



هیکل صف عاشر متقدم

Physics Grade 10 Advanced

Complete Study Guide - Question Bank



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Obj #	Pages	References	Arabic Text	English Text	SB Pages
1	3	كتاب الطالب	تعريف الحركة الدورية والكميات المرتبطة بالحركة الدورية مثل الدورة والسعة. وصف خصائص الحركة التوافقية البسيطة.	Define periodic motion and quantities associated with periodic motion like period and amplitude. Describe the characteristics of simple harmonic motion.	3



Periodic Motion and Simple Harmonic Motion

1-What is the definition of the period (T) of an object in periodic motion?

- a) The maximum distance the object moves from its equilibrium position.
- b) **The time needed for one full cycle of the motion.**
- c) The force that acts to bring the object back toward equilibrium.
- d) The point where the net force on the object is zero.

Q2 In simple harmonic motion, the restoring force is directly proportional to the:

- a) Amplitude
- b) Period
- c) **Displacement from equilibrium**
- d) Total energy



Q3 When a mass on a spring is at its equilibrium position, the net force on it is:

- a) At its maximum value
- b) **Zero**
- c) Pointing away from the equilibrium position
- d) Proportional to the mass

Q4 • The amplitude of an object in periodic motion is defined as the:

- a) Time for one complete cycle.
- b) Restoring force acting on the object.
- c) **Maximum distance from the equilibrium position.**
- d) Total energy of the system.

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Obj #	Pages	References	Arabic Text	English Text	SB Pages
2	5 7 27-23	كتاب الطالب مثال 1 تقويم الوحدة Q.(44,45,100)	يطبق قانون هوك لحساب القوة التي يؤثر بها الزنبرك، أو ثابت الزنبرك، أو المسافة التي يستطيلها الزنبرك أو ينضغطها.	Apply Hooke's law to calculate the force exerted by a spring, the spring constant, or the distance by which a spring is stretched or compressed.	4 6 6

Hooke's Law

Q5 • Hooke's Law is described by which of the following equations?

- a) $F = ma$
- b) $PE = mgh$
- c) **$F = -kx$**
- d) $KE = 1/2 mv^2$

Q6 • In the equation $F = -kx$, what does the variable 'k' represent?

- a) The displacement of the spring from its equilibrium position.
- b) The force exerted by the spring.
- c) **The spring constant.**
- d) The mass attached to the spring.



Q7 • The negative sign in Hooke's Law indicates that the force exerted by the spring is:

- a) In the same direction as the displacement.
- b) **In the opposite direction to the displacement.**
- c) Proportional to the spring constant.
- d) Constant regardless of the displacement.

Q8 • The potential energy stored in a spring is given by the formula:

- a) $PE = kx$
- b) $PE = 1/2 kx$
- c) **$PE = 1/2 kx^2$**
- d) $PE = kx^2$



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EXAMPLE Problem 1

THE SPRING CONSTANT AND THE ENERGY OF A SPRING A spring stretches by 18 cm when a bag of potatoes weighing 56 N is suspended from its end.

- Determine the spring constant.
- How much elastic potential energy does the stretched spring have?

1 ANALYZE AND SKETCH THE PROBLEM

- Sketch the situation.
- Show and label the distance the spring has stretched and its equilibrium position.

Known

$$x = 18 \text{ cm}$$

$$F = -56 \text{ N}$$

Unknown

$$k = ?$$

$$PE_e = ?$$

2 SOLVE FOR THE UNKNOWN

- Use Hooke's law and isolate k .

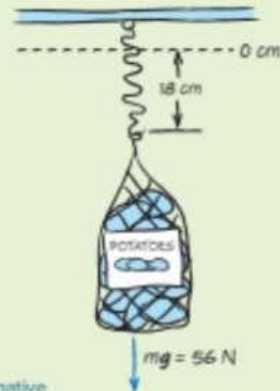
$$\begin{aligned} k &= -\frac{F}{x} \\ &= -\frac{-56 \text{ N}}{0.18 \text{ m}} \\ &= 310 \text{ N/m} \end{aligned}$$

Substitute $F = -56 \text{ N}$, $x = 0.18 \text{ m}$. The force is negative because it is in the opposite direction of x .

$$\text{b. } PE_e = \frac{1}{2}kx^2$$

$$\begin{aligned} &= \frac{1}{2}(310 \text{ N/m})(0.18 \text{ m})^2 \\ &= 5.0 \text{ J} \end{aligned}$$

Substitute $k = 310 \text{ N/m}$, $x = 0.18 \text{ m}$.



• Hooke's Law - Spring Extension

Question 3: A spring has a spring constant of 56 N/m. How far will a block weighing 18 N stretch it?

- A) 0.15 m
- B) 0.25 m
- ✓ C) 0.32 m
- D) 0.45 m
-



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-
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Solution:

Using Hooke's Law: $F = kx$

$$x = F/k = 18 \text{ N} / 56 \text{ N/m} = 0.3214 \text{ m} \approx 0.32 \text{ m}$$

Correct Answer: C) 0.32 m

Q2 • Spring Constant Calculation

Question 2: What is the spring constant of a spring that stretches 12 cm when an object weighing 24 N is hung from it?

- A) 150 N/m
- ✓ B) 200 N/m
- C) 250 N/m
- D) 300 N/m

Solution:



$$x = 12 \text{ cm} = 0.12 \text{ m}$$

$$k = F/x = 24 \text{ N} / 0.12 \text{ m} = 200 \text{ N/m}$$

Correct Answer: B) 200 N/m

Q3 • Elastic Potential Energy

Question 2: What is the elastic potential energy of a spring with $k = 144 \text{ N/m}$ that is compressed by 16.5 cm ?

- A) 1.8 J
- ☒ B) 2.0 J
- C) 2.2 J
- D) 2.4 J

Solution:

$$x = 16.5 \text{ cm} = 0.165 \text{ m}$$

$$PE = (1/2)kx^2 = (1/2) \times 144 \times (0.165)^2 = (1/2) \times 144 \times 0.027225 = 1.96 \text{ J} \approx 2.0 \text{ J}$$

Correct Answer: B) 2.0 J



Q3 • Hooke's Law - Spring Extension

Question 4: A spring has a spring constant of 56 N/m. How far will a block weighing 18 N stretch it?

- A) 0.15 m
- B) 0.25 m
- ✓ C) 0.32 m
- D) 0.45 m

Solution:

$$x = F/k = 18 \text{ N} / 56 \text{ N/m} = 0.3214 \text{ m} \approx 0.32 \text{ m}$$

Correct Answer: C) 0.32 m



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Q

• Elastic Potential Energy (CHALLENGE)

Question 5 (CHALLENGE): A spring has a spring constant of 256 N/m. How far must it be stretched to give it an elastic potential energy of 48 J?

- A) 0.5 m
- ✓ B) 0.6 m
- C) 0.7 m
- D) 0.8 m

Solution:

$$PE = (1/2)kx^2$$

$$48 = (1/2) \times 256 \times x^2$$

$$48 = 128 \times x^2$$

$$x^2 = 48/128 = 0.375$$

$$x = \sqrt{0.375} = 0.612 \text{ m} \approx 0.6 \text{ m}$$



Correct Answer: B) 0.6 m

Obj #	Pages	References	Arabic Text	English Text	SB Pages
3	5 8	كتاب الطالب Q.(9) مراجعة	يطبق قانون حفظ الطاقة لحركة كل من: نظام الكتلة- الزنبرك المهتز أفقياً، حركة البندول البسيط، وذلك لربط الطاقة الكلية لكل نظام عند لحظة معينة بالطاقة الكلية عند لحظة أخرى.	Apply the law of conservation of energy for both a horizontal oscillating mass-spring system and simple pendulum to relate the total energy of each system at one instant to the total energy at another instant.	5 8

Conservation of Energy in Oscillating Systems

Q9 • In a mass-spring system undergoing simple harmonic motion, when is the kinetic energy at its maximum?

In a mass-spring system undergoing simple harmonic motion, when is the kinetic energy at its maximum?

a) At the points of maximum displacement.

b) **At the equilibrium position.**



c) When the potential energy is also at its maximum.

d) Halfway between the equilibrium position and maximum displacement.

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Q10 • According to the law of conservation of energy, the total energy of an isolated oscillating system:

- a) Increases over time.
- b) Decreases over time.
- c) **Remains constant.**
- d) Is directly proportional to the amplitude.

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Q11 • When a mass on a spring is at its maximum displacement, the potential energy is:

- a) Zero
- b) At its minimum value
- c) **At its maximum value**
- d) Equal to the kinetic energy



Q9 • Pendulum and Gravitational Field

Question 9: A pendulum with a length of 36.9 cm has a period of 1.22 s. What is the gravitational field at the pendulum's location?

- ✓ A) 9.78 m/s²
- B) 9.81 m/s²
- C) 9.75 m/s²
- D) 9.85 m/s²

Solution:

$$T = 2\pi\sqrt{L/g}$$

$$1.22 = 2\pi\sqrt{(0.369/g)}$$

$$(1.22)^2 = 4\pi^2 \times 0.369/g$$

$$1.4884 = (4 \times 9.8696 \times 0.369)/g$$

$$1.4884 = 14.57/g$$

$$g = 14.57/1.4884 = 9.79 \text{ m/s}^2 \approx 9.78 \text{ m/s}^2$$

Correct Answer: A) 9.78 m/s²



What is the definition of the period (T) of an object in periodic motion?

What is the definition of the period (T) of an object in periodic motion?

- a) The maximum distance the object moves from its equilibrium position.
- b) **The time needed for one full cycle of the motion.**
- c) The force that acts to bring the object back toward equilibrium.
- d) The point where the net force on the object is zero.

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Q2 • Periodic Motion and Simple Harmonic Motion

In simple harmonic motion, the restoring force is directly proportional to the:

- a) Amplitude
- b) Period
- c) **Displacement from equilibrium**
- d) Total energy

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Q3 • Periodic Motion and Simple Harmonic Motion

Page: N/A

When a mass on a spring is at its equilibrium position, the net force on it is:

- a) At its maximum value
- b) **Zero**
- c) Pointing away from the equilibrium position
- d) Proportional to the mass



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Q4 • Periodic Motion and Simple Harmonic Motion

The amplitude of an object in periodic motion is defined as the:

- a) Time for one complete cycle.
- b) Restoring force acting on the object.
- c) **Maximum distance from the equilibrium position.**
- d) Total energy of the system.

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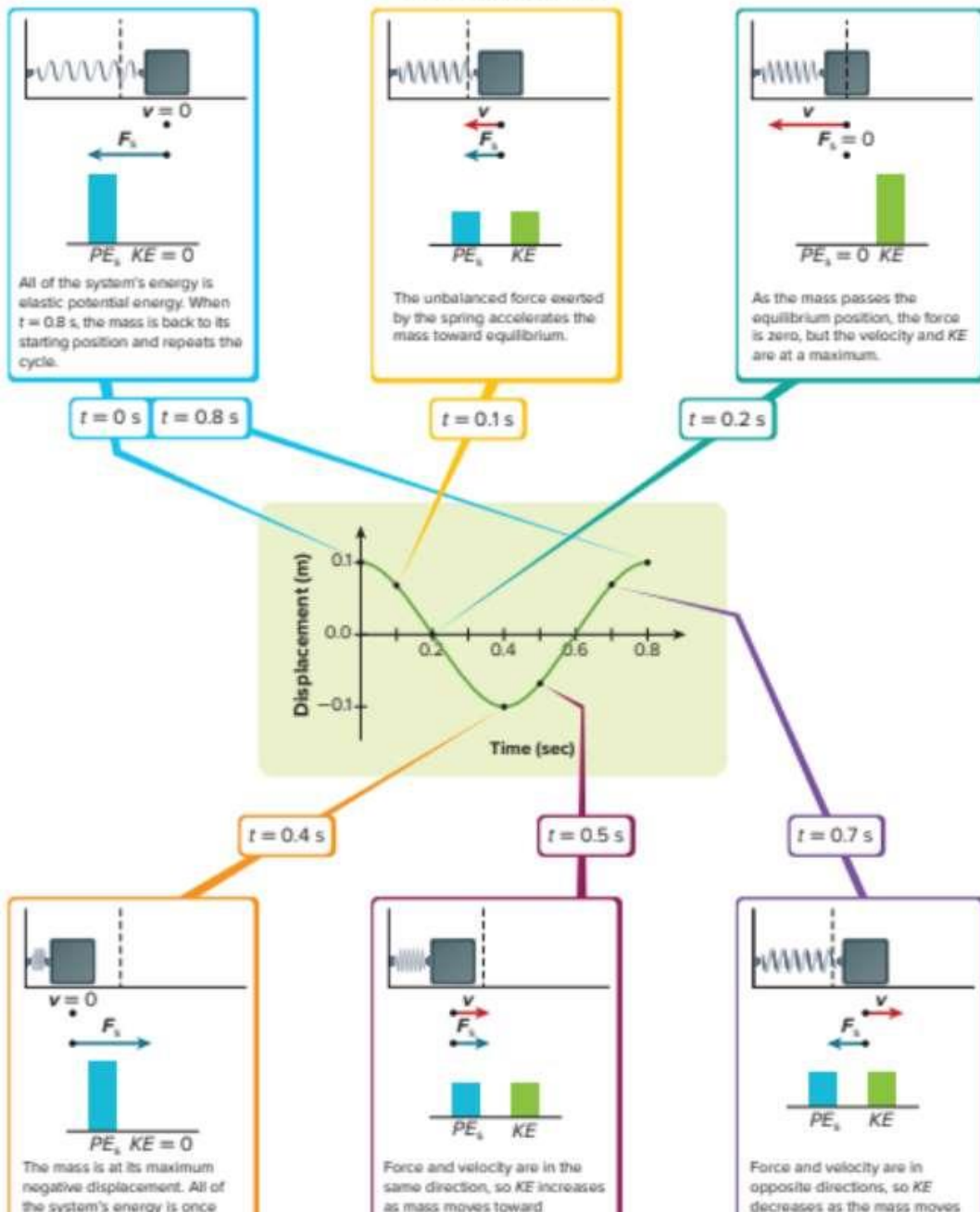
Obj #	Pages	References	Arabic Text	English Text	SB Pages
4	7 7	كتاب الطالب Get It	يحدد العوامل التي تؤثر في الزمن الدوري للبندول البسيط.	Determine what affects the period of a simple pendulum.	7 7



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Simple Harmonic Motion





Q5

What is the definition of the period (T) of an object in periodic motion?

- a) The maximum distance the object moves from its equilibrium position.
- b) **The time needed for one full cycle of the motion.**
- c) The force that acts to bring the object back toward equilibrium.
- d) The point where the net force on the object is zero.



Q2 • Periodic Motion and Simple Harmonic Motion

In simple harmonic motion, the restoring force is directly proportional to the:

- a) Amplitude
- b) Period
- c) **Displacement from equilibrium**
- d) Total energy

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Q3 • Periodic Motion and Simple Harmonic Motion

When a mass on a spring is at its equilibrium position, the net force on it is:

- a) At its maximum value
- b) **Zero**
- c) Pointing away from the equilibrium position
- d) Proportional to the mass

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Q4 • Periodic Motion and Simple Harmonic Motion

The amplitude of an object in periodic motion is defined as the:

- a) Time for one complete cycle.
- b) Restoring force acting on the object.
- c) **Maximum distance from the equilibrium position.**
- d) Total energy of the system.

Q12 • Simple Pendulum

The period of a simple pendulum is dependent on which of the following factors?

- a) The mass of the pendulum bob.
- b) The amplitude of the swing.
- c) **The length of the pendulum.**
- d) The material of the pendulum bob.



Q13 • Simple Pendulum

The formula for the period of a simple pendulum is:

- a) $T = 2\pi\sqrt{(g/L)}$
- b) $T = 2\pi\sqrt{(L/g)}$
- c) $T = 1/2\pi\sqrt{(L/g)}$
- d) $T = 2\pi\sqrt{(m/k)}$

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Q14 •

If you take a pendulum to a planet with a stronger gravitational field (g), what will happen to its period?

- a) The period will increase.
- b) **The period will decrease.**
- c) The period will remain the same.

Q13 • Simple Pendulum

The formula for the period of a simple pendulum is:

- a) $T = 2\pi\sqrt{g/L}$
- b) **$T = 2\pi\sqrt{L/g}$**
- c) $T = 1/2\pi\sqrt{L/g}$
- d) $T = 2\pi\sqrt{m/k}$



Q14 • Simple Pendulum

If you take a pendulum to a planet with a stronger gravitational field (g), what will happen to its period?

- a) The period will increase.
- b) **The period will decrease.**
- c) The period will remain the same.
- d) The period will become zero

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Obj #	Pages	References	Arabic Text	English Text	SB Pages
5	9→10	كتاب الطالب	يُميِّز بين الموجات المستعرضة والطولية والسطحية ويعطي أمثلة.	Differentiate between transverse, longitudinal, and surface waves and give examples.	8



Q15 • Wave Motion

Which of the following is an example of a longitudinal wave?

- a) A wave on a rope.
- b) **A sound wave.**
- c) A surface wave on water.
- d) An electromagnetic wave.

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Q16 • Wave Motion

In a transverse wave, the particles of the medium move:

- a) Parallel to the direction of wave travel.
- b) **Perpendicular to the direction of wave travel.**
- c) In circles.
- d) In ellipses.

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Obj #	Pages	References	Arabic Text	English Text	SB Pages
7	11 11	كتاب الطالب	يربط السعة بطاقة الموجة.	Relate amplitude to the energy of a wave.	11 11



Q17 • Wave Motion

A wave is a disturbance that transfers:

- a) Matter
- b) **Energy**
- c) Both matter and energy
- d) Neither matter nor energy



Q18 • Wave Properties

The energy of a wave is proportional to the square of its:

- a) Wavelength
- b) Speed
- c) **Amplitude**
- d) Frequency

Q19 • Wave Properties

The distance between two consecutive crests of a wave is called the:

- a) Amplitude
- b) Period
- c) **Wavelength**
- d) Phase



Q20 • Wave Properties

The speed of a mechanical wave is primarily determined by the:

- a) Amplitude of the wave.
- b) Frequency of the wave.
- c) **Properties of the medium.**
- d) Energy of the wave

Obj #	Pages	References	Arabic Text	English Text	SB Pages
8	12 14	كتاب الطالب تطبيق Q.(21,22,23)	يحسب تردد الموجة من معرفة الزمن الدوري ($f = 1/T$). والعكس صحيح	Calculate the frequency of a wave from its period and vice-versa ($f = 1/T$).	12 14

Q • Frequency and Period Relationship

Question 21: How does the frequency of a wave change when the period of the wave is doubled?

- A) It doubles



- ✓ B) It halves
- C) It remains the same
- D) It quarters

Solution:

Frequency and period are inversely related: $f = 1/T$
If T doubles, f becomes half.

Correct Answer: B) It halves

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Q7 • Wavelength and Period

Question 22: Describe the change in the wavelength of a wave when the period is reduced by one-half.

- A) It doubles
- ✓ B) It halves
- C) It remains the same
- D) It quarters



Solution:

When period is halved, frequency doubles ($f = 1/T$).

Using $v = f\lambda$, if frequency doubles and speed is constant, wavelength halves.

Correct Answer: B) It halves

Obj #	Pages	References	Arabic Text	English Text	SB Pages
6	10 11	كتاب الطالب مثال 2 Q.(19,20) تطبيق	$(v = f\lambda)$ يطبق معادلة الموجة لحساب سرعة الموجة $(f\lambda)$ أو ترددها أو طولها الموجي	Apply the wave equation ($v = f\lambda$) to calculate the speed, frequency, or wavelength of a wave.	10 11

Q • Wave Speed and Wavelength

Question 8: If the speed of a wave increases to 1.5 times its original speed while the frequency remains constant, how does the wavelength change?

- ✓ A) It becomes 1.5 times longer
- B) It becomes 2 times longer
- C) It remains the same
- D) It becomes 0.67 times the original



Solution:

$$v = f\lambda$$

If v becomes $1.5v$ and f remains constant, then λ becomes 1.5λ

Correct Answer: A) It becomes 1.5 times longer

Q3 • Doppler Effect - Moving Automobiles

Question 10: You are in an automobile travelling at 55 mph (26.6 m/s). A second automobile is moving toward you at the same speed. Its horn is sounding at 475 Hz. What frequency do you hear? Use 343 m/s as the speed of sound.

- ☒ A) 548 Hz
- ☐ B) 512 Hz
- ☐ C) 475 Hz
- ☐ D) 440 Hz

Solution:



Using Doppler effect formula:

$$f' = f(v + v_d)/(v - v_s)$$

$$f' = 475 \times (343 + 26.6)/(343 - 26.6)$$

$$f' = 475 \times 369.6/316.4$$

$$f' = 475 \times 1.168 = 554.8 \text{ Hz} \approx 548 \text{ Hz}$$

Correct Answer: A) 548 Hz

Q • Doppler Effect - Submarine Ultrasound

Question 11: A submarine is moving toward another submarine at 9.20 m/s. It emits a 3.50-MHz ultrasound. What frequency would the second sub, at rest, detect? The speed of sound in water at the depth the submarines are moving is 1482 m/s.

- ☒ A) 3.52 MHz
- ☐ B) 3.48 MHz
- ☐ C) 3.50 MHz
- ☐ D) 3.55 MHz

Solution:



$$f' = f \times v / (v - v_s)$$

$$f' = 3.50 \times 10^6 \times 1482 / (1482 - 9.20)$$

$$f' = 3.50 \times 10^6 \times 1482 / 1472.8$$

$$f' = 3.50 \times 10^6 \times 1.0062 = 3.5217 \times 10^6 \text{ Hz} \approx 3.52 \text{ MHz}$$

Correct Answer: A) 3.52 MHz

Q5 • Doppler Effect - Trumpet (CHALLENGE)

Question 12 (CHALLENGE): A trumpet plays middle C (262 Hz). How fast would it have to be moving to raise the pitch to C sharp (277 Hz)? Use 343 m/s as the speed of sound.

- A) 10 m/s
- B) 15 m/s
- ☒ C) 18 m/s
- D) 20 m/s

Solution:

$$f' = f \times v / (v - v_s)$$

$$277 = 262 \times 343 / (343 - v_s)$$

$$277/262 = 343 / (343 - v_s)$$



$$1.05725 = 343/(343 - v_s)$$
$$343 - v_s = 343/1.05725 = 324.4$$
$$v_s = 343 - 324.4 = 18.6 \text{ m/s} \approx 18 \text{ m/s}$$

Correct Answer: C) 18 m/s

Q • Longitudinal Wave Speed

Question 20: A periodic longitudinal wave that has a frequency of 20.0 Hz travels along a coiled spring toy. If the distance between successive compressions is 0.600 m, what is the speed of the wave?

- A) 10 m/s
- ☒ B) 12 m/s
- C) 15 m/s
- D) 20 m/s

Solution:

Distance between successive compressions = wavelength = 0.600 m
 $v = f\lambda = 20.0 \times 0.600 = 12.0 \text{ m/s}$

Correct Answer: B) 12 m/s



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Q14 • Sound Wave Properties

Question 14: A sound wave produced by a clock chime is heard 515 m away 1.50 s later.

a. Based on these measurements, what is the speed of sound in air?

- ✓ A) 343 m/s
- B) 340 m/s
- C) 333 m/s
- D) 350 m/s

Solution:

$$v = \text{distance/time} = 515 \text{ m} / 1.50 \text{ s} = 343.3 \text{ m/s} \approx 343 \text{ m/s}$$

Correct Answer: A) 343 m/s



b. The sound wave has a frequency of 436 Hz. What is the period of the wave?

- ☒ A) 0.0023 s
- B) 0.0033 s
- C) 0.0015 s
- D) 0.0045 s

Solution:

$$T = 1/f = 1/436 = 0.002294 \text{ s} \approx 0.0023 \text{ s}$$

Correct Answer: A) 0.0023 s

c. What is its wavelength?

- ☒ A) 0.79 m
- B) 0.85 m
- C) 0.75 m
- D) 0.70 m

Solution:

$$\lambda = v/f = 343/436 = 0.7867 \text{ m} \approx 0.79 \text{ m}$$



Correct Answer: A) 0.79 m

Conceptual Questions and Topics

Question 15 (Page 5)

Q15 • Periodic Motion

Question 15: The bobbing of a mass on a spring or the swaying of a pendulum are examples of periodic motion. Define periodic motion and quantities associated with periodic motion like period and amplitude.

Answer:

Periodic Motion:

Periodic motion is any motion that **repeats itself at regular time intervals**. The object returns to the same position with the same velocity after a fixed period of time.

Associated Quantities:

1. **Period (T):**
 - The **time** required to complete **one full cycle** of motion.
 - Measured in **seconds (s)**.
2. **Amplitude (A):**
 - The **maximum displacement** or distance moved by the object from its **equilibrium position**.
 - Measured in **meters (m)**.
3. **Frequency (f):**



- The **number of complete cycles** that occur per unit of time.
- It is the reciprocal of the period: $f = 1/T$.
- Measured in **Hertz (Hz)**, where 1 Hz = 1 cycle per second.

Similar Example:

A child on a swing completes one full back-and-forth motion in 3.0 seconds. The child swings out to a maximum distance of 2.0 meters from the center (lowest point). Identify the period and amplitude.

Solution: - **Period (T):** The time for one full swing is 3.0 s. - **Amplitude (A):** The maximum distance from the center is 2.0 m.

Question 16 (Page 6)

Q16 • Simple Pendulum Period

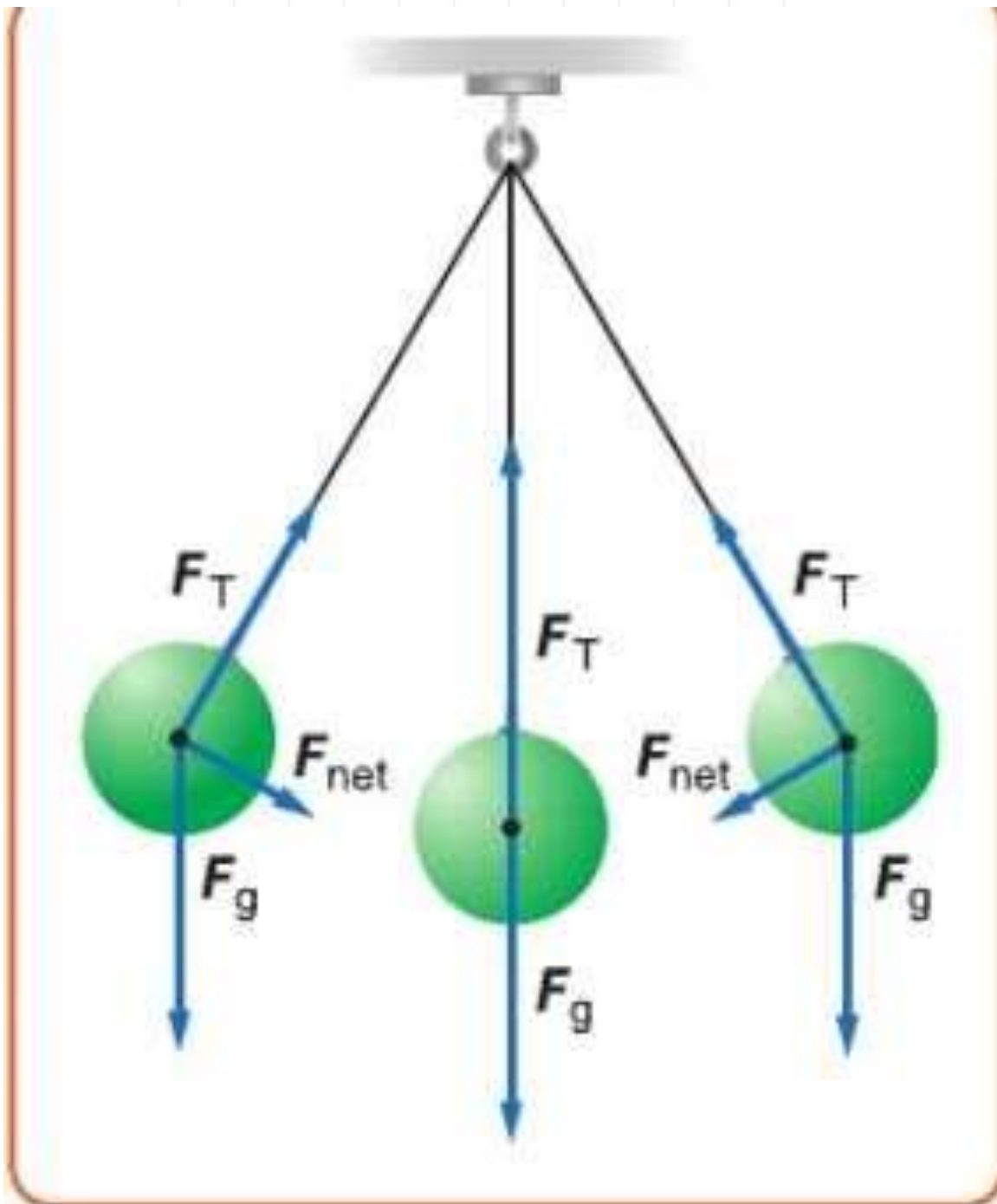
Question 16: Explain what affects the period of a simple pendulum.

Answer



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The period of a simple pendulum is affected by the following factors:

Formula:

$$T = 2\pi \sqrt{\frac{L}{g}}$$

Where: - T = Period (s) - L = Length of pendulum (m) - g = Gravitational acceleration (m/s²)

Factors:

4. **Length (L):** The period is directly proportional to the square root of the length. If the length increases, the period increases.
5. **Gravitational acceleration (g):** The period is inversely proportional to the square root of gravitational acceleration. Stronger gravity results in a shorter period.
6. **Mass:** The mass of the pendulum bob does NOT affect the period.

Amplitude: For small angles (less than 15°), the amplitude does NOT affect the period.

Similar Example: A pendulum with length 1.0 m has a certain period. If the length is increased to 4.0 m, how does the period change?

Solution: Since $T \propto \sqrt{L}$, when length quadruples, the period doubles:

$$\frac{T_2}{T_1} = \sqrt{\frac{L_2}{L_1}} = \sqrt{\frac{4.0}{1.0}} = 2$$



Question 17 (Page 15)

Q17 • Wave Types

Question 17: Differentiate between transverse, longitudinal, and surface waves and give examples.

Answer:

1. Transverse Waves: - Particle motion is **perpendicular** to the direction of wave propagation - The wave oscillates up and down while traveling horizontally -

Examples: - Light waves - Electromagnetic waves - Waves on a string - Radio waves

2. Longitudinal Waves: - Particle motion is **parallel** to the direction of wave propagation - The wave consists of compressions and rarefactions - **Examples:** - Sound waves in air - Ultrasound waves - Compression waves in springs - Seismic P-waves

3. Surface Waves: - Combination of both transverse and longitudinal motion - Particles move in circular or elliptical paths - **Examples:** - Water waves (ripples on water surface) - Ocean waves - Seismic surface waves

Similar Example: Classify the following: (a) A vibrating guitar string, (b) Sound traveling through water, (c) Ripples in a pond.

Answer: - (a) Transverse wave - (b) Longitudinal wave - (c) Surface wave



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Obj #	Pages	References	Arabic Text	English Text	SB Pages
9	15→16	كتاب الطالب	يصف سلوك الموجات الميكانيكية عند الحواجز (الانعكاس والانكسار). يصف أن الموجة الميكانيكية تنقلب إذا انعكست عن حاجز ثابت وتبقى قائمة إذا انعكست من نهاية حرة.	Describe the behaviour of mechanical waves at boundaries (reflection and refraction). Describe that a mechanical wave is inverted if reflected from a fixed end and remains upright if reflected from a free end.	15→16

Waves at Boundaries

Recall from Lesson 2 that the speed of a mechanical wave depends only on the properties of the medium it passes through, not on the wave's amplitude or frequency. For example, for waves on a spring, the speed depends on the spring's tension and mass per unit length. Examine what happens when a wave travels from one medium to another. **Figure 12** shows a wave pulse traveling from a larger spring into a smaller one. The pulse that strikes the boundary is called the **incident wave**. One pulse from the larger spring continues in the smaller spring, but the speed is different in the smaller spring. Note that this transmitted wave pulse remains upward.

Some of the energy of the incident wave's pulse is reflected backward into the larger spring. This returning wave is called the reflected wave. Whether the **reflected wave** is upright or inverted depends on the characteristics of the two springs. For example, if the waves in the smaller spring have a greater speed because the spring is stiffer, then the reflected wave will be inverted.



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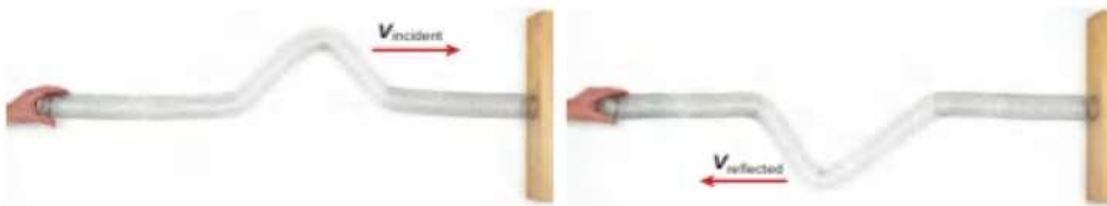


Figure 13 When a wave encounters a rigid boundary, the reflected wave is inverted. Note that the amplitude is not affected by the rigid boundary.

Rigid boundaries When a wave pulse hits a rigid boundary, the energy is reflected back, as shown in **Figure 13**. The wall is the boundary of a new medium through which the wave attempts to pass. Instead of passing through, the pulse is reflected from the wall with almost exactly the same amplitude as the pulse of the incident wave. Thus, almost all the wave's energy is reflected back. Very little energy is transmitted into the wall. Also note that the pulse is inverted.

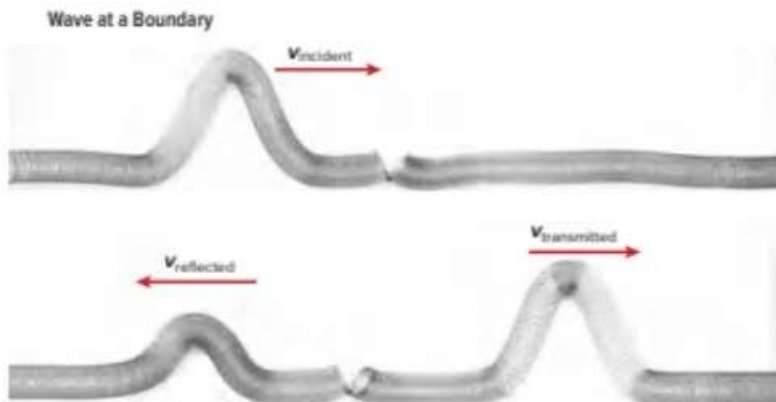


Figure 12 When the wave pulse meets the boundary between the two springs, a transmitted wave pulse and a reflected wave form.

Compare the energy of the incident wave to the energy of the reflected wave.

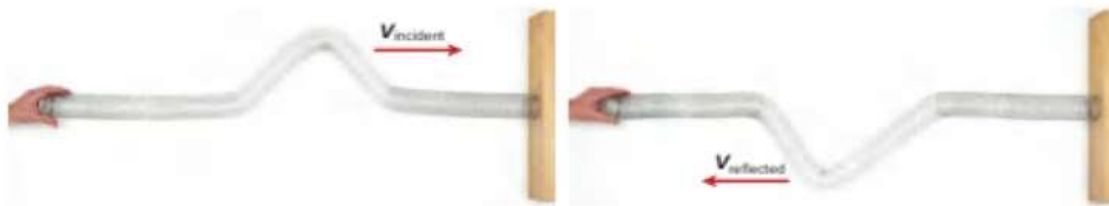


Figure 13 When a wave encounters a rigid boundary, the reflected wave is inverted. Note that the amplitude is not affected by the rigid boundary.

Rigid boundaries When a wave pulse hits a rigid boundary, the energy is reflected back, as shown in **Figure 13**. The wall is the boundary of a new medium through which the wave attempts to pass. Instead of passing through, the pulse is reflected from the wall with almost exactly the same amplitude as the pulse of the incident wave. Thus, almost all the wave's energy is reflected back. Very little energy is transmitted into the wall. Also note that the pulse is inverted.

Obj #	Pages	References	Arabic Text	English Text	SB Pages
10	17-16 24	كتاب الطالب تقويم الوحدة Q.(70,71)	يصف سلوك الموجات الميكانيكية عند الحواجز (الانعكاس والانكسار). يصف أن الموجة الميكانيكية تتقلب إذا انعكست عن حاجز ثابت وتبقى قائمة إذا انعكست من نهاية حرة	State and apply the principle of superposition to show that two overlapping waves add algebraically to give a resultant (or net) wave.	16→17

Q21 • Wave Reflection

Question 21: Describe that a mechanical wave is inverted if reflected from a fixed end and remains upright if reflected from a free end.



Question 22 (Page 31)

Q22 • Superposition Principle

Question 22: State and apply the principle of superposition to show that two overlapping waves add algebraically to give a resultant wave.

Principle of Superposition:

When two or more waves overlap in the same medium, the resultant displacement at any point is the **algebraic sum** of the individual displacements produced by each wave.

Mathematical

Expression:

$$y_{\text{resultant}} = y_1 + y_2 + y_3 + \dots$$

Where: - y_1, y_2, y_3 = displacements of individual waves - $y_{\text{resultant}}$ = total displacement

Types of Interference:

7. Constructive Interference:

- Waves are in phase (crests align with crests)
- Amplitudes add together
- Resultant amplitude = $A_1 + A_2$

8. Destructive Interference:

- Waves are out of phase (crests align with troughs)
- Amplitudes subtract
- Resultant amplitude = $|A_1 - A_2|$



Application Example: Two waves with amplitudes 5 cm and 3 cm meet at a point.

Case 1 - Constructive Interference:

$$A_{max} = 5 + 3 = 8 \text{ cm}$$

Case 2 - Destructive Interference:

$$A_{min} = |5 - 3| = 2 \text{ cm}$$

Similar Example: Two sound waves with equal amplitude A interfere. What are the maximum and minimum possible resultant amplitudes?

Answer: - Maximum (constructive): $2A$ - Minimum (destructive): 0 (complete cancellation)

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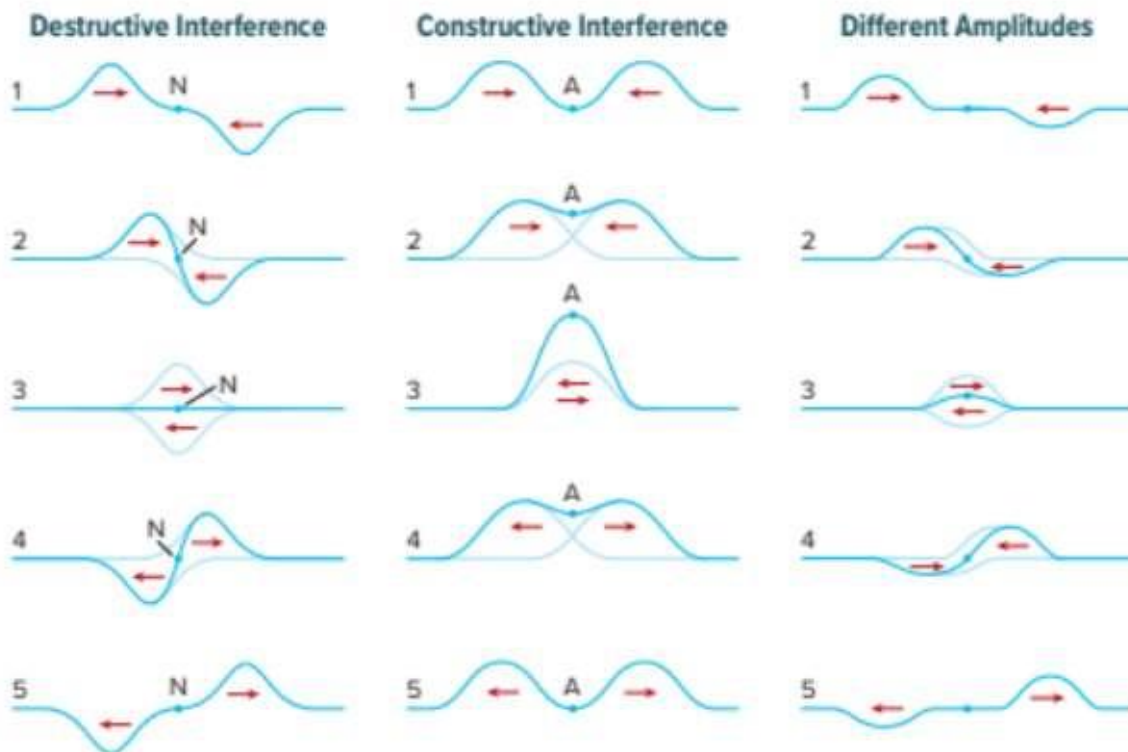


Figure 15 When waves add algebraically, the resulting combined waves can be quite different from the individual waves. *Summarize how waves behave during and after superposition.*



Obj #	Pages	References	Arabic Text	English Text	SB Pages
11	18 19	كتاب الطالب	يصف كيف تتكون الموجات الموقوفة ويحدد العقد والبطن.	Describe how standing waves are formed and identify nodes and antinodes.	18 19

Q23 • Standing Waves

Question 23: Describe the formation of standing waves on a string.

Standing Wave Formation:

Standing waves are formed when two waves of the **same frequency and amplitude** travel in **opposite directions** through the same medium and interfere with each other.

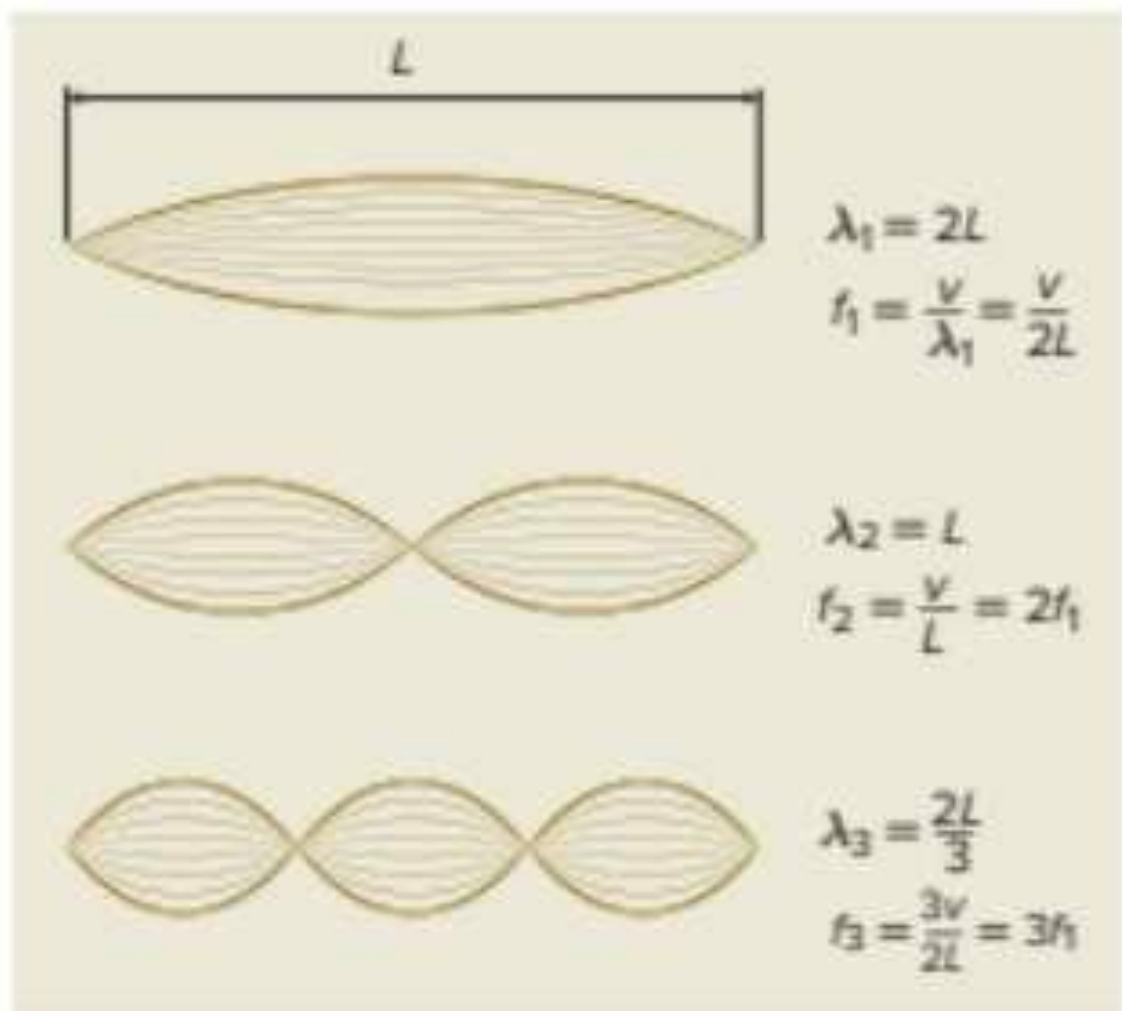
Formation Process:

9. **Incident Wave:** A wave travels along the string toward a fixed end
10. **Reflection:** The wave reflects from the fixed end (inverted)
11. **Interference:** The incident and reflected waves overlap and interfere
12. **Superposition:** Continuous interference creates a stationary pattern
13. **Standing Wave:** Certain points remain stationary (nodes) while others oscillate with maximum amplitude (antinodes)

Conditions for Standing Waves on a String:



- Both ends are fixed



- String length must be a multiple of half-wavelengths:

$$L = n \frac{\lambda}{2}$$



Where $n = 1, 2, 3, \dots$ (harmonic number)

Frequency of Standing Waves:

$$f_n = \frac{nv}{2L}$$

Where: - f_n = frequency of n th harmonic - v = wave speed on string - L = length of string - $n = 1$ (fundamental), 2 (second harmonic), 3 (third harmonic), ...

Similar Example: A string of length 0.6 m is fixed at both ends. If the wave speed is 30 m/s, what is the fundamental frequency?

Solution:

$$f_1 = \frac{v}{2L} = \frac{30}{2 \times 0.6} = \frac{30}{1.2} = 25 \text{ Hz}$$

Question 24 (Page 33)

Q24 • Nodes and Antinodes

Question 24: Define nodes and antinodes and describe how they are formed.

Definitions:

1. Node: - A point on a standing wave where the displacement is **always zero** - Point of **destructive interference** - The medium at a node does not move - Occurs where the incident and reflected waves are always out of phase



2. Antinode: - A point on a standing wave where the displacement is **maximum** - Point of **constructive interference** - The medium oscillates with maximum amplitude - Occurs where the incident and reflected waves are always in phase

Formation:

Nodes and antinodes are formed through the **continuous interference** of two waves traveling in opposite directions:

- **At nodes:** The two waves are always 180° out of phase, causing complete destructive interference
- **At antinodes:** The two waves are always in phase, causing complete constructive interference

Spacing:

- Distance between consecutive nodes = $\lambda/2$
- Distance between consecutive antinodes = $\lambda/2$
- Distance between a node and adjacent antinode = $\lambda/4$

Similar Example: A standing wave on a 1.2 m string has 3 complete loops (3 antinodes). What is the wavelength?

Solution: 3 loops means the string length equals 3 half-wavelengths:

$$L = 3 \times \frac{\lambda}{2}$$

$$1.2 = \frac{3\lambda}{2}$$

$$\lambda = \frac{2 \times 1.2}{3} = 0.8 \text{ m}$$



Question 26 (Page 36)

Q26 • Ripple Tank

Question 26: Use a ripple tank to model wave behaviour in two dimensions (such as reflection and refraction of waves traveling on the surface of water).

Answer:

A ripple tank is a shallow tray of water used to demonstrate and study wave phenomena in two dimensions.

Modeling Wave Behaviors:

14. Reflection:

- **Setup:** Place a solid barrier in the tank.
- **Observation:** When plane waves strike the barrier, they bounce off.
- **Law of Reflection:** The angle of incidence (angle between the incoming ray and the normal) is equal to the angle of reflection (angle between the reflected ray and the normal).

15. Refraction:

- **Setup:** Place a submerged glass plate to create a region of shallower water.
- **Observation:** When waves pass from deep to shallow water, they **slow down** and their **wavelength decreases**. If they enter at an angle, their



direction of travel **bends** towards the normal.

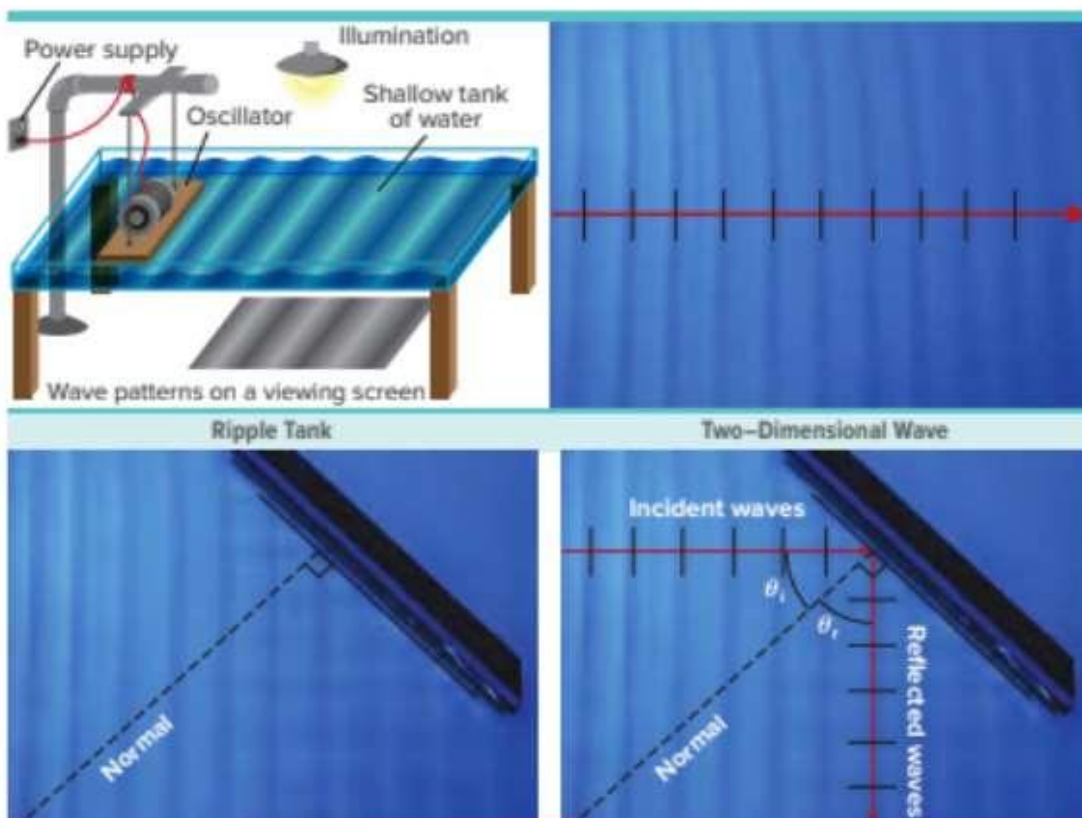


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Creating two-dimensional waves A ripple tank is a piece of laboratory equipment that is used to investigate the properties of two-dimensional waves. The main portion of the ripple tank shown in **Figure 18** is a shallow tank that contains a thin layer of water. A board attached to a mechanical oscillator produces waves with long, straight wavefronts. A lamp above the tank produces shadows below the tank that show the locations of the crests of the waves. The top photo in **Figure 18** shows a wave traveling through the ripple tank. The direction the wave travels is modeled by a ray diagram. For clarity, the wavefronts are not extended the entire length of the wave.

Reflection of two-dimensional waves The bottom row of pictures in **Figure 18** shows an incident ray encountering a rigid barrier placed at an angle to the ray's path. The orientation of the barrier is shown by a line, called the **normal**, drawn perpendicular to the barrier. The angle between the incident ray and the normal is called the angle of incidence and is labeled θ_i in the diagram. The angle between the normal and the reflected ray is called the angle of reflection and is labeled θ_r . The **law of reflection** states that the angle of incidence is equal to the angle of reflection. The law of reflection applies to many different kinds of waves, not just the waves in a ripple tank.





- This models how waves change speed and direction when entering a different medium.

16. Diffraction:

- **Setup:** Place barriers with a small gap between them.
- **Observation:** As waves pass through the gap, they spread out in a circular pattern.

Similar Example:

In a ripple tank, plane waves approach a straight barrier at an angle of 40° to the normal. At what angle will the waves reflect?

Solution: According to the law of reflection, the angle of reflection is equal to the angle of incidence. Therefore, the waves will reflect at an angle of 40° to the normal

Obj #	Pages	References	Arabic Text	English Text	SB Pages
14	34-33 39 52-55	كتاب الطالب Q.(8) مراجعة تقويم الوحدة Q.(42/a,69,82)	يُعرّف حدة (درجة) الصوت ويربطها مع تردد الموجة الصوتية. يُعرّف شدة الصوت ويربطها مع سعة موجة الضغط الصوتية.	Define sound pitch and relate it to the frequency of a sound wave. Define loudness and relate it to the amplitude of a sound wave.	29

Question 27 (Page 37)

Q27 • Speed of Sound



Question 27: Explain that the speed of sound varies with different mediums and temperatures.

Answer:

Speed of Sound in Different Mediums:

The speed of sound depends on the **properties of the medium** through which it travels:

General Trend:

$$v_{solid} > v_{liquid} > v_{gas}$$

Examples: - **Steel (solid):** ~5000 m/s - **Water (liquid):** ~1480 m/s - **Air (gas):** ~343 m/s (at 20°C)

Explanation: - Sound travels faster in denser, more rigid materials - In solids, molecules are tightly packed and transmit vibrations quickly - In gases, molecules are far apart and transmit vibrations slowly

Temperature Dependence (in Air):

The speed of sound in air **increases with temperature:**

$$v = 331 + 0.6T$$

Where: - v = speed of sound (m/s) - T = temperature (°C) - 331 m/s = speed of sound at 0°C

Explanation: - Higher temperature → faster molecular motion - Faster molecules transmit sound vibrations more quickly - For every 1°C increase, speed increases by approximately 0.6 m/s

Similar Example: Calculate the speed of sound in air at: (a) 0°C (b) 30°C



Solution: (a) At 0°C:

$$v = 331 + 0.6(0) = 331 \text{ m/s}$$

(b) At 30°C:

$$v = 331 + 0.6(30) = 331 + 18 = 349 \text{ m/s}$$

Q28 • Sound Pitch

Question 28: Define sound pitch and relate it to the frequency of a sound wave.

Answer:

Pitch:

Pitch is the **subjective perception** of how high or low a sound is. It is the characteristic that allows us to distinguish between a high note and a low note in music.

Relationship to Frequency:

Pitch is directly related to the **frequency** of a sound wave:

- **High pitch = High frequency**
 - Examples: Whistle, soprano voice, bird chirping
 - Frequency range: Above 1000 Hz typically
- **Low pitch = Low frequency**
 - Examples: Bass drum, bass voice, thunder
 - Frequency range: Below 500 Hz typically

Key Points:



17. **Pitch is subjective** (what we perceive)
18. **Frequency is objective** (what we measure in Hz)
19. Doubling the frequency raises the pitch by one octave
20. Human hearing range: 20 Hz to 20,000 Hz

Musical Examples: - Middle C: 262 Hz - A above middle C: 440 Hz (standard tuning note) - C one octave higher: 524 Hz

Similar Example: Two tuning forks vibrate at 256 Hz and 512 Hz. Compare their pitches.

Answer: The 512 Hz fork produces a sound with **twice the frequency**, so it has a pitch **one octave higher** than the 256 Hz fork. The 512 Hz fork sounds much higher pitched

Question 29 (Page 42)

Q29 • Loudness

Question 29: Define loudness and relate it to the amplitude of a sound wave.

Answer:

Loudness:

Loudness is the **subjective perception** of the intensity or volume of a sound. It describes how loud or soft a sound appears to our ears.

Relationship to Amplitude:

Loudness is directly related to the **amplitude** of a sound wave:



- **Loud sound = Large amplitude**
 - Greater displacement of air molecules
 - More energy carried by the wave
 - Examples: Jet engine, rock concert, shouting
- **Soft sound = Small amplitude**
 - Smaller displacement of air molecules
 - Less energy carried by the wave
 - Examples: Whisper, rustling leaves, quiet conversation

Mathematical Relationship:

Sound **intensity** (power per unit area) is proportional to the **square of amplitude**:

$$I \propto A^2$$

Measurement:

- Loudness is measured in **decibels (dB)**
- Logarithmic scale
- Every 10 dB increase $\approx$ perceived doubling of loudness
- 0 dB = threshold of hearing
- 120 dB = threshold of pain

Examples: - Whisper: 20 dB - Normal conversation: 60 dB - Heavy traffic: 70 dB - Rock concert: 110 dB - Jet engine: 140 dB

Similar Example: Two identical speakers produce sound. One has amplitude 2 mm, the other 6 mm. Compare their loudness.

Answer: Since intensity $\propto A^2$:

$$\frac{I_2}{I_1} = \left(\frac{6}{2}\right)^2 = 9$$



The second speaker is **9 times more intense** and sounds significantly louder.

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Obj #	Pages	References	Arabic Text	English Text	SB Pages
15	35	كتاب الطالب	يُعرّف حدة (درجة) الصوت ويربطها مع تردد الموجة الصوتية. يُعرّف شدة الصوت ويربطها مع سعة موجة الضغط الصوتية.	Define the Doppler Effect. Explain the Doppler Effect of sound.	30→31

Q30 • Doppler Effect Definition

Question 30: Define the Doppler effect.

Answer:

Doppler Effect:

The Doppler effect is the **apparent change in frequency (and wavelength) of a wave** as perceived by an observer due to **relative motion** between the source of the wave and the observer.



Key Characteristics:

21. **When source and observer approach each other:**
 - Observed frequency **increases** (higher pitch)
 - Wavelength **decreases**
22. **When source and observer move apart:**
 - Observed frequency **decreases** (lower pitch)
 - Wavelength **increases**
23. **The actual frequency of the source remains unchanged**

Formula:

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

Where: - f' = observed frequency - f = source frequency - v = wave speed in medium - v_d = detector (observer) velocity - v_s = source velocity

Sign Convention: - Use **+** in numerator when observer moves **toward** source - Use **-** in denominator when source moves **toward** observer

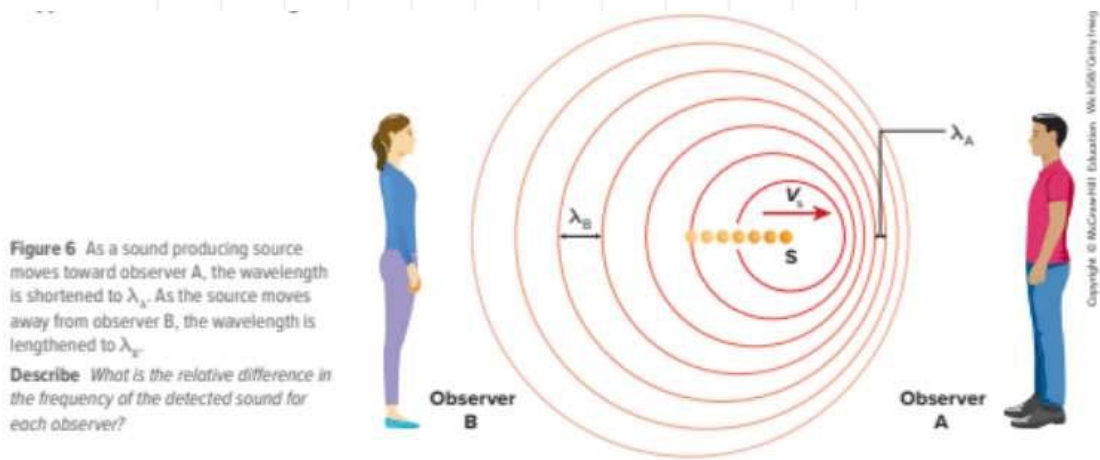
Everyday Examples:

24. **Ambulance siren:** Sounds higher-pitched when approaching, lower-pitched when receding
25. **Train whistle:** Pitch changes as train passes
26. **Car horn:** Frequency shift as vehicle passes by



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Applications: - Radar speed guns - Astronomy (measuring star velocities) - Medical ultrasound - Weather radar

Similar Example: Describe what you hear when a police car with a siren passes you while you're standing still.

Answer: As the police car **approaches**, the siren sounds **higher-pitched** than normal. As it **passes and moves away**, the pitch **suddenly drops** and sounds **lower** than normal. The actual frequency of the siren remains constant throughout.



Question 31 (Page 46)

Q31 • Doppler Effect in Sound

Question 31: Explain the Doppler effect in sound.

Answer:

Doppler Effect in Sound:

The Doppler effect in sound occurs when there is **relative motion** between a sound source and an observer, causing a change in the **perceived frequency** of the sound.

Physical Explanation:

When Source Approaches Observer: 1. Sound waves are **compressed** in front of the moving source 2. **Wavelength decreases** (wavefronts are closer together) 3. **Frequency increases** (more waves reach observer per second) 4. Observer hears a **higher pitch**

When Source Recedes from Observer: 1. Sound waves are **stretched** behind the moving source 2. **Wavelength increases** (wavefronts are farther apart) 3. **Frequency decreases** (fewer waves reach observer per second) 4. Observer hears a **lower pitch**

Mathematical Formula:

$$f' = f \frac{v + v_d}{v - v_s}$$

Where: - f' = observed frequency (Hz) - f = source frequency (Hz) - v = speed of sound (m/s) - v_d = detector velocity (+ toward source, - away from source) - v_s = source velocity (+ toward observer, - away from observer)

Important Notes:



27. The **actual frequency** of the source does **not change**
28. Only the **perceived frequency** changes
29. The effect is more pronounced at higher speeds
30. The effect occurs for both moving sources and moving observers

Similar Example: A fire truck siren emits sound at 800 Hz. The truck approaches a stationary observer at 20 m/s. What frequency does the observer hear? (Speed of sound = 340 m/s)

Solution:

$$f' = f \frac{v}{v - v_s} = 800 \times \frac{340}{340 - 20} = 800 \times \frac{340}{320} = 800 \times 1.0625 = 850 \text{ Hz}$$

The observer hears a higher frequency of **850 Hz**.

Obj #	Pages	References	Arabic Text	English Text	SB Pages
12	20 21	كتاب الطالب	يربط طول الوتر المهتز بالأطوال الموجية للموجات الموقوفة التي يمكن أن يدعمها.	Relate the length of a vibrating string to the wavelengths of the standing waves it can support.	20 21

Q32 • Pipes - Nodes and Antinodes

Question 32: Define nodes and antinodes and discuss pressure and displacements at these points in case of open and closed pipes.



Question 34: Define a beat as oscillating high and low sound levels produced from the interference of two sound waves of nearly identical frequencies.

Q37 • Spring Constant - Graphical

Question 37: Calculate the spring constant graphically from the slope of force vs extension graph.

Question 38 (Page 64)

Q38 • Simple Pendulum Motion

Question 38: Describe the motion of an oscillating simple pendulum.



Answer:

The motion of an oscillating simple pendulum is a classic example of **periodic motion**.

Characteristics of the Motion:

31. **Oscillation:** The pendulum bob swings back and forth in a circular arc about its lowest point, which is the **equilibrium position**.
32. **Restoring Force:** The force that brings the pendulum back to equilibrium is the tangential component of the gravitational force: **$F_{\text{restore}} = -mg \sin(\theta)$** . The negative sign indicates the force is always directed opposite to the displacement.
33. **Simple Harmonic Motion (SHM):** For **small angles** (typically less than 15°), $\sin(\theta) \approx \theta$, so the restoring force is approximately proportional to the displacement ($F \approx -mg\theta$). This makes the motion approximate Simple Harmonic Motion.
34. **Energy Transformation:**
 - At the **highest points** (extreme positions) of the swing, the pendulum has maximum **gravitational potential energy (PE)** and zero **kinetic energy (KE)** as it momentarily stops.
 - At the **lowest point** (equilibrium position), it has maximum **KE** (maximum speed) and minimum **PE**.
 - Throughout the swing, energy is continuously converted between PE and KE, but the total mechanical energy (PE + KE) remains constant (if we ignore air resistance).

Similar Example:

Describe where in its swing a pendulum has (a) maximum speed and (b) maximum acceleration.

Solution: - **(a) Maximum Speed:** The pendulum has maximum speed at the **bottom of its swing** (the equilibrium position), where all its potential energy has been converted to



kinetic energy. - **(b) Maximum Acceleration:** The pendulum has maximum acceleration at the **highest points of its swing** (the extreme positions). This is because the restoring force ($-mg \sin(\theta)$) is greatest at the maximum angle (θ), and since $F=ma$, the acceleration is also maximum there.

Question 39 (Page 64)

Q39 • Pendulum Period Equation

Question 39: Apply the equation ($T = 2\pi\sqrt{L/g}$) to calculate the period of a simple pendulum for small-angle oscillations.

Answer:

Simple Pendulum Period Formula:

$$T = 2\pi \sqrt{\frac{L}{g}}$$



Where: - T = Period (time for one complete oscillation) in seconds - L = Length of pendulum (from pivot to center of mass) in meters - g = Gravitational acceleration (m/s^2) - $\pi \approx 3.14159$

Conditions: - Valid for **small-angle oscillations** (amplitude $< 15^\circ$) - Pendulum mass does not affect the period - Air resistance is negligible

Rearrangements:

To find length:

$$L = \frac{gT^2}{4\pi^2}$$

To find gravitational acceleration:

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

Example Problem:

Calculate the period of a simple pendulum with length 2.45 m on Earth ($g = 9.8 \text{ m/s}^2$).

Solution:

$$T = 2\pi \sqrt{\frac{L}{g}}$$

$$T = 2\pi \sqrt{\frac{2.45}{9.8}}$$

$$T = 2\pi \sqrt{0.25}$$

$$T = 2\pi \times 0.5$$



$$T = \pi \approx 3.14 \text{ s}$$

Similar Example:

A pendulum has a period of 2.0 s on Earth where $g = 9.8 \text{ m/s}^2$. Calculate its length.

Solution:

$$L = \frac{gT^2}{4\pi^2}$$

$$L = \frac{9.8 \times (2.0)^2}{4\pi^2}$$

$$L = \frac{9.8 \times 4}{39.48}$$

$$L = \frac{39.2}{39.48}$$

$$L \approx 0.99 \text{ m}$$



Question 40 (Page 70)

Q40 • Wave Properties - Graphical

Question 40: Determine wave properties such as wavelength, period, frequency, amplitude, and speed using a graphical or a visual representation of a periodic mechanical wave.

Answer:

Wave Properties from Graphs:

1. Displacement vs. Position Graph (Snapshot at one instant):

- **Wavelength (λ):** Distance between two consecutive crests (or troughs)
- **Amplitude (A):** Maximum displacement from equilibrium (height from center to crest)

2. Displacement vs. Time Graph (At one fixed position):

- **Period (T):** Time for one complete oscillation
- **Amplitude (A):** Maximum displacement from equilibrium
- **Frequency (f):** Number of complete cycles per second, $f = 1/T$

3. Calculating Wave Speed:

$$v = f\lambda = \frac{\lambda}{T}$$

Step-by-Step Analysis:



From a position graph: 1. Identify two consecutive crests $\rightarrow$ measure distance $= \lambda$ 2. Measure maximum height from equilibrium $= A$

From a time graph: 1. Identify time for one complete cycle $= T$ 2. Calculate frequency: $f = 1/T$ 3. Measure maximum displacement $= A$

Combining both: - Wave speed: $v = f\lambda$

Example Problem:

A wave graph shows: - Distance between consecutive crests: 3.0 m - Time for one complete oscillation: 0.5 s - Maximum displacement: 0.2 m

Determine all wave properties.

Solution: - **Wavelength:** $\lambda = 3.0$ m - **Period:** $T = 0.5$ s - **Frequency:** $f = 1/T = 1/0.5 = 2.0$ Hz
- **Amplitude:** $A = 0.2$ m - **Speed:** $v = f\lambda = 2.0 \times 3.0 = 6.0$ m/s

Similar Example:

From a wave graph, you measure that 5 complete waves occupy 10 m, and it takes 2.0 s for one complete oscillation to pass a point. Find λ , f , and v .

Solution: - **Wavelength:** $\lambda = 10$ m / 5 waves $= 2.0$ m - **Period:** $T = 2.0$ s - **Frequency:** $f = 1/2.0 = 0.5$ Hz - **Speed:** $v = f\lambda = 0.5 \times 2.0 = 1.0$ m/s

Question 41 (Page 70)

Q41 • Wave Equation Application

Question 41: Apply the relation ($v = \lambda f$) to calculate the speed, wavelength, or frequency of a wave.



Answer:

Wave Equation:

$$v = \lambda f$$

Where: - v = wave speed (m/s) - λ = wavelength (m) - f = frequency (Hz)

Rearrangements:

To find wavelength:

$$\lambda = \frac{v}{f}$$

To find frequency:

$$f = \frac{v}{\lambda}$$

Alternative Form (using period):

Since $f = 1/T$:

$$v = \frac{\lambda}{T}$$

Applications:

1. Sound Waves: - Speed in air ≈ 343 m/s (at 20°C) - Example: $f = 440$ Hz $\rightarrow \lambda = 343/440 = 0.78$ m

2. Light Waves: - Speed in vacuum = 3×10^8 m/s - Example: $f = 5 \times 10^{14}$ Hz $\rightarrow \lambda = (3 \times 10^8)/(5 \times 10^{14}) = 6 \times 10^{-7}$ m

3. Water Waves: - Speed varies with depth - Example: $\lambda = 5$ m, $f = 0.4$ Hz $\rightarrow v = 5 \times 0.4 = 2$ m/s

Example Problem:



A sound wave has a frequency of 256 Hz and travels at 340 m/s. Calculate its wavelength.

Solution:

$$\lambda = \frac{v}{f} = \frac{340}{256} = 1.33 \text{ m}$$

Similar Example 1:

A wave on a string has wavelength 0.8 m and frequency 10 Hz. Find the wave speed.

42 (Page 70)

Q42 • Doppler Effect Calculations

Question 42: Apply the Doppler effect equation to calculate different frequencies and velocities.

Answer:

Doppler Effect Equation:

$$f' = f \frac{v + v_d}{v - v_s}$$

Where: - f' = observed frequency (Hz) - f = source frequency (Hz) - v = speed of sound in medium (m/s) - v_d = detector (observer) velocity (m/s) - v_s = source velocity (m/s)

Sign Conventions:



Numerator ($v + v_d$): - Use + when observer moves **toward** source - Use - when observer moves **away** from source

Denominator ($v - v_s$): - Use - when source moves **toward** observer - Use + when source moves **away** from observer

Special Cases:

1. Stationary observer, moving source:

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

2. Moving observer, stationary source:

$$f' = f \frac{v \pm v_d}{v}$$

3. Both stationary:

$$f' = f$$

Example Problem 1:

A car horn emits 400 Hz. The car approaches a stationary observer at 25 m/s. What frequency does the observer hear? ($v_{\text{sound}} = 343 \text{ m/s}$)

Solution: Source approaching, observer stationary:

$$f' = f \frac{v}{v - v_s} = 400 \times \frac{343}{343 - 25} = 400 \times \frac{343}{318} = 400 \times 1.079 = 431.6 \text{ Hz}$$

Example Problem 2:

An observer moves toward a stationary 500 Hz siren at 15 m/s. What frequency is heard? ($v = 343 \text{ m/s}$)

Solution: Observer approaching, source stationary:



$$f' = f \frac{v + v_d}{v} = 500 \times \frac{343 + 15}{343} = 500 \times \frac{358}{343} = 500 \times 1.044 = 522 \text{ Hz}$$

Example Problem 3 (Finding Velocity):

A train whistle emits 600 Hz. A stationary observer hears 660 Hz as the train approaches. Find the train's speed. ($v = 340 \text{ m/s}$)

Solution:

$$f' = f \frac{v}{v - v_s}$$

$$660 = 600 \times \frac{340}{340 - v_s}$$

$$\frac{660}{600} = \frac{340}{340 - v_s}$$

$$1.1 = \frac{340}{340 - v_s}$$

$$1.1(340 - v_s) = 340$$

$$374 - 1.1v_s = 340$$

$$1.1v_s = 34$$

$$v_s = 30.9 \text{ m/s}$$

Similar Example:

Two cars approach each other, each traveling at 20 m/s. One sounds a 480 Hz horn. What frequency does the other driver hear? ($v = 343 \text{ m/s}$)

Solution: Both source and observer moving toward each other:



$$f' = f \frac{v + v_d}{v - v_s} = 480 \times \frac{343 + 20}{343 - 20} = 480 \times \frac{363}{323} = 480 \times 1.124 = 539.5 \text{ Hz}$$

Obj #	Pages	References	Arabic Text	English Text	SB Pages
16	37-36 39	كتاب الطالب مراجعة Q.(10,11,12)	يُعرّف تأثير دوبلر. يوضح (يفسر) تأثير دوبلر في الصوت.	Define nodes and antinodes and discuss pressure and displacements at these points in case of open and closed pipes.	36→37
Obj #	Pages	References	Arabic Text	English Text	SB Pages
17	38 39	كتاب الطالب	يربط طول الأنبوب المغلق أو المفتوح بالطول الموجي للموجة الموقوفة التي يمكن أن يدعمها.	Relate the length of a closed or open pipe to the wavelength of the standing wave it can support.	38 39

Q43 • Resonance in Pipes

Question 43: Use the relation between resonance length and wavelength to solve problems for closed and open pipes.

Answer:

Resonance in Pipes:



Sound waves can form standing waves in pipes, creating resonance at specific frequencies.

1. CLOSED PIPE (One end closed, one end open):

Wavelength-Length Relationship:

$$L = \frac{(2n - 1)\lambda}{4}$$

Where $n = 1, 2, 3, \dots$ (harmonic number)

Resonant Frequencies:

$$f_n = \frac{(2n - 1)v}{4L}$$

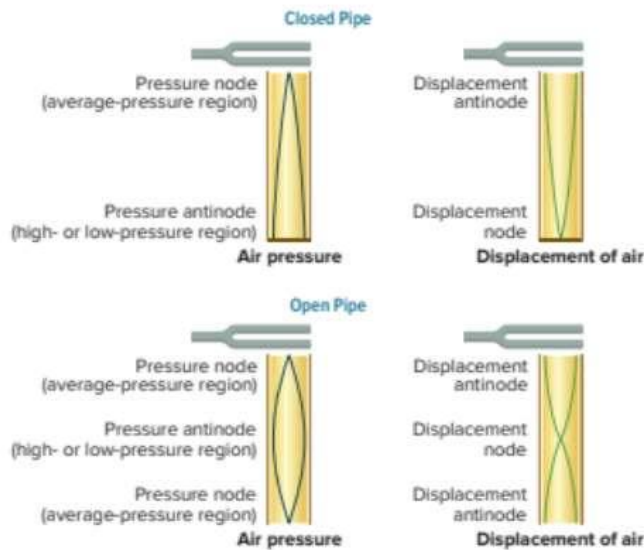


Figure 12 Standing waves in pipes can be represented by sine waves.

Identify Which are the areas of mean atmospheric pressure in the air pressure graphs?



Harmonics: - $n = 1$ (fundamental): $L = \lambda/4$, $f_1 = v/(4L)$ - $n = 2$ (3rd harmonic): $L = 3\lambda/4$, $f_3 = 3v/(4L)$ - $n = 3$ (5th harmonic): $L = 5\lambda/4$, $f_5 = 5v/(4L)$

Note: Only **odd harmonics** are present

Boundary Conditions: - **Closed end:** Displacement node, pressure antinode - **Open end:** Displacement antinode, pressure node

2. OPEN PIPE (Both ends open):

Wavelength-Length Relationship:

$$L = \frac{n\lambda}{2}$$

Where $n = 1, 2, 3, \dots$

Resonant Frequencies:

$$f_n = \frac{nv}{2L}$$

Harmonics: - $n = 1$ (fundamental): $L = \lambda/2$, $f_1 = v/(2L)$ - $n = 2$ (2nd harmonic): $L = \lambda$, $f_2 = 2v/(2L) = v/L$ - $n = 3$ (3rd harmonic): $L = 3\lambda/2$, $f_3 = 3v/(2L)$

Note: **All harmonics** are present

Boundary Conditions: - **Both ends:** Displacement antinodes, pressure nodes

Example Problem 1 (Closed Pipe):

A closed pipe has length 0.25 m. Find the fundamental frequency if the speed of sound is 340 m/s.

Solution:



$$f_1 = \frac{v}{4L} = \frac{340}{4 \times 0.25} = \frac{340}{1.0} = 340 \text{ Hz}$$

Example Problem 2 (Open Pipe):

An open pipe has length 0.5 m. Find the first three resonant frequencies ($v = 340 \text{ m/s}$).

Solution:

$$f_1 = \frac{v}{2L} = \frac{340}{2 \times 0.5} = \frac{340}{1.0} = 340 \text{ Hz}$$



$$f_2 = \frac{2v}{2L} = 2f_1 = 680 \text{ Hz}$$

$$f_3 = \frac{3v}{2L} = 3f_1 = 1020 \text{ Hz}$$

Example Problem 3 (Finding Length):

A closed pipe resonates at 440 Hz (fundamental frequency). Find the pipe length ($v = 340$ m/s).

Solution:

$$L = \frac{v}{4f_1} = \frac{340}{4 \times 440} = \frac{340}{1760} = 0.193 \text{ m} = 19.3 \text{ cm}$$

Similar Example:

A tuning fork of frequency 512 Hz is held above a closed pipe. The shortest length that produces resonance is 16.5 cm. Calculate the speed of sound.

Solution: For fundamental frequency in closed pipe:

$$L = \frac{v}{4f}$$

$$v = 4fL = 4 \times 512 \times 0.165 = 337.9 \text{ m/s} \approx 338 \text{ m/s}$$



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Obj #	Pages	References	Arabic Text	English Text	SB Pages
21	3 3 5	كتاب الطالب شكل 1	وصف خصائص الحركة التوافقية البسيطة. وصف الحركة التوافقية البسيطة (نظام الكتلة-الزنبرك المهنز والبندول البسيط) عند أقصى إزاحة وعند موضع الاتزان من حيث السرعة والتسارع وقوة الإرجاع والطاقة الحركية والطاقة الكامنة. وصف تحولات الطاقة بين الطاقة الكامنة والطاقة الحركية لكل من نظام (الكتلة-الزنبرك) المهنز أفقياً والبندول البسيط.	Describe the characteristics of simple harmonic motion. Describe simple harmonic motion (mass-spring oscillator and a simple pendulum) at maximum displacement and at equilibrium positions in terms of velocity, acceleration, restoring force, and kinetic and potential energy. Describe the energy transformations between potential energy and kinetic energy for both a horizontal oscillating (mass-spring) system and a simple pendulum.	3 3 5

Hooke's Law and Spring Mechanics

Student Book: Example 1, Unit Assessment Q.(44, 45, 100)

Hooke's law is used to calculate the force exerted by a spring, the spring constant, or the distance by which a spring is stretched or compressed.

Understanding Spring Force



The force exerted by a spring depends on its stiffness and other properties. When you stretch or compress a spring, it exerts a force that opposes the displacement. This relationship is described by Hooke's law, which states that the magnitude of the force is directly proportional to the distance the spring is stretched or compressed from its equilibrium position.

The Spring Constant

The spring constant (k) is a measure of the spring's stiffness. A larger spring constant indicates a stiffer spring that requires more force to stretch or compress. The constant has units of newtons per meter (N/m).

Hooke's Law Formula

The magnitude of the force exerted by a spring is equal to the spring constant times the distance the spring is stretched or compressed from its equilibrium position:

$$F = -kx$$

In this equation, k is the spring constant, which depends on the stiffness and other properties of the spring, and x is the distance the spring is stretched from its equilibrium position. The negative sign indicates that the force is in the direction opposite the stretch or compression direction.

Elastic Potential Energy

When you stretch a spring you transfer energy to the spring, giving it elastic potential energy. The work done by an applied force is equal to the area under a force v. distance graph.

$$PE_{\text{spring}} = (1/2)kx^2$$



Energy Conservation in Oscillating Systems

Student Book: Progress Check Q.(9)

Learning Objective

Apply the law of conservation of energy for both a horizontal oscillating mass-spring system and simple pendulum to relate the total energy of each system at one instant to the total energy at another instant.

Energy Transformations

The stored energy together with specified data, allows energy to be predicted and described. During simple harmonic motion the spring's elastic potential energy is converted to kinetic energy and back to potential energy.

In a **horizontal spring system**, the total mechanical energy remains constant as energy transforms between kinetic and potential forms. At maximum displacement, all energy is potential. At equilibrium position, all energy is kinetic.

Resonance Phenomena

Student Book: Pages 5-7



Understanding Resonance

To swing on a swing while sitting on it, you must push it by leaning back and pulling its rope from the same point in each oscillation of the motion, or ask someone to push you with repeated pushes at the appropriate moments.

Resonance occurs when small forces act on an oscillating or vibrating body at equal (regular) time intervals, and this leads to **an increase in the amplitude** of the oscillation or vibration. The time interval between applying the force to the body is equal to the period of the motion (oscillation).

Learning Objective

Identify the factors that affect the period of a simple pendulum.

Common Examples of Resonance

Common examples of resonance include rocking a car back and forth to free its tires stuck in sand, repeated jumping on diving boards or swimming platforms. The large amplitude resulting from resonance may produce a feeling of stress. It is also used in musical instruments to amplify sounds, and in clocks to increase their accuracy.

The Tacoma Narrows Bridge Case

In a famous and very exciting case, forces generated by wind led to the collapse of the Tacoma Narrows Bridge. The successive and regularly repeated forces generated by the wind added energy to the bridge's oscillation, which greatly increased the amplitude of its vibration and led to its collapse. Therefore, architects and engineers must pay great attention when designing and constructing buildings to ensure they are not affected by resonance.



Wave Types and Properties

Student Book: Pages 10-11, Q.(26, 27)

Learning Objective

Distinguish and compare between transverse waves, longitudinal waves, and surface waves, giving examples of each.

What is a Wave?

A wave is a disturbance that carries energy through matter or space without transferring matter. You have learned how Newton's laws of motion and the law of conservation of energy govern the behavior of particles. These laws also govern the behavior of waves. Water waves, sound waves, and the waves that travel along a rope or a spring are mechanical waves. Mechanical waves pass through a physical medium, such as water, air, or a rope.

Transverse Waves

A wave pulse is a single bump or disturbance that passes through a medium. The wave pulse disturbs the rope in the vertical direction, but the pulse travels horizontally. A wave that disturbs the particles in the medium perpendicular to the direction of the wave's travel is called a transverse wave. If the disturbances continue at a constant rate, a periodic wave is generated.

Longitudinal Waves



In a coiled spring toy, you can produce another type of wave. If you squeeze together several turns of the coiled spring toy and then suddenly release them, pulses will move away in both directions. The result is called a longitudinal wave because the disturbance is parallel to the direction of the wave's travel. Sound waves are longitudinal waves in which the molecules are alternately compressed or decompressed along the path of the wave.

Wave Amplitude and Energy

Student Book: Pages 10-11

Learning Objective

Describe wave properties like amplitude, energy of a wave, wavelength, speed, phase, period and frequency.

Understanding Amplitude

The amplitude of a wave is the maximum distance by which the wave is displaced from its equilibrium position. Since amplitudes are distances, they are always positive. The energy of a wave is proportional to the square of the amplitude.

Energy and Amplitude Relationship

Many waves share a common set of properties. The energy carried by a wave depends on its amplitude. Waves generated by gentle breezes have small amplitudes, whereas giant waves that move across the ocean have large amplitudes. The energy of a wave is proportional to the square of the amplitude.



Wave Frequency and Period

Student Book: Example Problem 3, Examples 14-15, Practice Problems Q.(22, 16)

Learning Objective

Calculate the frequency of a wave from its period and vice-versa $f = 1/T$.

Frequency Definition

The frequency of a wave (f) is the number of complete oscillations a point on that wave makes each second. Frequency is measured in hertz (Hz). One hertz is equal to $1/s$ or s^{-1} . The frequency and period are related by the following equation:

$$f = 1/T$$

where T is the period of the wave.

Wavelength and Wave Speed

The wavelength of a wave is the distance between adjacent crests or troughs. You can also calculate wavelength using the relationship between wavelength, frequency, and wave speed. The speed of a wave depends on the type of wave and the medium through which it is traveling. In one period, a wave travels one wavelength.

$$\lambda = v/f$$



The wavelength of a wave is equal to the velocity divided by the frequency.

Wave Reflection and Refraction

Student Book: Pages 16-17

Learning Objective

Describe that a mechanical wave is inverted if reflected from a fixed end and remains upright if reflected from a free end (reflection and refraction).

Waves at Boundaries

The speed of a mechanical wave depends only on the properties of the medium it passes through, not on the wave's amplitude or frequency. For example, for waves on a spring, the speed depends on the spring's tension and mass per unit length. When a wave travels from one medium to another, the pulse that strikes the boundary is called the incident wave.

Reflected Waves

Some of the energy of the incident wave's pulse is reflected backward. This returning wave is called the reflected wave. Whether the reflected wave is upright or inverted depends on the characteristics of the two media. For example, if the waves in the smaller spring have a greater speed because the spring is stiffer, then the reflected wave will be inverted.



Two-Dimensional Waves

Student Book: Pages 18-20

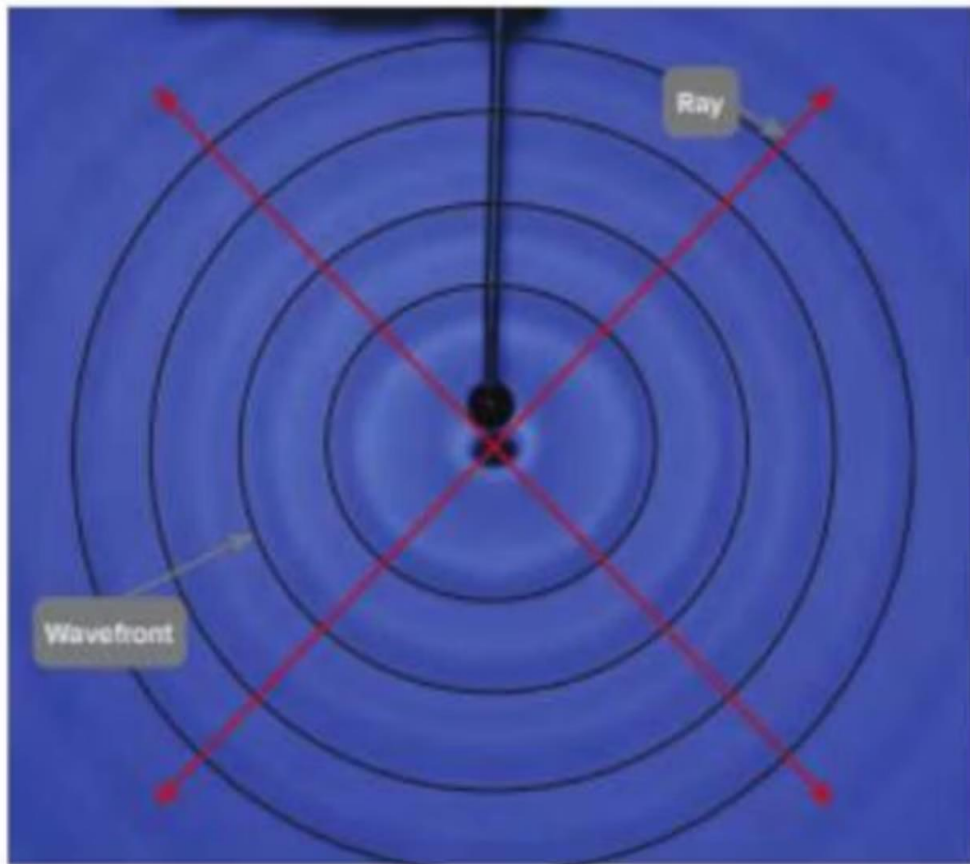
Learning Objective

Use a ripple tank to model wave behaviour in two dimensions (such as reflection and refraction of waves traveling on the surface of water).



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Waves in Two Dimensions

You have studied waves on a rope and on a spring reflecting from rigid supports. These mechanical waves travel in only one dimension. Waves on the surface of water, however, travel in two dimensions, and sound waves and electromagnetic waves travel in three dimensions.



Picturing Waves in Two Dimensions

When you throw a small stone into a calm pool of water, you see the circular crests and troughs of the resulting waves spreading out in all directions. You can sketch those waves by drawing circles to represent the wave crests. If you repeatedly dip your finger into water with a constant frequency, the resulting sketch would be a series of concentric circles, called wavefronts, centered on your finger. A wavefront is a line that represents the crest of a wave in two dimensions.

Rays and Wavefronts

Whatever their shape, two-dimensional waves always travel in a direction that is perpendicular to their wavefronts. That direction can be represented by a ray, which is a line drawn at a right angle to the wavefront. When all you want to show is the direction in which a wave is traveling, it is convenient to draw rays instead of wavefronts.

Wave Interference and Superposition

Student Book: Page 16

Learning Objective

State and apply the principle of superposition to show that two overlapping waves add algebraically to give a resultant (or net) wave.

Constructive and Destructive Interference



When two waves meet, they interact according to the principle of superposition. This principle states that when two or more waves overlap, the resulting displacement at any point is the algebraic sum of the displacements of the individual waves at that point.

Constructive Interference

Constructive interference occurs when two waves with the same phase meet. The amplitudes add together, creating a wave with larger amplitude than either of the original waves.

Destructive Interference

Destructive interference occurs when two waves with opposite phases meet. The amplitudes subtract from each other, potentially canceling out completely if the waves have equal amplitudes.

Sound Waves and Their Properties

Student Book: Pages 29, 33-34, 39, Review Q.(8), Problems Q.(42a, 69, 82)

Learning Objective

Define loudness and relate it to the amplitude of a sound wave. Explain the effect of medium and temperature on the speed of sound waves.

Describing Sound

A pressure oscillation that is transmitted through matter is a sound wave. Sound waves travel through air because a vibrating source produces regular variations, or oscillations,



in air pressure. The air particles collide, transmitting the pressure variations away from the source of the sound. Because the motion of the particles in air is parallel to the direction of the wave's motion, sound is a longitudinal wave.

Speed of Sound

The wavelength and frequency of a wave are related to one another by the speed of travel of the sound through the medium it passes. In air, the speed depends on the temperature, increasing by about 0.6 m/s for each 1°C increase in air temperature. At room temperature (20°C) and sea level, the speed of sound is 343 m/s.

Sound Pitch and Loudness

Student Book: Page 29

Learning Objective

Define sound pitch and relate it to the frequency. Define loudness and relate it to the amplitude of a sound wave.

Detection of Pressure Waves

Sound detectors transform sound energy—the kinetic energy of the vibrating particles of the transmitting medium—into another form of energy. A common detector is a microphone, which transforms sound energy into electrical energy. A microphone consists of a thin disk that vibrates in response to sound waves and produces an electrical signal.



The Human Ear

The human ear is a sound detector that receives pressure waves and converts them to electrical impulses. The tympanic membrane, also called the eardrum, vibrates when sound waves enter the auditory canal. Three tiny bones in the middle ear then transfer these vibrations to fluid in the cochlea. Tiny hairs lining the spiral-shaped cochlea detect certain frequencies in the vibrating fluid. These hairs stimulate nerve cells, which send impulses to the brain and produce the sensation of sound. The ear detects sound waves over a wide range of frequencies and is sensitive to an enormous range of amplitudes.

Simple Pendulum

From Page 5

1. What is the length of a simple pendulum on Earth whose period is 1.0 s? ($g = 9.8 \text{ N/kg}$)
2. What is the appropriate length for a simple pendulum on the surface of a planet where $g = 16 \text{ N/kg}$ so that its period is 2.0 s?
3. If the period of a simple pendulum with a length of 0.75 m is 1.8 s on one of the planets, what is the magnitude of g on that planet?

Springs and Hooke's Law

From Page 6



4. What is the spring constant of a spring that stretches 12 cm when an object weighing 24 N is hung from it?
5. What is the elastic potential energy of a spring with $k = 144 \text{ N/m}$ that is compressed by 16.5 cm?
6. A spring has a spring constant of 56 N/m. How far will a block weighing 18 N stretch it?
7. ****CHALLENGE:**** A spring has a spring constant of 256 N/m. How far must it be stretched to give it an elastic potential energy of 48 J?

Waves & Sound

From Page 9

8. Water waves pass a dock on a lake at a rate of 6.4 waves per minute. If the period of the waves is 1.5 s, what is the speed of the water waves?
9. What is the wavelength of the water waves?
10. A certain sonar signal has a frequency of $1.00 \times 10^6 \text{ Hz}$ and a wavelength of 1.50 mm in water. What is the speed of the signal in the water?
11. What is the period of the signal in the water?
12. A ship sends a sonar signal to the seafloor and receives the reflected echo after 0.180 s. If the speed of sound in water is 1498 m/s, what is the depth of the water?



Waves & Sound (Continued)

From Page 11

- 13.** A periodic longitudinal wave that has a frequency of 20.0 Hz travels along a coiled spring toy. If the distance between successive compressions is 0.600 m, what is the speed of the wave?
- 14.** A sound wave produced by a clock chime is heard 515 m away 1.50 s later.
- a.** Based on these measurements, what is the speed of sound in air?
 - b.** The sound wave has a frequency of 436 Hz. What is the period of the wave?
 - c.** What is its wavelength?

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Resonance & Pipes

From Page 13



15. A 440-Hz tuning fork is held above a closed pipe. Find the spacing between the resonances when the air temperature is 20°C .

16. **CHALLENGE:** A bugle can be thought of as an open pipe. If a bugle were straightened out, it would be 2.65 m long.

- a. If the speed of sound is 343 m/s, find the lowest frequency that is resonant for a bugle (ignoring end corrections).
- b. Find the next two resonant frequencies for the bugle.

Resonance & Pipes (Continued)

From Page 14

17. Arrange the following frequencies from smallest to largest: 35 Hz, 50 Hz, 83 Hz.

18. The bassoon is considered a closed pipe. If the bassoon produces a fundamental tone of 70 Hz, what are the frequencies of the first three overtones that this instrument reinforces?

19. A 440-Hz tuning fork is held over the open end of a pipe. Find the spacing between the resonances when the air temperature is 20°C . A bugle can be thought of as an open pipe. If it were straightened out, it would be 2.65 m long.

- a. If the speed of sound is 343 m/s, find the lowest resonant frequency of the bugle.
- b. Find the next two resonant frequencies for the bugle.



- 20.** In a musical instrument, if the lowest note produced by an organ pipe is 22 Hz and the pipe is 4.0 m long, is this pipe open or closed at both ends?
- What is the speed of sound for this pipe?
 - What sound frequency will be produced if the same organ pipe is closed?
- 21.** Figure 25 shows a plastic pipe that is 0.85 m long when open at both ends. If the fundamental frequency of its sound is lower than the fundamental frequency of a closed pipe of the same length, what is the frequency of the note?

Light & Illuminance

From Page 15

- 22.** A lamp has a luminous flux of 405 lm. Determine the amount of illuminance at a distance of 3.6 m.
- 23.** What is the illuminance on a surface 3.0 m away from a projected lamp with a power of 150 W and a luminous flux of 22275 lm?
- 24.** One public institution's laws require that the minimum illuminance be 160 lx on the surface of every desk. The recommended specifications state that the lighting should be mounted at a height of 2.0 m only. What is the minimum luminous flux the lamps must provide?
- 25.** A student wants to measure the luminous flux of a lamp using another lamp with a known luminous flux of 1750 lm. Each lamp is placed facing a screen. The lamp with a luminous flux of 1750 lm is placed 1.25 m from the paper, while the other lamp is placed 1.08 m away. What is the luminous flux of the unknown lamp?



26. A point light source is placed 2.0 m from screen A and 4.0 m from screen B, as shown in Figure 27. State the relationship between the illuminance on screen B and the illuminance on screen A.

Light & Illuminance (Continued)

From Page 17

- 27.** A 64-cd point source of light is 3.0 m away from a painting. What is the illumination on the painting in lux?
- 28.** What is the illumination on a surface that is 3.0 m below a 150-W incandescent lamp that emits a luminous flux of 2275 lm?
- 29.** A public school law requires a minimum illuminance of 160 lx at the surface of each student's desk. An architect's specifications call for classroom lights to be located 2.0 m above the desks. What is the minimum luminous flux that the lights must produce?
- 30.** ****EXAMPLE Problem 1:**** What is the illuminance on your desktop if it is lit by a 17 50-lm lamp that is 2.50 m above your desk?



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EXAMPLE Problem 1

ILLUMINATION OF A SURFACE What is the illuminance on your desktop if it is lit by a 1750-lm lamp that is 2.50 m above your desk?

1 ANALYZE AND SKETCH THE PROBLEM

- Assume the lightbulb is the point source.
- Diagram the position of the bulb and the desktop. Label P and r .

Known

$$P = 1.75 \times 10^3 \text{ lm}$$

$$r = 2.50 \text{ m}$$

Unknown

$$E = ?$$

2 SOLVE FOR THE UNKNOWN

The surface is perpendicular to the direction in which the light ray is traveling, so you can use the point-source illuminance equation.

$$E = \frac{P}{4\pi r^2}$$

$$= \frac{1.75 \times 10^3 \text{ lm}}{4\pi(2.50 \text{ m})^2}$$

$$= 22.3 \text{ lm/m}^2$$

$$= 22.3 \text{ lx}$$

