JUNIOR LEVEL

JUNIOR PHYSICS OLYMPIAD SUGGESTION BOOK

CLASSES 6, 7 & 8

ENGLISH VERSION

Concepts • Worked Examples • Multiple-Choice Practice

About This Suggestion Book

This book is a focused physics preparation resource for students of Classes 6, 7 and 8 in Bangladesh. It develops the basic concepts needed for junior-level science and physics olympiad questions without assuming advanced prior knowledge.

The three chapters combine clear explanations, essential relations, diagrams, worked examples and multiple-choice practice. Each chapter contains 50 MCQs with five options. Answers are intentionally not included so students can solve independently and discuss their reasoning with teachers or study partners.

The questions develop observation, calculation and logical application. This is a preparation and practice book; it does not claim that any exact question will appear in a particular competition.

Guidelines for Using This Book

1. Study each chapter in order, beginning with the explanations and definitions.
2. Write important formulas and units in a notebook and identify what every symbol means.
3. Redo each worked example without looking at its calculation, then compare your method.
4. Attempt all MCQs on paper. Show calculations and check units before selecting an option.
5. Mark difficult questions, return to the related theory, and try them again after revision.
6. Discuss unclear ideas with a teacher or study partner and explain the reasoning in your own words.

Table of Contents

CHAPTER 1: MECHANICS

Junior Level • Class 6–8

1. Motion

Distance is the total length of a path. Displacement is the change of position in a particular direction. Speed tells how quickly distance changes, while velocity includes direction. Average speed is found from the total distance and the total time, including any rest time.

Acceleration is the change of velocity per unit time. For motion with constant acceleration, $v = u + at$, $s = ut + \frac{1}{2}at^2$, and $v^2 = u^2 + 2as$. The slope of a speed–time graph gives acceleration, and the area below the graph gives distance.

2. Force and Friction

A force can change the speed, direction, or shape of an object. The net force on a body is $F = ma$. Weight is the gravitational force mg. Friction acts against relative motion between surfaces and can slow a moving object.

3. Work, Energy and Power

Work is done when a force causes displacement. A moving object has kinetic energy, and an object raised above the ground has gravitational potential energy. Energy can change form but the total energy of an isolated system remains constant. Power is the rate of doing work.

4. Gravitation and Circular Motion

Gravity attracts masses toward one another. Near Earth, freely falling objects have the same acceleration when air resistance is ignored. An object in circular motion continually changes direction. Gravity keeps planets and satellites in orbit.

5. Rotation, Rolling and Simple Machines

A rotating object turns through an angle. A wheel rolling without slipping travels one circumference in one full revolution. Levers, wheels and axles, and other simple machines change the size or direction of a force. In an ideal machine, input work equals output work.

Important Relations

Average speed = total distance ÷ total time • $a = (v - u)/t$ • $F = ma$
W = force × displacement • $K = \frac{1}{2}mv^2$ • $U = mgh$ • P = work ÷ time
Weight = mg • one revolution = $2\pi r$ • effort × effort arm = load × load arm

Multiple-Choice Questions

1. A student walks 3 m east and then 4 m west. What are the total distance and final displacement?

A. 7 m; 1 m east
B. 7 m; 1 m west
C. 1 m; 7 m west
D. 1 m; 1 m west
E. 7 m; 0 m

2. A cyclist travels 120 m at 6 m/s and then 180 m at 9 m/s. What is the average speed for the whole journey?

A. 5 m/s
B. 6 m/s
C. 7.5 m/s
D. 8 m/s
E. 9 m/s

3. A relay baton travels 60 m at 6 m/s, 120 m at 4 m/s, and 60 m at 3 m/s. What is its average speed?

A. 3 m/s
B. 4 m/s
C. 4.5 m/s
D. 5 m/s
E. 6 m/s

4. A runner moves at 5 m/s for 20 s and then rests for 10 s. The cycle repeats. How much time is needed to finish a 300 m race?

A. 60 s
B. 70 s
C. 80 s
D. 90 s
E. 100 s

5. A car's velocity increases uniformly from 5 m/s to 17 m/s in 6 s. What is its acceleration?

A. 1 m/s^2
B. 2 m/s^2
C. 3 m/s^2
D. 4 m/s^2
E. 6 m/s^2

6. A bus starts from rest with an acceleration of 2 m/s². How far does it travel in 5 s?

A. 10 m
B. 20 m
C. 25 m
D. 40 m
E. 50 m

7. A 12 kg box is pulled horizontally by 50 N while friction is 14 N. What is the box's acceleration?

A. 2 m/s²
B. 3 m/s²
C. 4 m/s²
D. 5 m/s²
E. 6 m/s²

8. What net force is required to give a 5 kg object an acceleration of 4 m/s²?

A. 9 N
B. 10 N
C. 20 N
D. 25 N
E. 40 N

9. A cyclist and bicycle have a total mass of 120 kg and move at 40 m/s. They stop after travelling 80 m. What is the average friction force?

A. 300 N
B. 600 N
C. 900 N
D. 1200 N
E. 2400 N

10. In which direction does friction act on a sliding book?

A. In the direction of motion
B. Opposite the direction of motion
C. Vertically upward
D. Vertically downward
E. It has no direction

11. A horizontal force of 20 N moves an object 5 m in the direction of the force. How much work is done?

A. 4 J
B. 25 J
C. 50 J
D. 100 J
E. 200 J

12. What is the kinetic energy of a 2 kg ball moving at 3 m/s?

A. 3 J
B. 6 J
C. 9 J
D. 12 J
E. 18 J

13. A 5 kg object is raised 4 m. Taking g = 10 m/s², what is the gain in gravitational potential energy?

A. 20 J
B. 50 J
C. 100 J
D. 200 J
E. 400 J

14. A 40 kg student climbs through a vertical height of 5 m in 10 s. Taking g = 10 m/s², what power is developed?

A. 100 W
B. 150 W
C. 200 W
D. 250 W
E. 400 W

15. An elevator is falling freely. A ball is released from its roof. Ignoring air resistance, what happens to the distance between the ball and the roof?

A. It becomes zero and remains zero
B. It increases at 9.8 m every second
C. It decreases uniformly
D. It first increases and then decreases
E. It depends on the mass of the ball

16. A bottle with a small hole at the bottom is dropped freely. Ignoring air resistance, what happens to the flow of water through the hole during the fall?

A. It becomes faster
B. It continues at the same rate
C. It nearly stops
D. All water leaves at once
E. The direction of flow reverses

17. A rock has a mass of 7 kg on Earth. What is its mass on the Moon?

A. 0 kg
B. 1.17 kg
C. 3.5 kg
D. 7 kg
E. 42 kg

18. A planet has four times Earth's mass and twice Earth's radius. Compared with Earth, the gravitational acceleration at its surface is—

A. one-fourth
B. one-half
C. the same
D. twice
E. four times

19. Three planets orbit the same star. Which one generally has the longest year?

A. The nearest planet
B. The smallest planet
C. The farthest planet
D. The hottest planet
E. All have equal years

20. Two robots move in the same direction around a 400 m circular track at 10 m/s and 6 m/s. After how long will the faster robot first overtake the slower one?

A. 25 s
B. 40 s
C. 50 s
D. 80 s
E. 100 s

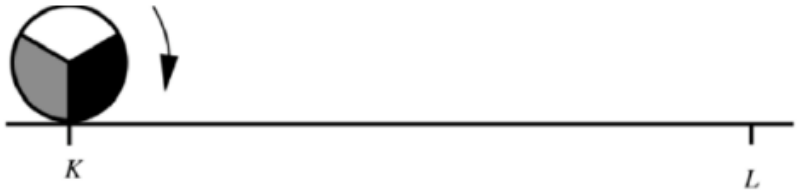
21. A ship moves along Earth's equator. In which direction should it move to make the solar day on the ship longer than 24 hours?

A. Eastward
B. Westward
C. Northward
D. Southward
E. Vertically upward

22. A wheel of radius 0.5 m rolls without slipping through a distance of 5π m. How many complete revolutions does it make?

A. 2
B. 2.5
C. 5
D. 10
E. 25

23. The marked wheel has circumference 2π and rolls from K to L, where KL = 11π. How is its final orientation related to the initial orientation?



A. Unchanged
B. Rotated by half a turn
C. Rotated by one-quarter turn clockwise
D. Rotated by one-quarter turn anticlockwise
E. Impossible to determine

24. A 30 kg child sits 2 m from the pivot of a balanced seesaw. Where should a 40 kg child sit on the other side?

A. 0.5 m
B. 1.0 m
C. 1.5 m
D. 2.0 m
E. 2.5 m

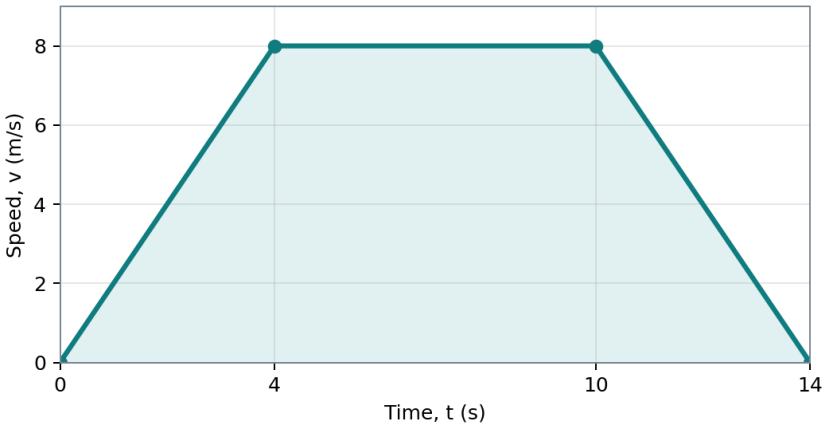
25. An ideal lever has an effort arm of 80 cm and a load arm of 20 cm. If the effort is 50 N, what load can be balanced?

A. 50 N
B. 100 N
C. 150 N
D. 200 N
E. 400 N

26. An ideal machine has a mechanical advantage of 5. What load can be lifted by an effort of 40 N?

A. 8 N
B. 45 N
C. 100 N
D. 200 N
E. 400 N

27. The speed–time graph shows the motion of a cart. What total distance does the cart travel in 14 s?

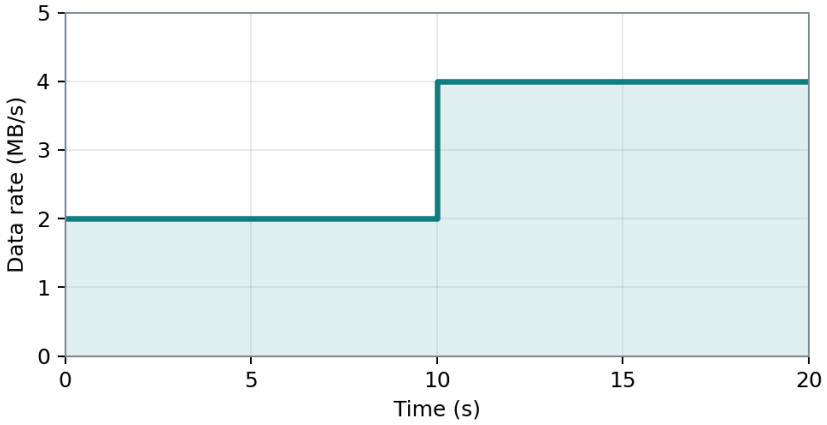


A. 48 m
B. 64 m
C. 72 m
D. 80 m
E. 112 m

28. A person covers half of a 240 m journey at 12 m/s in 10 s. The remaining distance is covered at 5 m/s for 15 s and 3 m/s for 15 s. What is the average speed?

A. 4 m/s
B. 5 m/s
C. 6 m/s
D. 7.5 m/s
E. 8 m/s

29. The graph shows a data-transfer rate of 2 MB/s for the first 10 s and 4 MB/s for the next 10 s. How much data is transferred?



A. 20 MB
B. 40 MB
C. 50 MB
D. 60 MB
E. 80 MB

30. Two cyclists travel in opposite directions around a 300 m circular track at 10 m/s and 5 m/s. After how long will they first meet?

A. 10 s
B. 15 s
C. 20 s
D. 25 s
E. 30 s

31. A bus travels 150 m in 30 s at a steady speed. What is its speed?

A. 2 m/s
B. 3 m/s
C. 5 m/s
D. 6 m/s
E. 10 m/s

32. A student walks 60 m in 10 s and then 40 m in another 10 s. What is the average speed?

A. 5 m/s
B. 6 m/s
C. 8 m/s
D. 10 m/s
E. 20 m/s

33. Which physical quantity always includes a direction?

A. Distance
B. Speed
C. Time
D. Velocity
E. Mass

34. A bicycle's speed increases uniformly from 2 m/s to 10 m/s in 4 s. What is its acceleration?

A. 0.5 m/s^2
B. 2 m/s^2
C. 3 m/s^2
D. 4 m/s^2
E. 8 m/s^2

35. A train moves at a constant speed of 8 m/s for 15 s. How far does it travel?

A. 23 m
B. 60 m
C. 80 m
D. 100 m
E. 120 m

36. A 6 kg box is pushed by 30 N to the right and 18 N to the left. What is its acceleration?

A. 2 m/s^2 left
B. 1 m/s^2 right
C. 2 m/s^2 right
D. 3 m/s^2 right
E. 8 m/s^2 right

37. Two equal and opposite forces act on an object already moving in a straight line. What will it do?

A. Continue with constant velocity
B. Speed up continuously
C. Turn around immediately
D. Move in a circle
E. Lose all its mass

38. Why is friction useful while a person walks?

A. It reduces the person's mass
B. It creates gravity
C. It stops the legs from moving
D. It provides grip between the feet and ground
E. It increases the walking distance automatically

39. What is the weight of a 4 kg object on Earth if g = 10 m/s²?

A. 4 N
B. 40 N
C. 400 N
D. 0.4 N
E. 14 N

40. Which quantity of an astronaut remains the same on Earth and on the Moon?

A. Weight
B. Gravitational force
C. Acceleration due to gravity
D. Falling speed after one second
E. Mass

41. A 10 N force lifts a box vertically through 2 m. How much work is done?

A. 5 J
B. 10 J
C. 20 J
D. 50 J
E. 100 J

42. If the speed of an object doubles while its mass stays constant, its kinetic energy becomes—

A. four times
B. three times
C. twice
D. half
E. unchanged

43. A 2 kg book is placed on a shelf 5 m above the floor. Taking g = 10 m/s², what is its gravitational potential energy?

A. 10 J
B. 20 J
C. 50 J
D. 100 J
E. 200 J

44. A machine does 600 J of work in 3 s. What is its power?

A. 100 W
B. 200 W
C. 300 W
D. 600 W
E. 1800 W

45. Ignoring air resistance, which energy conversion mainly occurs as a ball falls?

A. Kinetic energy to chemical energy
B. Heat energy to light energy
C. Electrical energy to sound energy
D. Kinetic energy to gravitational potential energy
E. Gravitational potential energy to kinetic energy

46. An object moves around a circular path at constant speed. Why does its velocity change?

A. Its mass changes
B. Its speed becomes zero
C. Its direction changes continuously
D. Gravity disappears
E. The path has no length

47. A wheel has a circumference of 2 m and rolls without slipping through 10 m. How many revolutions does it complete?

A. 5
B. 4
C. 10
D. 12
E. 20

48. A 100 N load is 0.20 m from a lever's pivot. If the effort is applied 1.0 m from the pivot, what effort balances the load?

A. 5 N
B. 10 N
C. 50 N
D. 20 N
E. 100 N

49. What is the main advantage of an ideal fixed pulley?

A. It multiplies the force five times
B. It changes the direction of the applied force
C. It removes the load's weight
D. It produces energy
E. It shortens the rope to zero

50. A machine receives 100 J of energy and gives 80 J of useful output. What is its efficiency?

A. 20%
B. 40%
C. 60%
D. 75%
E. 80%

CHAPTER 2: PROPERTIES OF MATTER AND HEAT

Junior Level • Class 6–8

1. Matter, Particles and States

Everything that has mass and takes up space is called matter. Air, water, wood and the human body are matter. Matter is made of extremely small particles. We cannot usually see the individual particles, but their arrangement explains how solids, liquids and gases behave.

Solid: Its particles are packed closely in an orderly arrangement. They only vibrate about fixed positions. A solid therefore has a fixed shape and a fixed volume.

Liquid: Its particles remain close together but can slide past one another. A liquid has a fixed volume but takes the shape of its container.

Gas: Its particles are far apart and move freely in every direction. A gas has no fixed shape or volume, fills its container, and is easy to compress because of the large empty spaces between particles.

Changes of state: Solid to liquid is melting; liquid to solid is freezing; liquid to gas is vaporisation; and gas to liquid is condensation. The particles rearrange, but the total mass remains the same in a closed container.

2. Mass, Volume and Density

Mass: Mass tells us how much matter an object contains. It is measured in kilograms (kg) or grams (g). Mass does not change when an object is taken from Earth to the Moon. Weight can change because weight depends on gravity.

Volume: Volume is the space occupied by an object. A box has volume length × width × height. Useful units are m^3 and cm^3. One millilitre (1 mL) is exactly 1 cm^3, and 1000 cm^3 is 1 litre.

Water displacement: To find the volume of an irregular solid, note the initial water reading in a measuring cylinder, submerge the solid, and note the final reading. Object volume = final reading − initial reading.

Density: Density tells us how tightly matter is packed. Density = mass ÷ volume. A large density means a large mass is packed into a small volume. Common units are kg/m^3 and g/cm^3.

Worked Example 1 — Density of a block

Mass = 540 g; dimensions = 6 cm × 5 cm × 4 cm

Volume = 6 × 5 × 4 = 120 cm^3

Density = mass ÷ volume = 540 ÷ 120 = 4.5 g/cm^3

Worked Example 2 — Density by displacement

A 7 kg rock displaces 7000 cm^3 of water. First convert 7 kg = 7000 g.

Density = 7000 g ÷ 7000 cm^3 = 1 g/cm^3.

Taking the rock to the Moon changes its weight, but not its mass, volume or density.

3. Pressure, Liquids and Buoyancy

Pressure: Pressure is the force acting normally on each unit area: P = F/A. Its unit is the pascal (Pa), where 1 Pa = 1 N/m^2. For the same force, a smaller area produces greater pressure. This is why a sharp nail enters wood easily.

Liquid pressure: A liquid pushes in every direction. Its pressure increases with depth because deeper points support a taller column of liquid. The pressure caused by a liquid is $p = \rho gh$. At the same depth in the same liquid, the pressure is the same.

Gas pressure: Moving gas particles collide with the walls of their container and produce pressure. At the same pressure and temperature, the number of gas particles is proportional to the container's volume. If all three dimensions double, volume and particle number become 2 × 2 × 2 = 8 times larger.

Buoyant force: A liquid pushes upward on an immersed object. This upward force is called buoyant force or upthrust. It equals the weight of the displaced liquid. It can also be found from apparent loss of weight: buoyant force = weight in air − apparent weight in liquid.

Floating: A floating object is in balance: buoyant force = its weight. For an object floating in water, submerged fraction = object density ÷ water density. An object less dense than the liquid floats; one denser than the liquid sinks.

Worked Example 3 — Pressure on the floor

Force (weight) = 600 N; contact area = 0.030 m^2

P = F/A = 600 ÷ 0.030 = 20,000 Pa.

Worked Example 4 — Buoyancy and floating

An object weighs 70 N in air and 50 N in water.

Buoyant force = 70 − 50 = 20 N.

A wood block of density 600 kg/m^3 floats in water of density 1000 kg/m^3.

Submerged fraction = 600 ÷ 1000 = 0.60 = 60%.

4. Temperature, Heat and Thermal Expansion

Temperature: Temperature describes the thermal condition of an object—how hot or cold it is. It is measured with a thermometer in degrees Celsius (°C) or kelvin (K). Kelvin temperature is approximately Celsius temperature + 273, so 27°C is 300 K.

Heat: Heat is energy transferred because two objects have different temperatures. Net heat always flows from the higher-temperature object to the lower-temperature object until both reach the same temperature. If heat goes from A to B and from B to C, then $T_a > T_\beta > T_\subset$.

Thermal expansion: Most materials expand when heated and contract when cooled. The liquid in a thermometer rises because it expands. Gaps are left in bridges and railway tracks so that expansion does not bend or crack them.

Temperature scales: Equal temperature changes correspond to equal changes on any linear scale. Begin with a known point, calculate the scale change per 1°C, and then calculate the required reading.

Worked Example 5 — A new temperature scale

The scale reads 15 E at 0°C and 65 E at 43.8°C.

A change of 43.8°C gives a change of 65 − 15 = 50 E.

At 90°C: reading = 15 + 90 × (50 ÷ 43.8) ≈ 117.7 E.

Heating power: Power is energy transferred per second. For the same liquid flowing at the same rate, heater power is proportional to the temperature rise. A heater producing a 15°C rise has 15/10 = 1.5 times the power of one producing a 10°C rise.

5. Heating Energy, Transfer and Changes of State

Specific heat capacity: Specific heat capacity c is the energy needed to raise the temperature of 1 kg of a substance by 1°C. The energy needed for a temperature change is Q = mcΔT, where m is mass and ΔT is final temperature − initial temperature.

Worked Example 6 — Energy needed to heat water

m = 0.20 kg, c = 4200 J/(kg·°C), ΔT = 5°C

Q = mcΔT = 0.20 × 4200 × 5 = 4200 J.

Mixing: In an insulated mixture, heat lost by the hotter substance equals heat gained by the colder substance. When the same substance is mixed, the final temperature is a mass-weighted average and must lie between the two starting temperatures.

Worked Example 7 — Mixing water

Mix 100 g of water at 80°C with 300 g at 20°C; ignore heat loss.

Final temperature = (100 × 80 + 300 × 20) ÷ (100 + 300)

= 14,000 ÷ 400 = 35°C.

Conduction: Energy passes through a material without the material moving as a whole. Metals are good conductors, so a metal spoon becomes hot from one end to the other.

Convection: Warmer parts of a liquid or gas expand, become less dense and rise; cooler, denser parts sink. This circulation forms a convection current. Sea breeze is caused mainly by convection in air.

Radiation: Thermal radiation travels as electromagnetic waves and does not require matter. Energy from the Sun crosses space and reaches Earth by radiation.

Melting and boiling: During melting or boiling of a pure substance at constant pressure, the temperature remains constant. The supplied energy separates or rearranges particles instead of increasing temperature.

Evaporation and condensation: Evaporation can occur from a liquid surface below its boiling point. Faster particles escape and take energy away, causing cooling. Condensation changes gas to liquid. If equal masses of the same vapour fully condense under the same conditions, they produce equal masses and equal volumes of liquid.

Multiple-Choice Questions

1. A solid block has a mass of 540 g and dimensions 6 cm × 5 cm × 4 cm. What is its density?

A. 0.45 g/cm³
B. 2.0 g/cm³
C. 4.5 g/cm³
D. 9.0 g/cm³
E. 45 g/cm³

2. A 7 kg rock displaces 7000 cm³ of water. What is the rock's density?

A. 0.1 g/cm³
B. 0.7 g/cm³
C. 1.0 g/cm³
D. 7.0 g/cm³
E. 10 g/cm³

3. A scientist finds the density of water to be 27 kg/lumba³. If water has density 1000 kg/m³, what length is 1 lumba?

A. 0.03 m
B. 0.30 m
C. 0.90 m
D. 3.0 m
E. 9.0 m

4. Equal masses of liquids A and B are placed in identical cylinders. Liquid A occupies less volume. Which statement is correct?

A. A is less dense than B
B. A is denser than B
C. Both have zero density
D. Both must have equal volume
E. Density cannot be compared

5. A block of density 800 kg/m³ floats in water of density 1000 kg/m³. What percentage of the block is submerged?

A. 20%
B. 40%
C. 60%
D. 80%
E. 100%

6. Why can a gas be compressed much more easily than a liquid?

A. Gas particles have no mass
B. Gas particles are much farther apart
C. Gas particles do not move
D. Liquid particles have no spaces
E. A gas has no pressure

7. A person of weight 600 N stands on shoes with a total contact area of 0.030 m^2. What pressure is exerted on the floor?

A. 20 Pa
B. 200 Pa
C. 2000 Pa
D. 20,000 Pa
E. 200,000 Pa

8. A sharp nail enters wood more easily than a blunt nail under the same force because the sharp nail—

A. has greater mass
B. has a smaller contact area
C. produces less pressure
D. removes friction completely
E. has a greater volume

9. What is the pressure caused by water 2 m below its surface? Take water density as 1000 kg/m^3 and g = 10 m/s^2.

A. 200 Pa
B. 2000 Pa
C. 10,000 Pa
D. 20,000 Pa
E. 200,000 Pa

10. A tank has small holes at different depths. Through which hole does water initially leave with the greatest speed?

A. The highest hole
B. The middle hole
C. The lowest hole
D. All at the same speed
E. Water cannot leave any hole

11. An object weighs 70 N in air and 50 N when fully immersed in water. What is the buoyant force?

A. 10 N
B. 20 N
C. 50 N
D. 70 N
E. 120 N

12. An object displaces 0.002 m^3 of water. What buoyant force acts on it? Take water density as 1000 kg/m^3 and g = 10 m/s^2.

A. 2 N
B. 10 N
C. 20 N
D. 200 N
E. 2000 N

13. A wooden block of density 600 kg/m^3 floats in water. What fraction of its volume is below the surface?

A. 20%
B. 40%
C. 50%
D. 60%
E. 80%

14. A room contains 10^{11} air molecules. Its length, width and height are each doubled while pressure and temperature remain unchanged. How many molecules are then in the room?

A. 2×10^{11}
B. 4×10^{11}
C. 6×10^{11}
D. 8×10^{11}
E. 10^{12}

15. Heat flows from A to B when they touch, and from B to C when they touch. What is the temperature order?

A. $T_a < T_\beta < T_\subset$
B. $T_a > T_\beta > T_\subset$
C. $T_\beta > T_a > T_\subset$
D. $T_\subset > T_a > T_\beta$
E. $T_a = T_\beta = T_\subset$

16. A new temperature scale reads 15 E at 0°C and 65 E at 43.8°C. What will it read at 90°C?

A. 90 E
B. 102.7 E
C. 117.7 E
D. 133.8 E
E. 150 E

17. A liquid-in-glass thermometer mainly works because the liquid—

A. changes mass when heated
B. expands when heated
C. loses all its energy
D. becomes a solid
E. produces electricity

18. A temperature of 27°C is approximately equal to—

A. 246 K
B. 273 K
C. 290 K
D. 300 K
E. 327 K

19. A metal block at 60°C touches a block at 20°C. Initially, heat flows—

A. from the colder block to the hotter block
B. from the hotter block to the colder block
C. in both directions equally with no net flow
D. only if their masses are equal
E. only if both are metals

20. Equal volumes of water pass each minute through two heaters. The first raises water temperature by 10°C and the second by 15°C. The second heater's power is how many times the first heater's power?

A. 0.5 times
B. 1.0 time
C. 1.5 times
D. 2.0 times
E. 2.5 times

21. How much energy is needed to heat 0.20 kg of water by 5°C? Use c = 4200 J/(kg·°C).

A. 420 J
B. 840 J
C. 2100 J
D. 4200 J
E. 8400 J

22. 100 g of water at 80°C is mixed with 300 g of water at 20°C. Ignoring heat loss, what is the final temperature?

A. 25°C
B. 30°C
C. 35°C
D. 40°C
E. 50°C

23. Equal masses of aluminium and water receive equal amounts of heat. Aluminium has the lower specific heat capacity. Which has the larger temperature rise?

A. Water
B. Aluminium
C. Both are equal
D. Neither changes temperature
E. It depends only on volume

24. During the melting of pure ice at normal pressure, its temperature—

A. rises continuously
B. falls continuously
C. remains constant until melting is complete
D. immediately becomes 100°C
E. depends only on the mass of ice

25. Three cylinders contain 10 g of water vapour each at the same temperature but occupy different volumes. If all the vapour is condensed to liquid water under the same conditions, the samples will have—

A. equal mass and equal volume
B. equal mass but different volume
C. different mass but equal volume
D. different mass and different volume
E. zero mass

26. Small gaps are left between railway tracks mainly to allow for—

A. thermal expansion
B. greater friction
C. sound reflection
D. water absorption
E. decreased pressure

27. A metal spoon becomes hot after one end is kept in hot soup. The main method of heat transfer through the spoon is—

A. conduction
B. convection
C. radiation
D. evaporation
E. condensation

28. A daytime sea breeze is mainly caused by—

A. conduction through seawater
B. convection in air
C. radiation from the Moon
D. evaporation of sand only
E. reflection of sound

29. Energy from the Sun reaches Earth mainly by—

A. conduction
B. convection
C. radiation
D. diffusion
E. condensation

30. Sweating cools the body mainly because—

A. water vapour condenses on the skin
B. evaporation takes energy from the skin
C. sweat increases body mass
D. conduction stops completely
E. the skin stops radiating

31. Which state of matter normally has both a fixed shape and a fixed volume?

A. Gas
B. Solid
C. Liquid
D. Vapour only
E. Plasma only

32. In which state of matter does diffusion generally occur fastest?

A. Solid
B. Liquid
C. Ice
D. Gas
E. All states at exactly the same rate

33. A sample has a mass of 200 g and a volume of 50 cm^3. What is its density?

A. 4 g/cm^3
B. 0.25 g/cm^3
C. 2 g/cm^3
D. 10 g/cm^3
E. 250 g/cm^3

34. An object is placed in a liquid and its density is greater than the liquid's density. What will the object usually do?

A. Float completely above the surface
B. Remain at the surface
C. Sink
D. Lose its mass
E. Turn into a gas

35. A force of 120 N acts normally on an area of 0.060 m^2. What pressure is produced?

A. 2 Pa
B. 20 Pa
C. 200 Pa
D. 720 Pa
E. 2000 Pa

36. How does pressure in a liquid change as depth increases?

A. It becomes zero
B. It increases
C. It always decreases
D. It changes into mass
E. It remains equal at every depth

37. According to Archimedes' principle, the buoyant force on an immersed object equals—

A. the object's mass
B. the liquid's total volume
C. the object's temperature
D. the weight of the displaced liquid
E. the depth multiplied by time

38. An object weighs 45 N in air and 35 N when fully immersed in water. What is the buoyant force?

A. 10 N
B. 35 N
C. 45 N
D. 80 N
E. 350 N

39. A wooden block floats at rest on water. Which relation is correct?

A. Its weight is greater than the buoyant force
B. Its weight is zero
C. The buoyant force equals its weight
D. The buoyant force is always twice its weight
E. No force acts on the block

40. Why does the liquid column in a liquid-in-glass thermometer rise when heated?

A. The liquid loses all its particles
B. The glass changes into a gas
C. Gravity becomes stronger
D. The liquid's mass increases greatly
E. The liquid expands

41. A temperature of 25°C is approximately equal to—

A. 248 K
B. 298 K
C. 273 K
D. 310 K
E. 325 K

42. Equal amounts of heat are given to two different masses of the same material. Which one has the larger temperature rise?

A. The larger mass
B. Both always rise by 100°C
C. Neither changes temperature
D. The smaller mass
E. The one with the larger volume only, regardless of mass

43. How much heat is needed to raise 0.50 kg of water by 2°C? Use c = 4200 J/(kg·°C).

A. 420 J
B. 2100 J
C. 4200 J
D. 8400 J
E. 42,000 J

44. Which material is the best conductor of heat?

A. Copper
B. Wood
C. Plastic
D. Rubber
E. Dry air

45. Warm water rises and cooler water sinks in a heated pot. This heat transfer is mainly—

A. radiation
B. reflection
C. evaporation
D. conduction only
E. convection

46. Which method of heat transfer can occur through empty space?

A. Conduction
B. Radiation
C. Convection
D. Diffusion only
E. Melting

47. A tight metal lid often becomes easier to open after hot water is poured over it because the lid—

A. loses all friction
B. becomes lighter
C. contracts
D. expands
E. melts completely

48. What happens to the temperature of pure ice while it melts at normal pressure?

A. It rises continuously
B. It falls continuously
C. It remains constant until melting is complete
D. It immediately becomes 100°C
E. It depends only on colour

49. Which statement about evaporation is correct?

A. It can occur from a liquid surface at temperatures below the boiling point
B. It occurs only at exactly 100°C
C. It occurs throughout the liquid only
D. It always heats the remaining liquid
E. It changes a gas into a liquid

50. During boiling of a pure liquid at constant pressure, the supplied heat mainly—

A. decreases the liquid's mass to zero instantly
B. stops all particle motion
C. changes the liquid into a solid
D. reduces the boiling point every second
E. changes the state while temperature remains constant

CHAPTER 3: OSCILLATIONS, WAVES AND SOUND

Junior Level • Class 6–8

1. Oscillation and Periodic Motion

An oscillation is a repeated to-and-fro motion about a central position. A swing, a pendulum and a vibrating ruler are familiar examples. The central position is called the equilibrium or mean position. One complete oscillation brings the object back to the same position moving in the same direction.

Amplitude (A): Amplitude is the maximum displacement from the equilibrium position. It is a distance, so its unit is metre (m) or centimetre (cm). The full distance from one extreme position to the other is 2A.

Period (T): Period is the time required for one complete oscillation. Its unit is second (s). If n oscillations take total time t, then T = t/n.

Frequency (f): Frequency is the number of complete oscillations per second. Its unit is hertz (Hz). If n oscillations occur in time t, then f = n/t. Period and frequency are related by f = 1/T and T = 1/f.

Worked Example 1 — Finding frequency and period

A pendulum completes 30 oscillations in 15 s.

Frequency: f = n/t = 30/15 = 2 Hz.

Period: T = t/n = 15/30 = 0.5 s. Check: fT = 2 × 0.5 = 1.

Counting per minute: Convert minutes to seconds before calculating hertz. Ten oscillations per minute means f = 10/60 = 1/6 Hz. Amplitude and frequency describe different things; amplitude alone cannot tell us how fast a wave travels.

Simple pendulum: For small swings, a longer pendulum has a longer period and a lower frequency. Changing the mass of the bob does not change the period significantly. The small-swing relation is $T \approx 2\pi\sqrt{(L/g)}$.

2. Understanding Waves

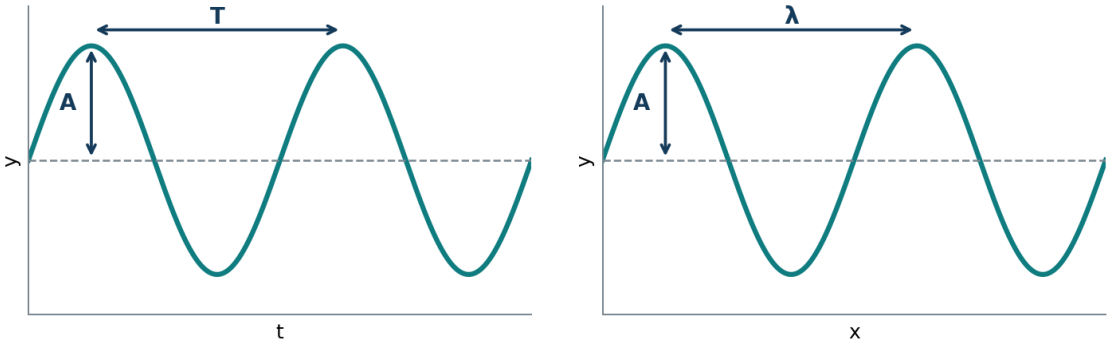
A wave is a travelling disturbance that transfers energy from one place to another. The particles of the medium may vibrate around their positions, but the medium as a whole is not carried along with the wave. A floating object mainly moves up and down while the water wave moves forward.

Transverse wave: Particles vibrate perpendicular to the direction in which the wave travels. A stretched rope provides an example. The highest point is a crest and the lowest point is a trough.

Longitudinal wave: Particles vibrate parallel to the direction of travel. Crowded regions are compressions and spread-out regions are rarefactions. Sound in air is longitudinal.

Wavelength (λ): Wavelength is the distance between two nearest points in the same stage of motion—for example, crest to crest or compression to compression. Its unit is metre (m).

Wave speed: In one period, a wave travels one wavelength. Therefore wave speed v = fλ. Speed is measured in m/s. Frequency is fixed by the source; when a wave enters a new medium, its speed and wavelength may change but its frequency remains unchanged.



Time graph: T is the time for one cycle. Space graph: λ is the length of one wave.

Worked Example 2 — Wave speed

A wave has frequency f = 4 Hz and wavelength λ = 3 m.

v = fλ = 4 × 3 = 12 m/s.

Worked Example 3 — Recognising missing information

A duck bobs 10 times per minute and the wave amplitude is 1 m.

The frequency can be found: f = 10/60 = 1/6 Hz.

Wave speed cannot be found because wavelength is missing from v = fλ.

3. Sound: Production, Speed, Pitch and Loudness

Production: Sound is produced by a vibrating source. The vibration makes nearby particles vibrate and pass the disturbance onward. Sound is a mechanical wave, so it needs matter—solid, liquid or gas—and cannot travel through a vacuum.

Speed: Sound generally travels fastest in solids, more slowly in liquids and slowest in gases because particles are linked most strongly in solids. In air near room temperature, a commonly used value is about 340 m/s.

Pitch: Pitch tells us whether a sound is high or low. A higher frequency gives a higher pitch. A child's voice usually has a higher pitch than an adult man's voice.

Loudness: Loudness mainly depends on amplitude. A vibration with larger amplitude carries more energy and produces a louder sound. Frequency controls pitch, not loudness.

Hearing range: A healthy young human can hear roughly from 20 Hz to 20,000 Hz. Frequencies below 20 Hz are infrasonic, and frequencies above 20,000 Hz are ultrasonic. Bats use ultrasound for navigation.

Worked Example 4 — Distance to lightning

Lightning is seen almost immediately, but thunder is heard 7 s later.

Using sound speed 350 m/s: distance = vt = 350 × 7 = 2450 m = 2.45 km.

The travel time of light over this distance is so small that it is ignored here.

4. Reflection, Echo and Reverberation

Reflection: Sound can bounce from a hard surface such as a wall or cliff. The reflected sound follows the same basic reflection rule as other waves: angle of incidence equals angle of reflection.

Echo: An echo is a reflected sound heard separately from the original sound. For a stationary source and wall, sound travels to the wall and back, so total distance = 2d. Hence d = vt/2.

Distinct echo: The ear normally needs about 0.10 s to separate two sounds. With sound speed 340 m/s, a reflecting wall should be about (340 × 0.10)/2 = 17 m or more away for a distinct echo.

Reverberation: In a hall, many reflections arrive close together and make sound continue briefly. This persistence is reverberation. Curtains, carpets and soft panels absorb sound and reduce excessive reverberation.

Worked Example 5 — Echo from a wall

A wall is 170 m away and the speed of sound is 340 m/s.

Round-trip distance = 2d = 340 m.

Echo time = distance/speed = 340/340 = 1.0 s.

Worked Example 6 — Listener running toward the wall

A person makes a sound 100 m from a wall and runs toward it at 10 m/s. Sound speed is 332 m/s.

The returning sound and runner approach each other, so (332 + 10)t = 2 × 100.

t = 200/342 ≈ 0.585 s, or about 0.58 s.

SONAR: SONAR sends sound through water and measures the return time of the echo. Distance to the object is d = vt/2. It is used to measure sea depth and locate underwater objects.

5. Natural Frequency, Resonance and Applications

Natural frequency: Every vibrating system has one or more frequencies at which it vibrates easily. These are its natural frequencies. They depend on the system—for example, pendulum length or the length, tension and thickness of a string.

Resonance: When a repeated driving force has the same frequency as a system's natural frequency, energy is transferred very effectively and the amplitude becomes large. This is resonance. One tuning fork can make another tuning fork of the same frequency vibrate.

Safe design: Resonance can strengthen musical sound, but unwanted resonance may damage machines or structures. Engineers avoid forcing frequencies that match dangerous natural frequencies.

Worked Example 7 — Using a given frequency relation

Suppose a vibrating star follows $f \propto \sqrt{\rho}$ when other factors remain unchanged.

If density becomes 4ρ, then the new frequency factor is $\sqrt{4} = 2$.

The frequency therefore becomes twice as large.

Multiple-Choice Questions

1. Which statement describes one complete oscillation?

A. Motion from the mean position to one extreme only
B. Motion from one extreme to the mean position only
C. Returning to the same position with the same direction of motion
D. Any motion lasting one second
E. Moving once in a straight line

2. The amplitude of an oscillating object is—

A. the total distance travelled in one minute
B. the maximum displacement from the mean position
C. the number of oscillations per second
D. the time for ten oscillations
E. the wave speed

3. A pendulum completes 30 oscillations in 15 s. What is its frequency?

A. 0.5 Hz
B. 1 Hz
C. 2 Hz
D. 15 Hz
E. 30 Hz

4. An oscillator has frequency 2 Hz. What is its period?

A. 0.25 s
B. 0.5 s
C. 1 s
D. 2 s
E. 4 s

5. A floating object completes 10 oscillations per minute. What is its frequency?

A. 1/60 Hz
B. 1/10 Hz
C. 1/6 Hz
D. 6 Hz
E. 10 Hz

6. A simple pendulum is made longer while its swing remains small. Its period generally—

A. decreases
B. increases
C. becomes zero
D. remains unchanged for every length
E. depends only on bob mass

7. A travelling wave mainly transfers—

A. matter only
B. energy without net transport of matter
C. the whole medium forward
D. mass into energy
E. temperature only

8. In a transverse wave, particles vibrate—

A. parallel to wave travel
B. perpendicular to wave travel
C. only clockwise
D. without any direction
E. at the speed of light

9. Sound travelling through air is mainly a—

A. transverse electromagnetic wave
B. longitudinal mechanical wave
C. stationary light wave
D. circular water wave
E. wave that needs no medium

10. The wavelength of a transverse wave can be measured from—

A. crest to the next crest
B. crest to the nearest trough
C. mean position to a crest
D. source to observer
E. one second to the next

11. A wave has frequency 4 Hz and wavelength 3 m. What is its speed?

A. 0.75 m/s
B. 1.33 m/s
C. 7 m/s
D. 12 m/s
E. 24 m/s

12. Sound travels at 340 m/s and has frequency 170 Hz. What is its wavelength?

A. 0.5 m
B. 1 m
C. 2 m
D. 170 m
E. 510 m

13. A duck bobs 10 times per minute on a wave of amplitude 1 m. What additional information is needed to calculate the wave speed?

A. Duck mass
B. Water temperature only
C. Wavelength
D. Amplitude again
E. Height above sea level only

14. A sound wave passes from air into water. Which quantity is fixed by the source and remains unchanged?

A. Speed
B. Wavelength
C. Frequency
D. Amplitude in every case
E. Direction in every case

15. If the amplitude of a sound-producing vibration increases, the sound usually becomes—

A. louder
B. higher in pitch only
C. slower
D. unable to travel
E. ultrasonic in every case

16. A higher-pitched sound has—

A. lower frequency
B. higher frequency
C. zero amplitude
D. lower speed in the same air
E. no wavelength

17. Why can sound not travel from the Sun to Earth through empty space?

A. Sound is too slow
B. Sound needs a material medium
C. The Sun does not vibrate
D. Gravity stops sound
E. Light absorbs all sound

18. In which medium does sound generally travel fastest?

A. Vacuum
B. Air
C. Water
D. Steel
E. All have the same speed

19. The approximate hearing range of a healthy young human is—

A. 0–20 Hz
B. 20–200 Hz
C. 20–20,000 Hz
D. 2000–200,000 Hz
E. above 20,000 Hz only

20. Lightning is seen and thunder is heard 7 s later. If sound speed is 350 m/s, how far away is the lightning?

A. 50 m
B. 350 m
C. 700 m
D. 2450 m
E. 4900 m

21. A wall is 170 m from a stationary observer. If sound speed is 340 m/s, after how long will the echo return?

A. 0.5 s
B. 1.0 s
C. 2.0 s
D. 17 s
E. 170 s

22. For a distinct echo, a time gap of about 0.10 s is needed. If sound speed is 340 m/s, the wall should be at least about—

A. 3.4 m away
B. 8.5 m away
C. 17 m away
D. 34 m away
E. 68 m away

23. A person makes a sound 100 m from a wall and runs toward it at 10 m/s. If sound speed is 332 m/s, approximately when will the echo be heard?

A. 0.29 s
B. 0.58 s
C. 0.60 s
D. 1.17 s
E. 2.00 s

24. Bats use frequencies above the human hearing range. These sounds are called—

A. infrasonic
B. audible
C. ultrasonic
D. stationary
E. transverse light

25. SONAR finds underwater distance mainly by measuring—

A. water colour
B. echo return time
C. air pressure
D. electric current
E. light intensity

26. Resonance occurs when the driving frequency is—

A. zero
B. much smaller than every natural frequency
C. equal or very close to a natural frequency
D. always 20 Hz
E. unrelated to the system

27. One tuning fork makes another nearby tuning fork of the same frequency vibrate. This is an example of—

A. refraction
B. dispersion
C. resonance
D. evaporation
E. conduction

28. A vibrating star follows $f \propto \sqrt{\rho}$ when other factors are fixed. If its density becomes four times larger, its frequency becomes—

A. one-fourth
B. one-half
C. the same
D. twice
E. four times

29. Curtains and carpets reduce excessive reverberation mainly because they—

A. reflect all sound
B. absorb sound
C. increase frequency
D. increase sound speed
E. create ultrasound

30. A source's frequency doubles while the wave remains in the same medium. If wave speed stays constant, the wavelength becomes—

A. four times
B. twice
C. unchanged
D. half
E. one-fourth

31. An oscillator has a frequency of 5 Hz. What is its period?

A. 5 s
B. 1 s
C. 0.20 s
D. 0.50 s
E. 10 s

32. A pendulum completes 12 oscillations in 6 s. What is its frequency?

A. 2 Hz
B. 0.5 Hz
C. 6 Hz
D. 12 Hz
E. 72 Hz

33. A vibrating object completes 15 oscillations in 5 s. What is its period?

A. 5 s
B. 3 s
C. 1 s
D. 1/3 s
E. 1/15 s

34. An object oscillates with an amplitude of 3 cm. What total distance does it travel in one complete oscillation?

A. 3 cm
B. 12 cm
C. 6 cm
D. 9 cm
E. 18 cm

35. A body oscillates with a frequency of 0.5 Hz. How many complete oscillations does it make in 30 s?

A. 5
B. 10
C. 12
D. 20
E. 15

36. A wave has frequency 5 Hz and wavelength 2 m. What is its speed?

A. 2.5 m/s
B. 5 m/s
C. 10 m/s
D. 20 m/s
E. 25 m/s

37. A wave travels at 300 m/s and has frequency 100 Hz. What is its wavelength?

A. 3 m
B. 0.3 m
C. 30 m
D. 100 m
E. 300 m

38. The frequency of a wave increases while its speed in the same medium stays constant. What happens to its wavelength?

A. It increases
B. It becomes infinite
C. It remains unchanged
D. It decreases
E. It becomes equal to the amplitude

39. In a longitudinal wave, the particles of the medium vibrate—

A. in circles only
B. parallel to the direction of wave travel
C. perpendicular to wave travel
D. only upward
E. without moving at all

40. The crowded regions in a longitudinal wave are called—

A. crests
B. troughs
C. nodes
D. wavelengths
E. compressions

41. What is necessary for producing sound?

A. A source at absolute zero
B. A beam of light
C. A vibrating source
D. A vacuum only
E. A magnetic pole

42. Which property of a sound wave mainly determines its pitch?

A. Frequency
B. Amplitude
C. Speed only
D. Loudness
E. Travel time only

43. A sound becomes louder when the vibration has a greater—

A. period only
B. wavelength only
C. speed in vacuum
D. amplitude
E. distance from the mean position equal to zero

44. In which of these media does sound generally travel fastest?

A. Vacuum
B. Steel
C. Air
D. Water vapour
E. Outer space

45. Thunder is heard 4 s after lightning is seen. If sound speed is 340 m/s, approximately how far away is the lightning?

A. 85 m
B. 340 m
C. 680 m
D. 1020 m
E. 1360 m

46. A wall is 85 m from a person. If sound speed is 340 m/s, how long does the echo take to return?

A. 0.25 s
B. 1.0 s
C. 0.50 s
D. 2.0 s
E. 4.0 s

47. A sound with frequency above 20,000 Hz is called—

A. ultrasound
B. infrasound
C. audible sound only
D. reverberation
E. echo

48. A sound with frequency below 20 Hz is called—

A. ultrasound
B. audible sound
C. resonance
D. infrasound
E. noise only

49. A strong resonance is most likely when the driving frequency—

A. is always zero
B. matches the natural frequency
C. is much smaller than every natural frequency
D. changes the mass to zero
E. stops the system completely

50. A SONAR pulse returns from the seabed in 2 s. If sound speed in water is 1500 m/s, what is the sea depth?

A. 375 m
B. 750 m
C. 3000 m
D. 6000 m
E. 1500 m