
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Question of the Day

Two people push a box along a frictional surface. One pushes the box at an angle of 30° to horizontal with force F while the other pushes the box horizontally with force $F\cos 30^\circ$. Which person does the most work?

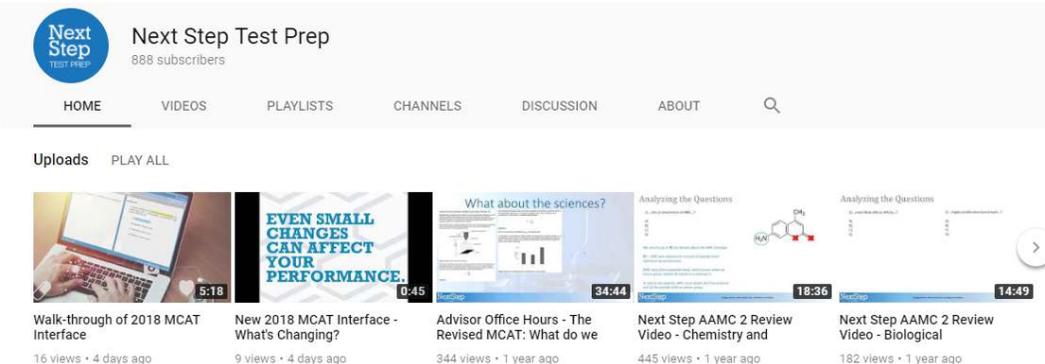


A) Person A
B) Person B
C) Person A and B do equal amounts of work
D) cannot be determined

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New 2018 MCAT Interface

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- New highlighting features
- New strikethrough features
- New keyboard shortcuts
- New Navigation/Review Screens

Next Step is ready. Are you?

Medical College Admission Test - Clara Gillan Time Remaining: 01:21:34 18 of 59

Highlight Strikethrough

Remove Highlight

Pause

Figure 1 Eosinophil activation as measured by percent of CD69-positive cells after 3 and 12 hours of co-culture (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$)

Next, researchers aimed to assess the effect of NK co-culture on eosinophil degranulation. After 3 and 12 hours of co-culture, samples were centrifuged at 1500 rpm, and ECP levels were measured in the supernatants (Figure 2). No ECP was detected in supernatant culture of NK cells alone.

Question 18

Which of the statements below is supported by the experimental results, as shown in Figures 1 and 2?

- A. The duration of Eos co-culture with NK cells directly and linearly correlates to the amount of ECP found in the supernatant after centrifugation.
- B. Cells cultured with a 1:1 NK-to-Eos ratio displayed statistically similar levels of activation to cells cultured with a 5:1 NK-to-Eos ratio, as measured by CD69 expression.
- C. NK co-culture stimulates Eos activation while inhibiting degranulation.
- D. Co-culture with NK cells significantly increased Eos degranulation in all groups, as compared to Eos cells cultured alone.

Periodic Table Review Screen

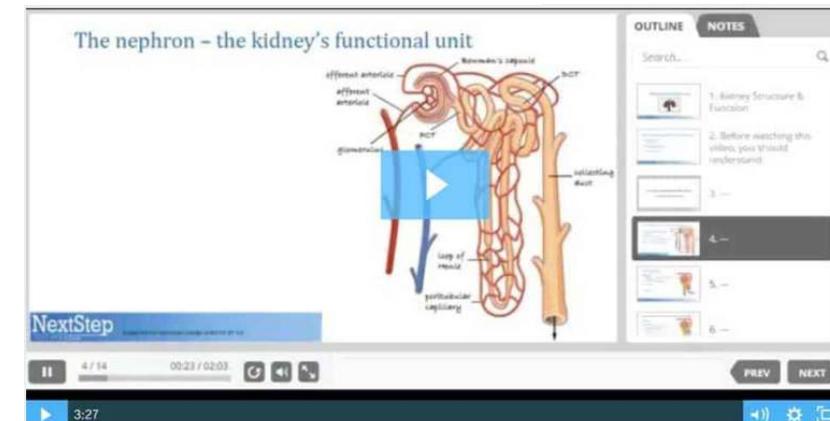
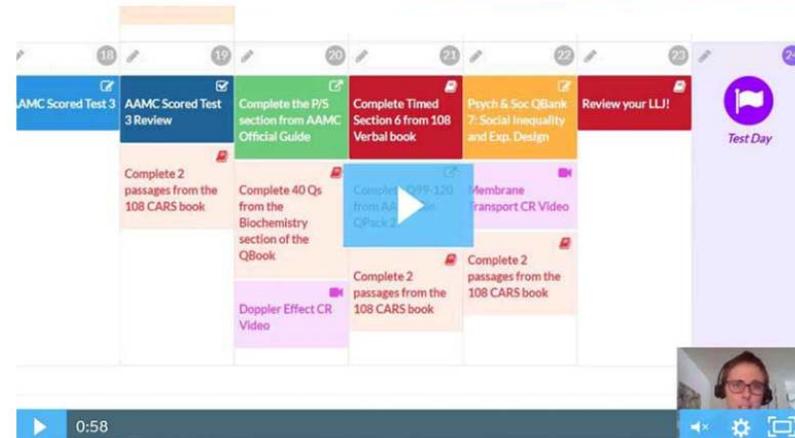
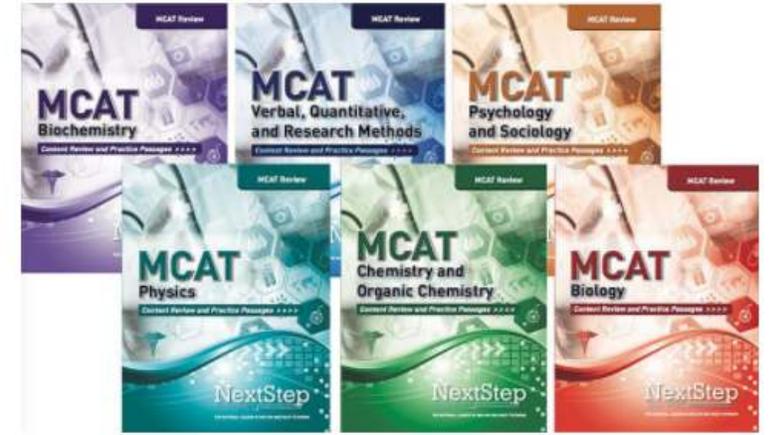
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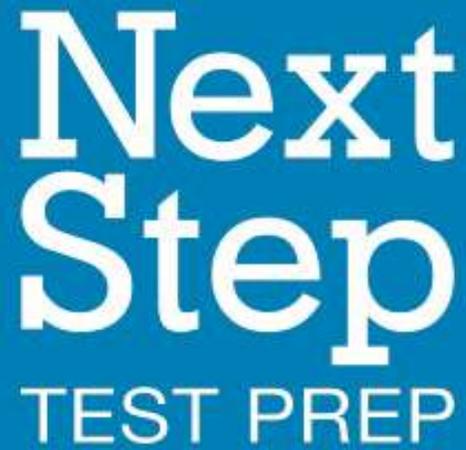
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Electricity and Magnetism

$$F = kQ_1Q_2 / r^2$$

$$F = qVB\sin\theta$$

$$F = iLB\sin\theta$$

$$V = IR$$

$$P = IV$$

$$R = \rho L / A$$

$$V_{rms} = V_{max} / \sqrt{2}$$

$$I_{rms} = I_{max} / \sqrt{2}$$

Resistors in series:

$$R_{tot} = R_1 + R_2 \dots$$

Resistors in parallel:

$$1/R_{tot} = 1/R_1 + 1/R_2 \dots$$

Capacitors in series:

$$1/C_{tot} = 1/C_1 + 1/C_2 \dots$$

Capacitors in parallel:

$$C_{tot} = C_1 + C_2 \dots$$

$$C = Q/V$$

$$\text{Energy} = (1/2)QV$$

$$F = qE$$

$$V = Ed$$

$$\text{Energy} = qEd$$

$$E = kQ/r^2$$

$$\text{Energy} = kQq/r$$

$$V = kQ/r$$

$$\Delta G = -nFE$$

$$E_{cell} = E_{cath} - E_{an}$$

Waves

$$v = f\lambda$$

$$T = 1/f$$

Light

$$n_1\sin\theta_1 = n_2\sin\theta_2$$

$$\sin\theta_c = n_2/n_1$$

$$E = hf$$

$$m = -d_i / d_o$$

$$P = 1/f$$

$$f = (1/2)\lambda r$$

$$n = c/v$$

$$1/f = 1/d_i + 1/d_o$$

Sound

$$d\beta = 10 \log(I/I_0)$$

$$L = n\lambda/2 \quad (n=1, 2, \dots)$$

$$L = n\lambda/4 \quad (n=1, 3, \dots)$$

$$f_{beat} = |f_1 - f_2|$$

$$f = f_s [v \pm v_d] / [v \pm v_s]$$

Fluids

$$\rho = m/V$$

$$P = F/A$$

$$P = P_{atm} + \rho g d$$

$$F_b = \rho g V$$

$$Q = Av$$

$$P + \rho g y + (1/2) \rho v^2 =$$

constant

Gases

$$PV = nRT$$

$$\text{Boyle: } PV = k$$

$$\text{Guy-Lussac: } P/T = k$$

$$\text{Charles: } V/T = k$$

$$\text{Avogadro: } n/V = k$$

$$R_1/R_2 = \sqrt{m_2/m_1}$$

$$P_A = X_A \times P_{tot}$$

Solutions

$$pH = pK_a + \log(A^-/HA)$$

$$M = \text{mol} / L$$

$$m = \text{mol} / \text{kg}$$

$$N = M \times \# \text{ of } H^+$$

$$pH = -\log[H^+]$$

$$M_i V_i = M_f V_f$$

$$\Pi = MRT$$

$$\Delta T_f = i k_f m$$

$$\Delta T_b = i k_b m$$

$$X_A = \text{mol}_A / \text{mol}_{tot}$$

Thermo

$$\Delta U = Q - W$$

$$\Delta U = (3/2)nRT$$

$$W = P\Delta V$$

$$Q = mc\Delta T$$

$$Q = mH_L$$

$$\Delta G = \Delta H - T\Delta S$$

$$\Delta H_{rxn} = \Delta H_{prod} - \Delta H_{react}$$

Kinematics

$$v_f = v_o + at$$

$$d = v_o t + (1/2)at^2$$

$$v_f^2 = v_o^2 + 2ad$$

$$a_c = v^2 / r$$

$$F_c = mv^2 / r$$

$$v_x = v_o \cos\theta$$

$$v_y = v_o \sin\theta$$

Mechanics

$$F = ma$$

$$F_{a \text{ on } b} = -F_{b \text{ on } a}$$

$$F_{fric} = \mu F_N$$

$$F_g = GM_1 m_2 / r^2$$

$$F_g = mg$$

$$F = kx$$

$$\tau = rF\sin\theta$$

$$P = W/t$$

$$W = Fd\cos\theta$$

$$E_K = (1/2)mv^2$$

$$U = mgh$$

$$U = -GM_1 m_2 / r$$

Inclined Plane

$$F_{incline} = mg\sin\theta$$

$$F_N = mg\cos\theta$$

$$F_{fric} = \mu mg\cos\theta$$