Temari.et

Physics, 2017 EC, natural science, entrance exam

Grade 12 · Physics · 2017 E.C.

MARKING KEY — CONFIDENTIAL

Time allowed: 120 minutes **Questions:** 60 **Total marks:** 60

1. Block A of mass $m_1 = 8.0$ kg is travelling initially at $u_1 = 6.0$ m/s in the positive x-direction. It collides with block B of mass $m_2 = 12.0$ kg, which is moving in the same direction with velocity $u_2 = 3.0$ m/s. If immediately after the collision, the velocity of block A is $v_1 = 4.0$ m/s in the positive x-direction, find the velocity of block B (v_2) immediately after the collision. (1)

A. 4.33 m/s to the negative x-axis
B. 3.71 m/s to the negative x-axis
C. 3.71 m/s to the positive x-axis
D. ✓ **4.33 m/s to the positive x-axis**

Answer: D

No outside force acts on the two blocks, so the total momentum before the collision equals the total momentum after it: $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$.

Momentum before: $(8.0)(6.0) + (12.0)(3.0) = 48 + 36 = 84\,\mathrm{kg}\backslash\mathrm{cdotp}\mathrm{m/s}$.

Momentum after: $(8.0)(4.0) + 12.0\,v_2 = 32 + 12v_2$.

Set them equal: $84 = 32 + 12v_2$, so $12v_2 = 52$ and $v_2 = 4.33\,\mathrm{m/s}$.

The result is positive, so block B keeps moving along the positive x-direction. Options A and B fail because a positive answer cannot point along the negative x-axis.

Textbook: Physics Grade 11, Unit 4 Dynamics, section 4.6 Impulse and Linear Momentum (page 148).

2. A force that is exerted on a simple machine in order to produce input work is called (1)

A. friction.
B. load.
C. ✓ **effort.**
D. normal.

Answer: C

A simple machine takes in work on one side and gives out work on the other side. The force you apply to the machine is called the **effort**, and the work it does is the input work.

The **load** is the force the machine works against, so it belongs to the output side, not the input side. Friction wastes some of the input work, and the normal force is a support force from a surface; neither of them is the applied force.

Textbook: Physics Grade 9, Unit 5 Simple Machines, section 5.5 Mechanical Advantage, Velocity Ratio and Efficiency (page 92).

3. Which one of the following statements is correct about transverse and longitudinal waves? (1)

A. The directions of wave motion and vibration of the particles are parallel for transverse waves and perpendicular for longitudinal waves.

B. Waves on a string are longitudinal whereas sound waves are transverse.

C. ✓ **The directions of wave motion and vibration of particles are parallel for longitudinal waves but perpendicular for transverse waves.**

D. A longitudinal wave comprises a series of crests and troughs, whereas a transverse wave comprises a series of compressions and rarefactions.

> **Answer:** C
>
> In a **longitudinal** wave, the particles of the medium vibrate parallel to the direction the wave travels. Sound in air is the common example, and it is made of compressions and rarefactions.
>
> In a **transverse** wave, the particles vibrate perpendicular to the direction the wave travels. A wave on a string is the common example, and it shows crests and troughs.
>
> Option C states exactly this. Options A and D swap the two descriptions, and option B swaps the examples.
>
> **Textbook:** Physics Grade 9, Unit 6 Mechanical Oscillation and Sound Wave, section 6.1 Common Characteristics of Waves (page 114).

4. An object that is partially or fully submerged in a fluid experiences an upward force from the fluid. The apparent weight of the object is the weight of the (1)

A. fluid it displaces.

B. ✓ **object in air minus the buoyant force.**

C. object in air.

D. fluid it displaces minus the buoyant force.

> **Answer:** B
>
> A fluid pushes up on a submerged object with the buoyant force. Because of this upward push, the object seems lighter than it does in air.
>
> So the apparent weight is:
>
> $$W_{\text{apparent}} = W_{\text{in air}} - F_{\text{buoyant}}$$
>
> Option A describes the size of the buoyant force itself (Archimedes' principle says it equals the weight of the displaced fluid), not the apparent weight.
>
> **Textbook:** Physics Grade 12, Unit 3 Fluid Mechanics, section 3.3 Archimedes' principle (page 96).

5. A force is used to push a box of mass, m along the slope of an inclined plane with constant velocity. If the coefficient of friction between the box and the inclined plane be μ, the actual mechanical advantage (AMA) of the inclined plane is (1)

Question Diagram

A. $\frac{1}{\cos\theta+\mu\sin\theta}$

B. ✓ $\frac{1}{\sin\theta+\mu\cos\theta}$

C. $\cos\theta+\mu\sin\theta$

D. $\sin\theta+\mu\cos\theta$

Answer: B

Actual mechanical advantage is the load divided by the real effort: $\mathrm{AMA} = \frac{\text{load}}{\text{effort}}$. Here the load is the weight being raised, mg.

The box moves up the slope at constant velocity, so the forces along the slope balance. The effort must overcome the weight component along the slope, $mg\sin\theta$, plus friction, $f = \mu N = \mu mg\cos\theta$:

$$F = mg\sin\theta + \mu mg\cos\theta$$

Divide the load by this effort:

$$\mathrm{AMA} = \frac{mg}{mg(\sin\theta+\mu\cos\theta)} = \frac{1}{\sin\theta+\mu\cos\theta}$$

Option A wrongly puts $\cos\theta$ with the weight component; the component of weight along a slope goes with $\sin\theta$.

Textbook: Physics Grade 9, Unit 5 Simple Machines, section 5.5 Mechanical Advantage, Velocity Ratio and Efficiency (page 92).

6. A wheel and axle of radii 40 cm and 8 cm, respectively, is used to lift a bucket of 6 kg of water from a well by applying an effort of 20 N on the wheel. The percentage efficiency of this simple machine is (1)

A. ✓ **60%**

B. 66.7%

C. 30%

D. 80%

Answer: A

Velocity ratio of a wheel and axle is the wheel radius over the axle radius: $\mathrm{VR} = \frac{R}{r} = \frac{40}{8} = 5$.

The load is the weight of the water: $W = mg = 6\times 10 = 60\,\mathrm{N}$. The actual mechanical advantage is $\mathrm{AMA} = \frac{\text{load}}{\text{effort}} = \frac{60}{20} = 3$.

Efficiency compares the two:

$$\eta = \frac{\mathrm{AMA}}{\mathrm{VR}} \times 100\% = \frac{3}{5}\times 100\% = 60\%$$

Textbook: Physics Grade 9, Unit 5 Simple Machines, section 5.5 Mechanical Advantage, Velocity Ratio and Efficiency (page 92).

7. The magnetic field created by a long straight current carrying wire (1)

A. is directed in the same direction as the current.

B. ✓ **forms circular pattern around the wire.**

C. is directly proportional to the distance from the wire.

D. is inversely proportional to the current in the wire.

Answer: B

A current in a long straight wire creates a magnetic field whose lines are circles centered on the wire. The right-hand rule shows the direction: point the thumb along the current and the curled fingers give the circular field direction.

The field strength is $B = \frac{\mu_0 I}{2\pi r}$. It grows with the current (so D is wrong) and gets weaker as you move away from the wire (so C is wrong). The field is not along the current; it circles around it (so A is wrong).

Textbook: Physics Grade 10, Unit 5 Magnetism, section 5.4 Magnetic field of a current carrying conductor.

8. What will happen on a pure semiconductor when it is doped by group III element? (1)

A. ✓ **It becomes P-type semiconductor.**

B. It gets extra free electrons.

C. It becomes intrinsic semiconductor.

D. It becomes N-type semiconductor.

> **Answer:** A
>
> Atoms of a group III element (such as boron) have three outer electrons. When one replaces a silicon atom, which needs four bonds, one bond is left incomplete. That missing electron is a **hole**.
>
> Holes act as positive charge carriers, so the doped crystal becomes a **P-type** semiconductor.
>
> Extra free electrons (option B) come from group V donors, which make an N-type semiconductor (option D). An intrinsic semiconductor is a pure, undoped one, so doping cannot produce it (option C).
>
> **Textbook:** Physics Grade 12, Unit 5 Basics of electronics, section 5.1 Semiconductors (page 143).

9. We usually use plastic materials to cover metallic wires that carry electricity to protect living things from danger. Which of the following statement correctly describes the nature of the plastic to use for this purpose? (1)

A. Since every electron in plastic is slightly bound to the parent atom, it becomes poor conductor.

B. ✓ **Since every electron in plastic is tightly bound to the parent atom, it becomes poor conductor.**

C. Since it has free electrons, it facilitates the easy flow of electric current in the metallic wires

D. Since it has no free electrons, it directs the electrons in the wire to flow in the same direction.

> **Answer:** B
>
> Plastic is an insulator. In an insulator, every electron is held tightly by its own atom, so there are almost no free electrons to carry current. That is why plastic is a poor conductor and is safe as a cover for wires.
>
> Option A says the electrons are only slightly bound; slightly bound electrons would break free easily and the material would conduct. Options C and D wrongly give the plastic a role in carrying or steering the current; the cover carries no current at all.
>
> **Textbook:** Physics Grade 12, Unit 5 Basics of electronics, section 5.1 Semiconductors (page 143).

10. Which one of the following statements is correct about the current-voltage (I–V) characteristics of a typical semiconductor diode? (1)

A. ✓ **The region of the I-V curve that rises very rapidly after the voltage exceeds the cut-in voltage is the forward bias region.**

B. The region of the I-V curve that increases very rapidly after the bias voltage exceeds the breakdown voltage is in the forward bias region.

C. The current due to the minority charge carriers is represented in the forward bias region of the I-V curve.

D. The current due to the majority charge carriers is represented in the reverse bias region of the I-V curve.

> **Answer:** A
>
> On the I-V curve of a diode, the **forward bias** branch stays almost flat until the applied voltage reaches the cut-in voltage (about 0.7 V for silicon). Past that point the current rises very steeply. This matches option A.
>
> Option B mixes the two branches: breakdown belongs to the **reverse** bias side, where a large reverse voltage suddenly lets current flow. Option C is wrong because forward current is carried by the majority carriers; the tiny reverse current is due to minority carriers, which makes option D wrong too.
>
> **Textbook:** Physics Grade 12, Unit 5 Basics of electronics, section 5.2 Diodes and their Functions (page 147).

11. Consider a circuit containing diode and load resistor R_L are connected to an AC voltage source as shown in the figure below. If initially, polarity of 'a' is positive while 'b' is negative, (1)

Question Diagram

A. ✓ During the second half-cycle, the diode is forward biased and current flows in the load resistor.

B. During the first half-cycle, the diode is reverse biased and voltage is developed across the load resistor.

C. During the first half-cycle, the diode is forward biased and voltage is developed across the load resistor.

D. During the second half-cycle, the diode is reverse biased and no current flow in the load resistor.

Answer: A

Look at the diode symbol in the figure. Its arrow points from terminal b toward the load resistor R_L, so conventional current can only pass from b, through the diode, into R_L.

During the first half-cycle, a is positive and b is negative. Current would have to pass through the diode against its arrow, so the diode is reverse biased and no current flows.

During the second half-cycle, b becomes positive. Now current leaves b, passes through the diode in its forward direction, and flows through R_L. The diode is forward biased and the load carries current, which is option A.

This one-way action is how a half-wave rectifier turns AC into pulsing DC.

Textbook: Physics Grade 12, Unit 5 Basics of electronics, section 5.3 Rectification (page 150).

12. A circular coil is located in a uniform magnetic field of magnitude $0.50\ \mathrm{T}$ directed perpendicular to the plane of the coil. If the area of the coil changes with uniform rate, in such a way that it increases by $4.0 \times 10^{-3}\ \mathrm{m}^2$ in $2\ \mathrm{s}$, what is the magnitude of the induced electromotive force (emf) in the coil? (1)

A. $1.0 \times 10^{3}\ \mathrm{V}$

B. $2.5 \times 10^{2}\ \mathrm{V}$

C. ✓ $1.0 \times 10^{-3}\ \mathrm{V}$

D. $4.0 \times 10^{-3}\ \mathrm{V}$

Answer: C

Faraday's law says the induced emf equals the rate of change of magnetic flux. Here the field is fixed and the area changes, so:

$$\varepsilon = B\frac{\Delta A}{\Delta t}$$

Substitute the numbers:

$$\varepsilon = 0.50 \times \frac{4.0 \times 10^{-3}}{2} = 0.50 \times 2.0 \times 10^{-3} = 1.0 \times 10^{-3}\ \mathrm{V}$$

Textbook: Physics Grade 12, Unit 4 Electromagnetism, section 4.5 Faraday's Law of electromagnetic Induction (page 129).

13. Vector quantities are represented by ______ (1)

A. direction only.

B. ✓ magnitude and direction.

C. dimensionless values.

D. magnitude only.

Answer: B

A vector is a physical quantity that needs both a size (magnitude) and a direction to be fully described. Examples are displacement, velocity, and force.

A quantity described by magnitude alone, such as mass or time, is a scalar. That is why option D fails: magnitude alone is not enough for a vector.

Textbook: Physics Grade 10, Unit 1 Vector Quantities, section 1.1 Scalars and vectors.

14. According to Newton's first law, an object that is in motion continues its state of motion with (1)

A. constant velocity if the resultant force exerted on it is not zero.

B. a decreasing speed if the resultant force exerted on it is zero.

C. ✓ **constant velocity if the resultant force exerted on it is zero.**

D. an increasing speed if the resultant force exerted on it is not zero.

> **Answer:** C
>
> Newton's first law: if the resultant (net) force on an object is zero, the object keeps its state of motion. An object at rest stays at rest, and a moving object keeps moving with constant velocity, meaning the same speed in the same straight line.
>
> Options A and D describe a nonzero net force, but a nonzero net force changes the velocity; it never keeps it constant. Option B is wrong because zero net force means no change in speed at all.
>
> **Textbook:** Physics Grade 9, Unit 4 Force, Work, Energy and Power, section 4.2 Newton's Laws of Motion (page 63).

15. Which of the following correctly describes the difference between distance and displacement? (1)

A. Distance depends on the initial and final points, while displacement depends on the path followed by a moving body.

B. Distance can be described both in magnitude and direction, while displacement is described only by magnitude.

C. Distance has either positive or negative values, while displacement has only positive value.

D. ✓ **Distance is always greater than or equal to the magnitude of displacement, while the magnitude of the displacement is always less than or equal to distance.**

> **Answer:** D
>
> Distance is the length of the actual path followed, so it is a scalar and can never be negative. Displacement is the straight line from the start point to the end point, so it is a vector.
>
> The straight line between two points is the shortest possible path. So the distance travelled is always greater than or equal to the magnitude of the displacement, and they are equal only for straight-line motion in one direction. This is option D.
>
> Options A and B swap the meanings of the two quantities, and option C has the signs backwards: it is displacement, not distance, that can be negative along an axis.
>
> **Textbook:** Physics Grade 9, Unit 3 Motion in a Straight Line, section 3.1 Position, Distance and Displacement (page 36).

16. Which of the following statements is correct about a uniformly accelerated motion? (1)

A. ✓ **The acceleration is constant.**

B. The velocity is constant.

C. The displacement increases at a uniform rate.

D. The speed is constant but the direction is changing.

> **Answer:** A
>
> Uniformly accelerated motion means the velocity changes by the same amount in every equal time interval. In other words, the acceleration is constant. That is option A.
>
> Option B describes uniform (unaccelerated) motion. Option C fails because with constant acceleration the displacement grows faster and faster, not at a uniform rate. Option D describes uniform circular motion, a different kind of motion.
>
> **Textbook:** Physics Grade 10, Unit 2 Uniformly Accelerated Motion, section 2.3 Acceleration.

17. Two displacement vectors have magnitudes 4 m and 3 m. Which one of the following is NOT the possible value of the magnitude of their resultant vector? (1)

A. 7m

B. 1m

C. ✓ **12m**

D. 5m

Answer: C

When two vectors of magnitudes 4 m and 3 m are added, the resultant is largest when they point the same way and smallest when they point opposite ways:

- Maximum: $4 + 3 = 7\,\mathrm{m}$
- Minimum: $4 - 3 = 1\,\mathrm{m}$

Any value from 1 m to 7 m is possible, depending on the angle between them. So 7 m, 1 m, and 5 m can all occur (5 m happens at 90 degrees), but 12 m is outside the range and is impossible.

Textbook: Physics Grade 10, Unit 1 Vector Quantities, section 1.3 Vector addition and subtraction.

18. A train is moving along a straight line with a constant acceleration of $5\,\mathrm{m/s}^2$ when it passes by a traffic light point. From there on, if the time taken by the train to reach a velocity of $30\,\mathrm{m/s}$ is 4 seconds, then what is the distance of the train from the traffic point after 8 seconds? (1)

A. 160 m

B. 80m

C. 320m

D. ✓ **240m**

Answer: D

First find the train's velocity at the traffic light. It accelerates at $5\,\mathrm{m/s}^2$ and reaches $30\,\mathrm{m/s}$ after 4 s, so from $v = u + at$:

$$u = v - at = 30 - (5)(4) = 10\,\mathrm{m/s}$$

Now use the displacement equation for the 8 seconds after the light:

$$s = ut + \frac{1}{2}at^2 = (10)(8) + \frac{1}{2}(5)(8)^2$$

$$s = 80 + \frac{1}{2}(5)(64) = 80 + 160 = 240\,\mathrm{m}$$

The tempting mistake is to take $u = 0$ at the light, which gives 160 m. But the train passes the light already moving at 10 m/s, so 160 m leaves out the 80 m covered by that initial velocity.

Textbook: Physics Grade 11, Unit 3 Motion in one and two dimensions, section 3.2 Equations of Uniformly Accelerated Motion in 1D (page 54).

19. Which one of the following statements is a necessary condition for an object to be in linear equilibrium? (1)

A. The linear acceleration of the object is non-zero constant.

B. The linear speed of the object is constant.

C. ✓ **The linear acceleration of the object is zero.**

D. The net force acting on the object is non-zero constant.

Answer: C

An object is in linear (translational) equilibrium when the net force on it is zero. By Newton's second law, $\vec{F}_{net} = m\vec{a}$, zero net force means the linear acceleration is exactly zero. That is option C.

Options A and D fail because any nonzero net force or acceleration changes the velocity, so the object is not in equilibrium. Option B is tempting but wrong: an object can keep a constant speed while its direction changes, as in circular motion, and such an object is accelerating, not in equilibrium.

Textbook: Physics Grade 11, Unit 4 Dynamics, section 4.3 The First Condition of Equilibrium (page 126).

20. When an object tends to slide over the surface of another object, tiny bumps at the surface of the two objects knocking and locking together. This causes (1)

A. ✓ **frictional force.**
B. normal force.
C. electrostatic force.
D. gravitational force.

Answer: A

Real surfaces are never perfectly smooth. They are covered with tiny bumps. When one surface tends to slide over another, these bumps knock against each other and lock together, resisting the sliding. The force this produces is **friction**.

The normal force is the push of a surface perpendicular to itself, not a resistance to sliding. Electrostatic and gravitational forces act between charges and masses and do not come from surface bumps.

Textbook: Physics Grade 9, Unit 4 Force, Work, Energy and Power, section 4.3 Forces of Friction (page 69).

21. Suppose a ball is thrown vertically upward and after reaching a maximum height, it returns back to its initial position. Which of the following statement is correct about energy changes and work done on the ball? (1)

A. On its way down, change in its potential energy is positive.
B. ✓ **On its way down, work done by gravity is positive.**
C. On its way up, change in its kinetic energy is positive.
D. On its way up, work done by gravity is positive.

Answer: B

Work done by a force is positive when the force and the displacement point the same way, and negative when they point opposite ways.

On the way down, gravity points down and the ball moves down, so the work done by gravity is positive. That is option B.

Check the others: on the way down the ball loses height, so its potential energy change is negative (A wrong). On the way up the ball slows down, so its kinetic energy change is negative (C wrong), and gravity acts against the upward motion, so its work is negative (D wrong).

Textbook: Physics Grade 11, Unit 4 Dynamics, section 4.5 Conservation of mechanical energy (page 144).

22. The mechanical energy of an oscillating object at any point through its path is equal to (1)

A. the difference between its kinetic and potential energies.
B. the sum of its potential and internal energies.
C. the sum of its kinetic and internal energies.
D. ✓ **the sum of its kinetic and potential energies.**

Answer: D

Mechanical energy is defined as the sum of kinetic energy and potential energy:

$$E = KE + PE$$

For an oscillating object with no friction, this sum stays the same at every point of the path. Energy simply changes back and forth between the kinetic and potential forms.

Options B and C bring in internal energy, which is thermal energy inside the material, not part of mechanical energy. Option A takes a difference instead of a sum.

Textbook: Physics Grade 11, Unit 4 Dynamics, section 4.5 Conservation of mechanical energy (page 144).

23. A 2 kg object accelerates with $1.5\,\mathrm{m/s}^2$ to the right on a horizontal frictionless surface under the action of two horizontal forces, F_1 and F_2 as shown in the figure below. What should be the magnitude of F_1? (1)

Question Diagram

A. ✓ **4N**
B. 3N
C. 1N
D. 2N

> **Answer:** A
>
> From the figure, F_1 pulls to the right, $F_2 = 1\,\mathrm{N}$ pulls to the left, and the block accelerates to the right at $1.5\,\mathrm{m/s}^2$.
>
> Apply Newton's second law along the horizontal, taking right as positive:
>
> $$F_1 - F_2 = ma$$
>
> $$F_1 = ma + F_2 = (2)(1.5) + 1 = 3 + 1 = 4\,\mathrm{N}$$
>
> Choosing 3 N forgets the opposing 1 N force; the net force must be 3 N, so the applied F_1 has to be larger than that.
>
> **Textbook:** Physics Grade 11, Unit 4 Dynamics, section 4.1 The Concept of Force and Newton's Laws of motion (page 96).

24. A tennis ball of mass 0.10 kg traveling horizontally at 40.0 m/s is struck back by a racket. If the ball returns back with a speed of 30.0 m/s in the opposite direction, what is the magnitude of the impulse delivered to the ball by the racket? (1)

A. 1.0 kg m/s
B. ✓ **7.0 kg m/s**
C. 4.0 kg m/s
D. 3.0 kg m/s

> **Answer:** B
>
> Impulse equals the change in momentum: $J = \Delta p = m(v_f - v_i)$. Directions matter, so set the first direction of travel as positive.
>
> Initial velocity: $+40.0\,\mathrm{m/s}$. Final velocity: $-30.0\,\mathrm{m/s}$ (opposite direction).
>
> $$J = 0.10 \times (-30.0 - 40.0) = 0.10 \times (-70.0) = -7.0\,\mathrm{kg}\text{\textbackslash cdotp}\mathrm{m/s}$$
>
> The magnitude is $7.0\,\mathrm{kg}\text{\textbackslash cdotp}\mathrm{m/s}$. The tempting wrong answer 1.0 kg·m/s comes from subtracting the speeds without minding direction; because the ball reverses, the velocity change is 70 m/s, not 10 m/s.
>
> **Textbook:** Physics Grade 11, Unit 4 Dynamics, section 4.6 Impulse and Linear Momentum (page 148).

25. The flow rate of a fluid is defined as (1)

A. ✓ **the volume of the fluid crossing an area per unit time taken.**
B. the speed with which the fluid flowing through a pipe.
C. the mass of the fluid crossing an area per unit time taken.
D. the rate of change of the speed with which fluid flowing through a pipe.

> **Answer:** A
>
> The flow rate (volume flow rate) of a fluid is the volume of fluid that crosses a given area in one unit of time:
>
> $$Q = \frac{V}{t} = Av$$
>
> Its unit is cubic meters per second. That matches option A.
>
> Option B describes the fluid's speed, not the flow rate. Option C describes mass flow rate, a different quantity. Option D describes a rate of change of speed, which is not flow rate at all.
>
> **Textbook:** Physics Grade 12, Unit 3 Fluid Mechanics, section 3.4 Fluid flow (page 103).

26. At normal condition, solids are almost incompressible compared to liquids and gases. The reason is that (1)

A. their atoms are free to slide about and interact with neighbors.

B. ✓ **their atoms are relatively fixed distance apart and held together.**

C. their atoms vibrate and free to move.

D. there is much space and little force between atoms.

Answer: B

In a solid, the atoms sit at nearly fixed distances from each other and are held in place by strong forces between them. There is very little empty space, so pressing on a solid can barely push the atoms closer. That is why solids are almost incompressible.

Options A and C describe atoms that can slide or move freely, which fits liquids and gases. Option D, much space and little force between atoms, describes a gas, and that is exactly why gases compress easily.

Textbook: Physics Grade 12, Unit 3 Fluid Mechanics, section 3.1 Fluid Statics (page 69).

27. Which of the following statements is correct about magnets? (1)

A. The north pole of one magnet repels the south pole of another magnet.

B. Like electric charges, magnetic poles exist in a single isolated form.

C. Unlike permanent magnets, electromagnets are magnets without poles.

D. ✓ **If you cut a bar magnet into two, each piece has both north and south poles.**

Answer: D

Magnetic poles always come in pairs. If you cut a bar magnet in two, each piece immediately shows its own north and south pole. No experiment has ever found a single isolated magnetic pole. So option D is correct and option B is wrong.

Option A is wrong because unlike poles attract; a north pole attracts a south pole. Option C is wrong because an electromagnet has north and south poles just like a permanent magnet while current flows.

Textbook: Physics Grade 10, Unit 5 Magnetism, section 5.1 Magnet.

28. A wheel of radius, $r = 50\text{cm}$, rotates about a fixed perpendicular axis that passes through its center. If the angular speed is $\omega = 200\frac{\text{rad}}{\text{s}}$, how much is the tangential speed of a point on the rim of the wheel? (1)

A. 10,000 m/s

B. 800 m/s

C. 80,000 m/s

D. ✓ **100 m/s**

Answer: D

For a rotating wheel, the tangential speed of a point at radius r is:

$$v = r\omega$$

Convert the radius to meters: $r = 50\,\text{cm} = 0.50\,\text{m}$. Then:

$$v = 0.50 \times 200 = 100\,\text{m/s}$$

The large wrong answers come from forgetting to change 50 cm into 0.50 m before multiplying.

Textbook: Physics Grade 12, Unit 2 Two-dimensional motion, section 2.2 Rotational Motion (page 39).

29. Suppose your mass is measured to be 50 kg. If your friend having a mass of 55 kg is at a distance 2 m apart from you, what is the magnitude of gravitational force between you and your friend? (1)

A. $9.2 \times 10^{-8}\mathrm{N}$

B. $9.2 \times 10^{-11}\mathrm{N}$

C. ✓ $4.6 \times 10^{-9}\mathrm{N}$

D. $4.6 \times 10^{-11}\mathrm{N}$

Answer: C

Use Newton's law of universal gravitation:

$$F = G\frac{m_1 m_2}{r^2}$$

Substitute $G = 6.67 \times 10^{-11}\,\mathrm{N}\backslash\mathrm{cdotpm}^2/\mathrm{kg}^2$, $m_1 = 50\,\mathrm{kg}$, $m_2 = 55\,\mathrm{kg}$, and $r = 2\,\mathrm{m}$:

$$F = 6.67 \times 10^{-11} \times \frac{50 \times 55}{2^2} = 6.67 \times 10^{-11} \times \frac{2750}{4}$$

$$F = 6.67 \times 10^{-11} \times 687.5 \approx 4.6 \times 10^{-8}\,\mathrm{N}$$

This tiny force shows why we never feel gravity from people around us.

Note: the exact result, $4.6 \times 10^{-8}\,\mathrm{N}$, does not appear in the choices. Option C carries the correct digits 4.6 but with a misprinted power of ten, so C is the intended answer.

Textbook: Physics Grade 12, Unit 2 Two-dimensional motion, section 2.5 Newton's law of universal Gravitation (page 59).

30. A 10 N force is applied to the smaller circular piston of a hydraulic lift of radius 0.1 m to lift a 2500 N load placed on the larger piston. What is the area of the larger piston? (1)

A. $2.50\mathrm{m}^2$

B. $0.25\mathrm{m}^2$

C. $3.14\mathrm{m}^2$

D. ✓ $7.85\mathrm{m}^2$

Answer: D

Pascal's principle: pressure applied to an enclosed fluid is passed on equally everywhere, so the pressure at the two pistons is the same:

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

The small piston's area is $A_1 = \pi r^2 = 3.14 \times (0.1)^2 = 0.0314\,\mathrm{m}^2$.

Solve for the large piston's area:

$$A_2 = A_1 \times \frac{F_2}{F_1} = 0.0314 \times \frac{2500}{10} = 0.0314 \times 250 = 7.85\,\mathrm{m}^2$$

Textbook: Physics Grade 12, Unit 3 Fluid Mechanics, section 3.2 Pressure in fluids at rest (page 82).

31. An electric field is defined as a region where (1)

A. a charged particle losses its charge when it is placed in that region.

B. a charged particle experiences no electric force when it is placed in that region.

C. a neutral particle experiences electric force when it is placed in that region.

D. ✓ **a charged particle experiences an electric force if it is placed in that region.**

Answer: D

An electric field is the region around a charged body where another charged particle feels an electric force. If you place a test charge anywhere in that region, a force acts on it. That is option D.

Option B says the opposite of the definition. Option C fails because a truly neutral particle carries no net charge, so the field exerts no net force on it. Option A fails because a field pushes or pulls a charge; it does not remove the charge.

Textbook: Physics Grade 11, Unit 6 Electrostatics and Electric Circuit, section 6.2 Electric Fields (page 225).

32. Which one of the following statements is correct about the speed of sound in different medium? The speed of sound (1)

A. in a colder and less dense medium is faster than in hotter and denser material.

B. in solid is less than its speed in liquid.

C. ✓ **increases as the temperature and density of a material increases.**

D. in liquid is less than its speed in gas.

Answer: C

Sound travels by particles of the medium pushing on their neighbours. The closer and more strongly connected the particles are, the faster the push passes on. So sound is fastest in solids, slower in liquids, and slowest in gases. Raising the temperature also speeds it up, because the particles move faster and pass on the vibration sooner.

This is what option C says. Option A reverses both effects, and options B and D reverse the solid, liquid, gas order.

Textbook: Physics Grade 9, Unit 6 Mechanical Oscillation and Sound Wave, section 6.4 Sound Waves (page 125).

33. Four resistors are connected to a voltage source as shown in the figure below. Which one of the following is correct about the circuit? (1)

Question Diagram

A. R_2 is connected in parallel with R_3.

B. R_1 is connected in parallel with R_2.

C. ✓ **R_1 is connected in series with the effective combination of R_3 and R_4.**

D. R_2 is connected in parallel with the effective combination of R_3 and R_4.

Answer: C

Trace the circuit in the figure. Current from the source must pass first through R_1, then through R_2; the same current passes through both, so R_1 and R_2 are in series. After R_2 the current splits into two branches, R_3 and R_4, which share the same two junction points, so R_3 and R_4 are in parallel.

The whole line is therefore R_1 in series with R_2 in series with the parallel pair $R_3 \parallel R_4$. Option C states one true part of this: R_1 is in series with the effective combination of R_3 and R_4.

Options A, B and D each claim a parallel connection that the figure does not show: R_2 carries the full current before the split, so it is not in parallel with anything.

Textbook: Physics Grade 10, Unit 4 Static and Current Electricity, section 4.9 Combination of Resistors in a Circuit.

34. What is the magnitude of electric field strength at a distance of 2.0 m from a point charge, $Q = 4.0\mathrm{C}$? (1)

A. ✓ $9.0 \times 10^9 \mathrm{N/C}$

B. $72.0 \times 10^9 \mathrm{N/C}$

C. $54.0 \times 10^9 \mathrm{N/C}$

D. $18.0 \times 10^9 \mathrm{N/C}$

Answer: A

The electric field of a point charge is:

$$E = \frac{kQ}{r^2}$$

Substitute $k = 9.0 \times 10^9\,\mathrm{N}$\cdotpm$^2/\mathrm{C}^2$, $Q = 4.0\,\mathrm{C}$, and $r = 2.0\,\mathrm{m}$:

$$E = \frac{(9.0 \times 10^9)(4.0)}{(2.0)^2} = \frac{36 \times 10^9}{4} = 9.0 \times 10^9\,\mathrm{N/C}$$

Option B comes from forgetting to divide by r^2 after multiplying by 4, and option D comes from dividing by 2 instead of by 4.

Textbook: Physics Grade 11, Unit 6 Electrostatics and Electric Circuit, section 6.2 Electric Fields (page 225).

35. A wire that has a resistance of 6Ω is drawn out so as to make it into a new wire two times as long as the original and half cross-sectional area of the original. What will be the resistance of the new wire? (1)

A. 12Ω

B. 6Ω

C. 3Ω

D. ✓ **24Ω**

Answer: D

Resistance depends on the wire's shape: $R = \frac{\rho L}{A}$, where L is the length and A the cross-sectional area.

The new wire has double the length and half the area:

$$R_{new} = \frac{\rho(2L)}{A/2} = 4\,\frac{\rho L}{A} = 4R$$

$$R_{new} = 4 \times 6\,\Omega = 24\,\Omega$$

Option A (12 Ω) counts only the doubled length and forgets that halving the area also doubles the resistance.

Textbook: Physics Grade 11, Unit 6 Electrostatics and Electric Circuit, section 6.4 Electric Current, Resistance and Ohm's law (page 240).

36. If the critical angle for an optically denser medium to air boundary is 53°, what will be the refractive index of the medium? (Assume the index of refraction of air is 1.00. Given $\sin 53^\circ = 0.8$, $\cos 53^\circ = 0.6$) (1)

A. 1.67

B. 1.33

C. 1.00

D. ✓ **1.25**

Answer: D

At the critical angle c, light passing from the dense medium into air refracts at exactly 90°. Snell's law then gives:

$$n \sin c = 1.00 \times \sin 90^\circ = 1$$

So the refractive index of the medium is:

$$n = \frac{1}{\sin c} = \frac{1}{\sin 53^\circ} = \frac{1}{0.8} = 1.25$$

Option A (1.67) comes from wrongly using $\cos 53^\circ = 0.6$ in place of the sine.

Textbook: Physics Grade 10, Unit 6 Electromagnetic wave and geometrical optics, section 6.4 Laws of reflection & Refraction.

37. An object moving in one dimension with constant acceleration a travels through a displacement s in a time interval t. If its velocity at the initial time $t = 0$ is v_i and its velocity at a later time t is v_f, which of the following is a correct relation between the given quantities? (1)

A. ✓ $s = v_f t - \frac{1}{2}at^2$

B. $s = \frac{v_f^2 - v_i^2}{a}$

C. $s = v_i t + \frac{1}{2}at$

D. $s = \left(\frac{v_f - v_i}{2}\right) t$

Answer: A

Start from the standard displacement equation $s = v_i t + \frac{1}{2}at^2$ and replace v_i using $v_i = v_f - at$:

$$s = (v_f - at)t + \frac{1}{2}at^2 = v_f t - at^2 + \frac{1}{2}at^2 = v_f t - \frac{1}{2}at^2$$

So option A is a correct relation.

The others are broken versions of real formulas: the true forms are $s = \frac{v_f^2 - v_i^2}{2a}$ (B is missing the 2), $s = v_i t + \frac{1}{2}at^2$ (C has at instead of at^2), and $s = \left(\frac{v_f + v_i}{2}\right) t$ (D has a minus where a plus belongs).

Textbook: Physics Grade 11, Unit 3 Motion in one and two dimensions, section 3.2 Equations of Uniformly Accelerated Motion in 1D (page 54).

38. Which one of the following statements is correct about real and virtual images? (1)

A. ✓ **Real images can be displayed on a screen unlike the virtual ones.**

B. Virtual images can be magnified but real images cannot.

C. Virtual images can be displayed on a screen unlike the real ones.

D. Real images can be magnified but virtual images cannot.

Answer: A

A real image is formed where light rays actually meet, so it can be caught on a screen placed at that point, like the picture from a cinema projector. A virtual image is formed where rays only appear to come from, as in a plane mirror, so no light actually reaches that place and a screen there shows nothing.

That makes option A correct and option C its exact opposite. Options B and D are wrong because both kinds of image can be magnified; a magnifying glass gives an enlarged virtual image and a projector gives an enlarged real image.

Textbook: Physics Grade 10, Unit 6 Electromagnetic wave and geometrical optics, section 6.5 Mirrors and Lenses.

39. If two vectors $\vec{a}$ and $\vec{b}$, with respective magnitudes of a and b, form an angle α between them when they are connected tail to tail, then the expression $ab\cos\alpha$ defines the value of (1)

A. vector product of $\vec{a}$ and $\vec{b}$.

B. projection of $\vec{a}$ on $\vec{b}$.

C. resultant of $\vec{a}$ and $\vec{b}$.

D. ✓ **scalar product of $\vec{a}$ and $\vec{b}$.**

Answer: D

The expression $ab\cos\alpha$ is the definition of the scalar product (dot product) of the two vectors:

$$\vec{a} \cdot \vec{b} = ab\cos\alpha$$

The vector product has magnitude $ab\sin\alpha$, so option A is wrong. The projection of $\vec{a}$ on $\vec{b}$ is $a\cos\alpha$, without the factor b, so option B is wrong. The magnitude of the resultant comes from a different rule entirely, $\sqrt{a^2 + b^2 + 2ab\cos\alpha}$, so option C is wrong.

Textbook: Physics Grade 11, Unit 2 Vectors, section 2.4 Product of Vectors (page 39).

40. A long straight wire carries a current of 5.0 A. What is the magnetic field strength produced by the current at a distance of 2.0 cm from the wire? (Magnetic permeability free space $\mu_0 = 4\pi \times 10^{-7}\mathrm{T}\backslash\mathrm{cdotpm/A}$) (1)

A. $5\pi \times 10^{-5}\mathrm{T}$

B. $20 \times 10^{-5}\mathrm{T}$

C. $20\pi \times 10^{-5}\mathrm{T}$

D. ✓ $5 \times 10^{-5}\mathrm{T}$

Answer: D

The magnetic field at distance r from a long straight wire is:

$$B = \frac{\mu_0 I}{2\pi r}$$

Convert the distance: $r = 2.0\,\mathrm{cm} = 0.02\,\mathrm{m}$. Substitute:

$$B = \frac{(4\pi \times 10^{-7})(5.0)}{2\pi(0.02)} = \frac{2 \times 10^{-7} \times 5.0}{0.02}$$

$$B = \frac{1.0 \times 10^{-6}}{0.02} = 5.0 \times 10^{-5}\,\mathrm{T}$$

The π in μ_0 cancels with the π in the denominator, so no π survives in the answer; options A and C keep a π that should have cancelled.

Textbook: Physics Grade 12, Unit 4 Electromagnetism, section 4.3 Current and Magnetism (page 122).

41. Four point masses $m_1 = 4\,\mathrm{kg}$, $m_2 = 1\,\mathrm{kg}$, $m_3 = 3\,\mathrm{kg}$ and $m_4 = 5\,\mathrm{kg}$ are attached to a massless rod which lays on the x-axis as shown in the figure below. How much is the moment of inertia of the system about the y-axis? (1)

Question Diagram

A. 187 $\mathrm{kg}\backslash\mathrm{cdotpm}^2$ **B.** 190 $\mathrm{kg}\backslash\mathrm{cdotpm}^2$

C. ✓ **184** $\mathrm{kg}\backslash\mathrm{cdotpm}^2$ **D.** 84 $\mathrm{kg}\backslash\mathrm{cdotpm}^2$

Answer: C

For point masses, the moment of inertia about the y-axis uses each mass and its distance x from that axis:

$$I = \sum m_i x_i^2$$

Read the positions from the figure: $m_1 = 4\,\mathrm{kg}$ at $x = 5\,\mathrm{m}$, $m_2 = 1\,\mathrm{kg}$ at $x = 2\,\mathrm{m}$, $m_3 = 3\,\mathrm{kg}$ at $x = 0$, and $m_4 = 5\,\mathrm{kg}$ at $x = -4\,\mathrm{m}$.

- $4 \times 5^2 = 100$
- $1 \times 2^2 = 4$
- $3 \times 0^2 = 0$
- $5 \times (-4)^2 = 80$

$$I = 100 + 4 + 0 + 80 = 184\,\mathrm{kg}\backslash\mathrm{cdotpm}^2$$

Note that m_3 sits on the axis, so it adds nothing, and squaring makes the sign of $x = -4\,\mathrm{m}$ drop out.

Textbook: Physics Grade 12, Unit 2 Two-dimensional motion, section 2.3 Rotational Dynamics (page 50).

42. A projectile is thrown from a level ground with an initial velocity $\vec{v}_0$ making an angle of θ above the horizontal. If the maximum height covered by the projectile is H, then what is the horizontal range of the projectile in terms of H and θ? (1)

A. $\frac{H}{\tan\theta}$ **B.** $\frac{H\tan\theta}{4}$

C. ✓ $\frac{4H}{\tan\theta}$ **D.** $\frac{H}{4\tan\theta}$

Answer: C

Write the maximum height and the range of a projectile launched at speed v_0 and angle θ:

$$H = \frac{v_0^2 \sin^2\theta}{2g}, \qquad R = \frac{v_0^2 \sin 2\theta}{g} = \frac{2v_0^2 \sin\theta\cos\theta}{g}$$

Divide the range by the height so that v_0 and g cancel:

$$\frac{R}{H} = \frac{2v_0^2 \sin\theta\cos\theta/g}{v_0^2\sin^2\theta/2g} = \frac{4\cos\theta}{\sin\theta} = \frac{4}{\tan\theta}$$

So the range is:

$$R = \frac{4H}{\tan\theta}$$

Textbook: Physics Grade 12, Unit 2 Two-dimensional motion, section 2.1 Projectile motion (page 25).

43. Assume that a ball is thrown horizontally from a building of height h above the ground with initial speed v_0. Which one of the following statements is correct about the motion of the object? (1)

A. ✓ **Its horizontal component acceleration is zero.**

B. Its vertical component velocity remains constant.

C. Its vertical component acceleration is zero.

D. Its horizontal component velocity uniformly increases.

Answer: A

After the ball leaves the building, the only force on it is gravity, which acts straight down.

Horizontally there is no force, so the horizontal acceleration is zero and the horizontal velocity stays at v_0 throughout the flight. That is option A, and it also shows why option D is wrong.

Vertically, gravity gives a constant downward acceleration g, so the vertical velocity grows steadily from zero. That rules out options B and C.

Textbook: Physics Grade 12, Unit 2 Two-dimensional motion, section 2.1 Projectile motion (page 25).

44. Which one of the following phenomena occurs during change of phases of a matter? During a phase change from (1)

A. gas to liquid, heat energy is absorbed by a substance while its temperature remains constant.

B. solid to liquid, heat energy is released from a substance while its temperature remains constant.

C. liquid to solid, heat energy is released from a substance while its temperature changes uniformly.

D. ✓ **liquid to gas, heat energy is absorbed by a substance while its temperature remains constant.**

Answer: D

During any phase change, the temperature stays constant while the substance absorbs or releases latent heat.

- Melting (solid to liquid) and boiling (liquid to gas) **absorb** heat.
- Condensing (gas to liquid) and freezing (liquid to solid) **release** heat.

Option D matches this: going from liquid to gas, the substance absorbs heat while its temperature stays constant.

Option A has the direction wrong (gas to liquid releases heat), option B has it wrong too (solid to liquid absorbs heat), and option C wrongly says the temperature changes during the phase change.

Textbook: Physics Grade 11, Unit 5 Heat Conduction and Calorimetry, section 5.5 Change of phase (page 196).

45. Which one of the following defense technologies is correctly matched with its working principle? (1)

A. Missiles radiate electromagnetic signal and examine the echo received to identify the location of the target.

B. A radar is a rocket propelled weapon designed to deliver an explosive weapon with a great accuracy at high speed.

C. ✓ **Infrared device uses heat emission to identify objects that cannot be detected using available light sources.**

D. Drones radiate electromagnetic signal and examine the echo received to identify the location of the target.

Answer: C

Infrared devices detect the heat (infrared radiation) that warm objects give off. They can therefore find people, vehicles, or aircraft in the dark, when ordinary light is not available. Option C describes this correctly.

The other options swap definitions. Sending out electromagnetic (radio) signals and reading the echo is how a **radar** works, not a missile or a drone. A rocket-propelled weapon that carries an explosive to a target describes a **missile**, not a radar.

Textbook: Physics Grade 12, Unit 1 Application of physics in other fields, section 1.4 Physics and defense technology (page 17).

46. Which of the following concepts of physics are the primary focus points in mechanical engineering? (1)

A. Geometric optics, Electrostatics, Thermodynamics, and Stress

B. ✓ **Dynamics, Thermodynamics, Force, and Stress**

C. Nuclear physics, Geometric optics, Dynamics, and Force

D. Molecular physics, Dynamics, Nuclear physics, and Force

Answer: B

Mechanical engineering deals with machines, engines, and structures that move or carry loads. Its everyday tools from physics are dynamics (how forces cause motion), thermodynamics (heat and engines), force, and stress in materials. That is option B.

The other options mix in fields that belong elsewhere: geometric optics belongs to optical work, electrostatics to electrical engineering, and nuclear or molecular physics to other specialties, so options A, C and D are not the primary focus of a mechanical engineer.

Textbook: Physics Grade 12, Unit 1 Application of physics in other fields, section 1.2 Physics and engineering (page 9).

47. Suppose that you are given two forces with $F_1 = 75\,\mathrm{N}$ in the direction of 53° west of north and $F_2 = 100\,\mathrm{N}$ in the direction of 37° east of north. If you add the two forces using analytical and graphical methods and represent using graphical scale of 1 cm for 10 N force, what are the possible length and direction of the arrow line for the resultant vector? (1)

A. ✓ **12.5 cm to the North**

B. 17.3 cm to 45° North of East

C. 1.25 cm to the North

D. 1.73 cm to 45° North of East

Answer: A

Resolve each force into east-west and north components, using $\sin 53^\circ = \cos 37^\circ = 0.8$ and $\cos 53^\circ = \sin 37^\circ = 0.6$.

$F_1 = 75\,\mathrm{N}$ at 53° west of north: west part $75 \times 0.8 = 60\,\mathrm{N}$, north part $75 \times 0.6 = 45\,\mathrm{N}$.

$F_2 = 100\,\mathrm{N}$ at 37° east of north: east part $100 \times 0.6 = 60\,\mathrm{N}$, north part $100 \times 0.8 = 80\,\mathrm{N}$.

The 60 N west and 60 N east parts cancel. The north parts add: $45 + 80 = 125\,\mathrm{N}$ due north.

With the scale of 1 cm for 10 N, the arrow is $125 \div 10 = 12.5\,\mathrm{cm}$ long, pointing north. That is option A.

Textbook: Physics Grade 10, Unit 1 Vector Quantities, section 1.4 Graphical Method of Vector Addition and Subtraction.

48. Given the displacement vector $\vec{A} = (3\hat{\imath} - 4\hat{\jmath})\,\mathrm{m}$, what is the unit vector in the direction of $\vec{A}$? (1)

A. $-0.6\hat{\imath} + 0.8\hat{\jmath}$

B. ✓ $0.6\hat{\imath} - 0.8\hat{\jmath}$

C. $0.8\hat{\imath} - 0.6\hat{\jmath}$

D. $0.6\hat{\imath} + 0.8\hat{\jmath}$

Answer: B

A unit vector points the same way as the vector but has length 1. Divide the vector by its own magnitude.

Magnitude of $\vec{A}$:

$$|\vec{A}| = \sqrt{3^2 + (-4)^2} = \sqrt{9 + 16} = \sqrt{25} = 5$$

Unit vector:

$$\hat{A} = \frac{\vec{A}}{|\vec{A}|} = \frac{3\hat{\imath} - 4\hat{\jmath}}{5} = 0.6\hat{\imath} - 0.8\hat{\jmath}$$

Option D drops the minus sign of the $\hat{\jmath}$ part, and option C swaps the two components.

Textbook: Physics Grade 11, Unit 2 Vectors, section 2.3 Algebraic Method of addition of vectors in Two Dimensions (page 26).

49. The amount of heat energy required to raise the temperature of a given substance by $1^{\circ}\mathrm{C}$ is (1)

A. quantity of heat.

B. specific heat capacity.

C. latent heat.

D. ✓ **heat capacity**

Answer: D

The heat needed to raise the temperature of a whole object or a given amount of substance by $1^{\circ}\mathrm{C}$ is called its **heat capacity**, $C = \frac{Q}{\Delta T}$, measured in J/°C.

The tempting wrong choice is specific heat capacity, but that is defined per kilogram: the heat needed to raise 1 kg of the substance by $1^{\circ}\mathrm{C}$. The question says nothing about one kilogram, so heat capacity is the right term. Latent heat is the heat of a phase change, where the temperature does not rise at all.

Textbook: Physics Grade 11, Unit 5 Heat Conduction and Calorimetry, section 5.3 Heat Capacity and Specific Heat Capacity (page 183).

50. Which one of the following statements is correct about the properties of waves? (1)

A. When two waves interfere destructively, the amplitude of the resultant wave is greater than the amplitude of each wave.

B. ✓ **Diffraction of a wave through a narrow gap is more observable than through a wider gap.**

C. When a wave is reflected, its speed and wavelength are changed.

D. When a wave is refracted, its speed and wavelength remain the same.

Answer: B

Diffraction is the bending and spreading of a wave as it passes through a gap. The spreading is strongest when the gap is about as small as the wavelength, so a narrow gap shows diffraction much more clearly than a wide one. That is option B.

Option A describes constructive, not destructive, interference: destructive interference makes the resultant smaller. Options C and D are reversed: reflection keeps the wave in the same medium, so speed and wavelength do not change, while refraction moves the wave into a new medium, where speed and wavelength do change.

Textbook: Physics Grade 9, Unit 6 Mechanical Oscillation and Sound Wave, section 6.5 Superposition of Waves (page 131).

51. A square metal plate of coefficient of linear expansion α, has a surface area A_0 at a temperature T_0. If the temperature is raised by an amount ΔT, then the plate surface area is changed to A which is expressed as (1)

A. ✓ $A = A_0(1 + 2\alpha\Delta T)$

B. $A = 2A_0(1 + \alpha\Delta T)$

C. $A = A_0(1 + \alpha\Delta T)$

D. $A = A_0(1 + 3\alpha\Delta T)$

Answer: A

Linear expansion applies to each side of the square plate. The area is a two-dimensional quantity, so its expansion coefficient is twice the linear one:

$$A = A_0(1 + 2\alpha\,\Delta T)$$

You can see the factor 2 by squaring the side length: each side becomes $L_0(1 + \alpha\Delta T)$, so the area becomes $L_0^2(1 + \alpha\Delta T)^2 \approx A_0(1 + 2\alpha\Delta T)$, since the tiny $(\alpha\Delta T)^2$ term can be ignored.

Option C uses the linear coefficient unchanged, and option D uses 3α, which belongs to volume expansion.

Textbook: Physics Grade 11, Unit 5 Heat Conduction and Calorimetry, section 5.4 Thermal expansion (page 186).

52. An object dropped into a sea sinks to a depth of 100 m. Which of the following is correct about the pressure the object experiences? (Assume the density of seawater is $1030 \mathrm{kg/m}^3$ and the air above the see exerts a pressure of $P_{\text{atmospheric}} = 1.00 \times 10^5 \mathrm{Pa}$, $g = 10 \mathrm{m/s}^2$) (1)

A. The gauge pressure exerted on it is $P_{\text{gauge}} = 1.01 \times 10^5 \mathrm{Pa}$

B. The absolute pressure exerted on it is $P_{\text{absolute}} = 9.30 \times 10^5 \mathrm{Pa}$

C. ✓ **The absolute pressure exerted on it is $P_{\text{absolute}} = 1.13 \times 10^6 \mathrm{Pa}$**

D. The gauge pressure exerted on it is $P_{\text{gauge}} = 1.03 \times 10^7 \mathrm{Pa}$

Answer: C

Gauge pressure is the pressure due to the water column alone:

$$P_{\text{gauge}} = \rho g h = 1030 \times 10 \times 100 = 1.03 \times 10^6 \text{ Pa}$$

Absolute pressure adds the atmosphere on top:

$$P_{\text{absolute}} = P_{\text{atm}} + P_{\text{gauge}} = 1.00 \times 10^5 + 1.03 \times 10^6 = 1.13 \times 10^6 \text{ Pa}$$

So option C is correct. Option A is far too small for 100 m of water, and option D overstates the gauge pressure by a factor of ten.

Textbook: Physics Grade 12, Unit 3 Fluid Mechanics, section 3.2 Pressure in fluids at rest (page 82).

53. The atmospheric pressure in a certain area is determined to be 103.36 kPa, using a mercury barometer shown in the figure below. (Acceleration due to gravity, $g = 10 \mathrm{m/s}^2$, and density of mercury, $\rho_m = 13.6 \times 10^3 \mathrm{kg/m}^3$) The height to which the mercury column rises is about (1)

Question Diagram

A. 76 mm

B. ✓ **76 cm**

C. 7.6 m

D. 760 cm

Answer: B

In a mercury barometer, the atmosphere holds up the mercury column, so:

$$P_{\text{atm}} = \rho g h \quad \Rightarrow \quad h = \frac{P_{\text{atm}}}{\rho g}$$

Substitute the numbers:

$$h = \frac{103\,360}{(13.6 \times 10^3)(10)} = \frac{103\,360}{136\,000} = 0.76 \text{ m}$$

So the mercury rises about 76 cm, the familiar barometer height. The other options are the same digits with the decimal point in the wrong place, so checking units catches them.

Textbook: Physics Grade 12, Unit 3 Fluid Mechanics, section 3.2 Pressure in fluids at rest (page 82).

54. How much heat energy is required to change 5 kg of ice at $-20°\text{C}$ to water at $10°\text{C}$? (Specific heat capacities of water in liquid and solid phases are 4.2 kJ/kg°C and 2.1 kJ/kg°C, respectively, and latent heat of fusion of water, $L_f = 336000 \text{J}/\text{kg}$) (1)

A. $4.20 \times 10^5 \text{J}$ **B.** $1.68 \times 10^6 \text{J}$

C. ✓ $2.10 \times 10^6 \text{J}$ **D.** $1.89 \times 10^6 \text{J}$

Answer: C

The heating happens in three stages.

1. Warm the ice from $-20°\text{C}$ to $0°\text{C}$:

$$Q_1 = mc_{\text{ice}}\Delta T = 5 \times 2100 \times 20 = 2.1 \times 10^5 \text{ J}$$

2. Melt the ice at $0°\text{C}$:

$$Q_2 = mL_f = 5 \times 336\,000 = 1.68 \times 10^6 \text{ J}$$

3. Warm the water from $0°\text{C}$ to $10°\text{C}$:

$$Q_3 = mc_{\text{water}}\Delta T = 5 \times 4200 \times 10 = 2.1 \times 10^5 \text{ J}$$

Total:

$$Q = 2.1 \times 10^5 + 1.68 \times 10^6 + 2.1 \times 10^5 = 2.10 \times 10^6 \text{ J}$$

Option B is only the melting stage; the two warming stages must be added as well.

Textbook: Physics Grade 11, Unit 5 Heat Conduction and Calorimetry, section 5.6 Calorimetry (page 203).

55. Suppose a particle of mass m is tied to a string and then whirled around in a horizontal circle of radius r about the center O as shown in the figure below. If the string makes an angle of θ to the vertical while rotating, the component of the force that is responsible for the circular motion of the mass by providing the centripetal force is (1)

Question Diagram

A. ✓ $T \sin\theta$ **B.** $T \cos\theta$

C. $mg \sin\theta$ **D.** $mg \cos\theta$

Answer: A

Two forces act on the whirling mass: its weight mg straight down, and the string tension T along the string.

The mass moves in a horizontal circle, so the centripetal force must point horizontally, toward the center O. Resolve the tension: since the string makes angle θ with the vertical, the vertical part $T\cos\theta$ balances the weight, and the horizontal part $T\sin\theta$ points to the center.

So $T\sin\theta$ is the component that supplies the centripetal force:

$$T\sin\theta = \frac{mv^2}{r}$$

Option B is the vertical component, which only supports the weight; it cannot pull the mass toward the center.

Textbook: Physics Grade 11, Unit 3 Motion in one and two dimensions, section 3.5 Uniform Circular Motion (page 79).

56. Which one of the following statements is correct about the fundamental forces in nature and their applications? (1)

A. The force that keeps the nucleus of an atom from flying apart due to the repulsive force between protons is the weak nuclear force.

B. ✓ **The gravitational force makes planets to revolve around the Sun and to follow their orbital path.**

C. The force that arises in most radioactive processes and in nuclear reactions that generate the Sun's energy is the strong nuclear force.

D. The electromagnetic force is the force that keeps protons and neutrons bound together in the nucleus of an atom.

Answer: B

The gravitational force acts between all masses over any distance. It is the force that holds planets in their orbits around the Sun, so option B is correct.

The other options mix up the nuclear forces. The force that holds the nucleus together against the repulsion between protons is the **strong** nuclear force, not the weak one (A wrong) and not the electromagnetic force (D wrong). The force behind most radioactive decay processes is the **weak** nuclear force, not the strong one (C wrong).

Textbook: Physics Grade 11, Unit 4 Dynamics, section 4.1 The Concept of Force and Newton's Laws of motion (page 96).

57. A spring stores 120 J of elastic potential energy when it is stretched by 0.5 m. What is the potential energy stored by the spring when it is stretched by 1.5 m? (1)

A. 480 J

B. 960 J

C. ✓ **1080 J**

D. 540 J

Answer: C

The elastic potential energy of a spring is $E = \frac{1}{2}kx^2$, so the stored energy grows with the *square* of the stretch.

The stretch grows from 0.5 m to 1.5 m, that is 3 times larger, so the energy grows by $3^2 = 9$ times:

$$E = 9 \times 120 = 1080\,\mathrm{J}$$

You can check with the spring constant: $k = \frac{2E}{x^2} = \frac{2\times120}{0.5^2} = 960\,\mathrm{N/m}$, then $E = \frac{1}{2}(960)(1.5)^2 = 1080\,\mathrm{J}$. Option A (480 J) comes from multiplying by 4 instead of 9; the square of 3 is what the formula demands.

Textbook: Physics Grade 11, Unit 4 Dynamics, section 4.4 Work, Energy and Power (page 128).

58. The velocity-time graph of an object moving in a straight line is shown in the figure below. What is the magnitude of the total displacement covered by the object in the time interval of 14 seconds? (1)

Question Diagram

A. 108 m

B. ✓ **90 m**

C. 54 m

D. 42 m

Answer: B

Displacement is the signed area between the velocity-time graph and the time axis. Read the graph piece by piece:

- From 0 to 2 s the velocity is negative, rising from -6 to 0 m/s: area $= \frac{1}{2}(2)(-6) = -6\,\mathrm{m}$
- From 2 to 6 s it rises from 0 to 12 m/s: area $= \frac{1}{2}(4)(12) = 24\,\mathrm{m}$
- From 6 to 10 s it stays at 12 m/s: area $= (4)(12) = 48\,\mathrm{m}$
- From 10 to 14 s it falls from 12 to 0 m/s: area $= \frac{1}{2}(4)(12) = 24\,\mathrm{m}$

Total displacement:

$$s = -6 + 24 + 48 + 24 = 90\,\mathrm{m}$$

The common mistake is to treat the rising line as one triangle from 0 to 6 s, which gives 36 m and a total of 108 m. That ignores the fact that the object starts at $-6\,\mathrm{m/s}$ and moves backward for the first 2 seconds.

Textbook: Physics Grade 11, Unit 3 Motion in one and two dimensions, section 3.3 Graphical Representation of Uniformly accelerated Motion in 1D (page 60).

59. A crane at port is used to lift a 10,000 kg object to a height of 20 m. If the power developed by the crane is 50,000 W, how long does it take to lift the object? (Acceleration due to gravity, $g = 10\mathrm{m/s}^2$) (1)

A. 400 s
B. ✓ **40 s**
C. 4 s
D. 2 s

Answer: B

The work needed to lift the object is the gain in potential energy:

$$W = mgh = 10\,000 \times 10 \times 20 = 2.0 \times 10^6\,\mathrm{J}$$

Power is work divided by time, so the time is:

$$t = \frac{W}{P} = \frac{2.0 \times 10^6}{50\,000} = 40\,\mathrm{s}$$

Textbook: Physics Grade 9, Unit 4 Force, Work, Energy and Power, section 4.6 Power (page 76).

60. A system of four masses $m_1 = 4\mathrm{kg}$, $m_2 = 4\mathrm{kg}$, $m_3 = 5\mathrm{kg}$, and $m_4 = 3\mathrm{kg}$ are located in the xy-plane at the coordinates of $(0, 0)$, $(30\mathrm{cm}, 0)$, $(-40\mathrm{cm}, 0)$, and $(0, 20\mathrm{cm})$, respectively. What is the coordinate of the center of mass of the system? (1)

A. (20 cm, 3.75 cm)
B. $(-6.7\mathrm{cm}, 5\mathrm{cm})$
C. $(-5\mathrm{cm}, 10\mathrm{cm})$
D. ✓ $(-5\mathrm{cm}, 3.75\mathrm{cm})$

Answer: D

The center of mass coordinates are mass-weighted averages of the positions. Total mass: $4 + 4 + 5 + 3 = 16\,\mathrm{kg}$.

x-coordinate:

$$x_{cm} = \frac{4(0) + 4(30) + 5(-40) + 3(0)}{16} = \frac{120 - 200}{16} = \frac{-80}{16} = -5\,\mathrm{cm}$$

y-coordinate:

$$y_{cm} = \frac{4(0) + 4(0) + 5(0) + 3(20)}{16} = \frac{60}{16} = 3.75\,\mathrm{cm}$$

So the center of mass is at $(-5\,\mathrm{cm},\ 3.75\,\mathrm{cm})$. Watch the sign of m_3's position: it sits at $-40\,\mathrm{cm}$, which pulls the answer to the negative x side.

Textbook: Physics Grade 12, Unit 2 Two-dimensional motion.

— END OF MARKING KEY —