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Physics, 2016 EC, natural science, entrance exam

Grade 12 · Physics · 2016 E.C.

MARKING KEY — CONFIDENTIAL

Time allowed: 120 minutes **Questions:** 48 **Total marks:** 48

1. Lenz's law states that the direction of the induced current in a loop is in such a way that the current (1)

A. is in opposite direction to that of the applied magnetic fied that is causing it.

B. creates a magnetic field that reinforces the change in J magnetic flux through the loop.

C. is in the same direction as that of the applied iagnetic field that is causing it.

D. ✓ **creates a magnetic field that opposes the change in magnetic flux through the loop.**

Answer: D

Lenz's law says that an induced current always flows in the direction that fights the change which produced it. The induced current sets up its own magnetic field, and that field **opposes the change in magnetic flux** through the loop. This is option D.

Option A is the common trap. The rule is not about the direction of the applied field. It is about the *change* in flux. If the flux is decreasing, the induced field actually points the same way as the applied field, to slow the decrease. So the induced field can be with or against the applied field, but it is always against the change.

Lenz's law follows from conservation of energy: if the induced current helped the change instead, the current would grow on its own for free.

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

2. Which one of the following statements is correct about the resistance of a conducting wire? The resistance of the wire is (1)

A. directly proportional to the square of its length.

B. directly proportional to the square of its cross-sectional area.

C. ✓ **inversely proportional to its cross-sectional area.**

D. inversely proportional to its length.

Answer: C

The resistance of a wire is given by $R = \dfrac{\rho L}{A}$, where ρ is the resistivity of the material, L is the length, and A is the cross-sectional area.

From this formula, resistance is directly proportional to the length L (not its square), and **inversely proportional to the cross-sectional area** A. A longer wire gives electrons a longer path, so resistance rises. A thicker wire gives them more room to flow, so resistance falls.

Only option C matches the formula. Options A and B insert squares that do not belong, and option D reverses the length relation.

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

3. Consider an ideal transformer having N_p and N_s turns, and voltages V_p and V_s in its primary and secondary coils, respectively. Which one of the following is the correct ideal transformer equation? (1)

A. V_p = (N_(p) / N_(s))^(2) V_(s)

B. N_(s)/N_(p) = (V_(s)/V_(p))^(2)

C. V_(s)/V_(p) = N_(p)/N_(s)

D. ✓ **V_(s)/V_(p) = N_(s) /N_(p)**

Answer: D

In an ideal transformer, the same changing magnetic flux passes through both coils. Faraday's law then gives each coil an emf in proportion to its number of turns: the emf per turn is the same on both sides.

So

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

This is option D. More turns on the secondary means a larger secondary voltage (step-up); fewer turns means a smaller voltage (step-down).

Option C writes the turns ratio upside down, and options A and B square the ratios, which has no basis in the physics.

Textbook: Physics Grade 12, Unit 4 Electromagnetism, section 4.6 Transformers (page 131).

4. Which one of the following statements is correct about the electrical conductivity of materials? Materials in which all the (1)

A. outer most shell electrons are tightly bound to its parent atom are conductors.

B. outer most shell electrons are free to move within the material are semiconductors.

C. inner and outer most shell electrons are free to move within the material are conductors.

D. ✓ **inner and outer most shell electrons are tightly bound to its parent atom are insulators.**

Answer: D

Electrical conductivity depends on how free the electrons are to move.

- **Conductors:** the outermost (valence) electrons are loosely held and move freely through the material. The inner electrons stay bound to their atoms.
- **Insulators:** all electrons, inner and outermost, are tightly bound to their parent atoms, so almost no charge can flow.
- **Semiconductors:** in between; a few electrons can break free, and heat or doping increases that number.

Option D describes an insulator correctly. Option A actually describes an insulator but calls it a conductor. Option B describes a conductor but calls it a semiconductor. Option C is wrong because even in conductors the inner electrons are not free.

Textbook: Physics Grade 12, Unit 5 Basics of electronics, section 5.1 Semiconductors (page 143).

5. Which one of the following statements distinguishes precision from accuracy? (1)

A. Precision indicates how close a measured value is to the true value, whereas accuracy refers to the closeness of repeatedly measuied values to each other.

B. Accuracy measures how exact a value is whereas precision indicates how close a measured value is to the true value.

C. Precision is a measure of the closeness of repeatedly measured values to each other, whereas accuracy is related to the number of significant figures.

D. ✓ Precision is a measure of the closeness of repeatedly measured values to each other, whereas accuracy refers to the closeness of measured values to the true value.

Answer: D

These two words describe different qualities of a measurement.

- **Precision** tells how closely repeated measurements agree with *each other*. Small spread means high precision.
- **Accuracy** tells how close a measured value is to the *true value*.

A measurement can be precise but not accurate: if a faulty balance always reads 2 g too high, the readings cluster tightly (precise) but they are all wrong (not accurate).

Option D states both definitions correctly. Options A and B swap the two meanings, and option C wrongly ties accuracy to significant figures.

Textbook: Physics Grade 9, Unit 2 Physical Quantities, section 2.2 Measurement and Safety (page 17).

6. Which of the following statements about the nature electromagnetic waves is correct? Electromagnetic waves are transverse waves produced when (1)

A. ✓ electric and magnetic fields are oscillating perpendicular to each other.

B. charges are placed at rest in an electric and magnetic fields that are perpendicular to each other.

C. electric and magnetic fields are oscillating parallel to each other.

D. charges are placed at rest in an electric and magnetic fields that are parallel to each other.

Answer: A

An electromagnetic wave is made of an electric field and a magnetic field that oscillate **perpendicular to each other**, and both are perpendicular to the direction the wave travels. That is why the wave is transverse. This is option A.

A changing electric field creates a magnetic field, and a changing magnetic field creates an electric field, so the two fields keep regenerating each other and the wave carries itself through empty space with no medium needed.

Options B and D fail because charges *at rest* produce only steady fields and no wave; a wave needs accelerating (oscillating) charges. Option C fails because parallel oscillating fields do not form an electromagnetic wave.

Textbook: Physics Grade 10, Unit 6 Electromagnetic wave and geometrical optics, section 6.1 Electromagnetic Waves.

7. A concave mirror has a radius of curvature of 30.0 cm . It is positioned so that the upright image of an object is 2.0 times the size of the object. How far is the object from the mirror? (1)

A. 10.0 cm

B. 15.0 cm

C. 22.5 cm

D. ✓ **7.5 cm**

Answer: D

Step 1: find the focal length.

$$f = \frac{R}{2} = \frac{30.0}{2} = 15.0 \text{ cm}$$

Step 2: use the magnification. The image is upright and 2.0 times larger, so it is a virtual image and the magnification is positive:

$$m = -\frac{d_i}{d_o} = +2 \quad \Rightarrow \quad d_i = -2d_o$$

Step 3: apply the mirror equation.

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{d_o} - \frac{1}{2d_o} = \frac{1}{2d_o}$$

So $2d_o = 15.0$ and $d_o = 7.5$ cm.

The object sits inside the focal point (7.5 cm is less than 15 cm), which is exactly when a concave mirror gives an enlarged upright virtual image. The answer is D.

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

8. Which one of the following is correct about the four basic forces in nature? (1)

A. Electromagnetic force is the weakest of all the forces in nature.

B. Gravitational force is attractive force that acts on the scale of the atomic nucleus.

C. ✓ **Strong nuclear force is short-range force that holds protons and neutrons together inside a nucleus.**

D. Weak nuclear force keeps the electrons in their orbit around a nucleus.

Answer: C

Nature has four basic forces: gravitational, electromagnetic, strong nuclear, and weak nuclear.

The **strong nuclear force** acts only over a very short range, about the size of a nucleus. It binds protons and neutrons together and is strong enough to beat the electric repulsion between the protons. This is option C.

The other options mix up the forces. Option A: gravity, not the electromagnetic force, is the weakest of the four. Option B: gravity is a long-range force that rules planets and stars, not the atomic nucleus. Option D: the electromagnetic force, not the weak force, holds electrons around the nucleus; the weak force is behind certain radioactive decays.

9. Which of the following is correct about impulse? (1)

A. ✓ The direction of the impulse is in the same direction to change in the momentum of the object.

B. During momentum change final momentum of an object is along the impulse on the object.

C. Impulse due to a force exerted for a short time is equal to impulse due to the same force exerted for a long time.

D. The impulse is smaller than change of momentum which caused by the applied force.

Answer: A

Impulse is defined as $\vec{J} = \vec{F}\,\Delta t$, and the impulse-momentum theorem says

$$\vec{J} = \Delta\vec{p}$$

Impulse *equals* the change in momentum. Since they are equal vectors, they point in the **same direction**. This is option A.

Option C fails because for the same force, a longer contact time gives a larger impulse ($J = F\Delta t$ grows with time). Option D fails because impulse is never smaller than the momentum change; the two are exactly equal. Option B is wrong because it is the *change* in momentum, not the final momentum, that lies along the impulse.

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

10. Which of the following pair of vectors is collinear? (1)

A. C = i + j and D = i - j

B. A = 2i + 3j and B = -4i + 6j

C. ✓ E = -i + j and F = 3i - 3j

D. G = 2i + 3j and F = 3i + 2j

Answer: C

Two vectors are collinear when they lie along the same line, meaning one is a scalar multiple of the other. The scalar can be negative; pointing in exactly opposite directions still counts as collinear.

Check option C: $\vec{E} = -\vec{i} + \vec{j}$ and $\vec{F} = 3\vec{i} - 3\vec{j}$. Multiply $\vec{E}$ by -3:

$$-3(-\vec{i} + \vec{j}) = 3\vec{i} - 3\vec{j} = \vec{F}$$

So $\vec{F} = -3\vec{E}$, and the pair is collinear.

The others fail the ratio test (the x and y components must scale by the same factor). Option A: $1/1 \neq 1/(-1)$. Option B: $-4/2 = -2$ but $6/3 = 2$. Option D: $3/2 \neq 2/3$.

Textbook: Physics Grade 11, Unit 2 Vectors, section 2.1 Vectors and Types of Vectors (page 17).

11. A ball is thrown vertically upward with 12 m/s from the ground. Its speed when the ball is 4.0 m above the ground is (1)

A. ✓ 8 m/s.

B. 15 m/s.

C. 10 m/s

D. 12 m/s

Answer: A

Use the kinematic equation for vertical motion (take $g = 10\ \mathrm{m/s^2}$):

$$v^2 = u^2 - 2gh$$

Substitute $u = 12\ \mathrm{m/s}$ and $h = 4.0\ \mathrm{m}$:

$$v^2 = (12)^2 - 2(10)(4.0) = 144 - 80 = 64$$

$$v = \sqrt{64} = 8\ \mathrm{m/s}$$

The ball loses speed on the way up because gravity pulls against its motion. Using $g = 9.8\ \mathrm{m/s^2}$ gives $v \approx 8.1\ \mathrm{m/s}$, still closest to 8 m/s. The answer is A.

Textbook: Physics Grade 11, Unit 3 Motion in one and two dimensions, section 3.4 Vertical Motion (page 70).

12. An object is projected at angle θ from the horizontal with initial velocity v_0. Which one of the following expressions represents the relationship between maximum height, h_{max}, and range of the projectile, R ? (1)

A. R = h_(max)((tanθ)/2)

B. R = 4h_(max)(tanθ)

C. R = (2h_(max))/(tan θ)

D. ✓ **R = (4h_(max))/(tan θ)**

Answer: D

Write down the two standard projectile results:

$$h_{max} = \frac{v_0^2 \sin^2\theta}{2g} \qquad R = \frac{v_0^2 \sin 2\theta}{g} = \frac{2v_0^2 \sin\theta\cos\theta}{g}$$

Divide the range by the maximum height:

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

So

$$R = \frac{4h_{max}}{\tan\theta}$$

which is option D. A quick check: at $\theta = 45°$, $\tan\theta = 1$, so the range is 4 times the maximum height, which is the known result.

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

13. A 0.5 kg block moving with an initial speed of 5.0 m/s slides 2.5 m on a A rough horizontal surface before coming to rest. The coefficient of kinetic friction is (1)

A. ✓ **0.5**

B. 0.3

C. 0.1

D. 0.4

Answer: A

Friction is the only horizontal force, so it does the work that removes all the kinetic energy:

$$\mu mg\, d = \frac{1}{2}mv^2$$

The mass cancels. Solve for the coefficient of kinetic friction (take $g = 10\ \mathrm{m/s^2}$):

$$\mu = \frac{v^2}{2gd} = \frac{(5.0)^2}{2(10)(2.5)} = \frac{25}{50} = 0.5$$

The answer is A. Notice that the 0.5 kg mass was extra information; it cancels out of the equation.

Textbook: Physics Grade 11, Unit 4 Dynamics, section 4.2 Frictional Force (page 112).

14. A 0.2 kg ball is kicked from the ground at 16 m/s in a direction making an angle θ above the horizontal. Neglecting air resistance, the magnitude of velocity of the ball when it is 3.0 m from the ground is (1)

A. 7 m/s.
B. 2 m/s.
C. ✓ **14 m/s.**
D. 16 m/s.

Answer: C

With no air resistance, mechanical energy is conserved, so the speed at any height depends only on the launch speed and the height, not on the launch angle:

$$\frac{1}{2}mv^2 + mgh = \frac{1}{2}mv_0^2$$

The mass cancels:

$$v^2 = v_0^2 - 2gh$$

Substitute $v_0 = 16\ \mathrm{m/s}, h = 3.0\ \mathrm{m}, g = 10\ \mathrm{m/s}^2$:

$$v^2 = (16)^2 - 2(10)(3.0) = 256 - 60 = 196$$

$$v = \sqrt{196} = 14\ \mathrm{m/s}$$

The answer is C. Both the 0.2 kg mass and the angle θ were extra information.

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

15. The angular speed of a disk rotating about its axis increases by 2000rad/s in a time interval of 3.0s . If the moment of inertia of the disk is 0.6kgm^2, what is the average torque on the disk? (1)

A. 670 Nm
B. 1200Nm
C. 6000 Nm
D. ✓ **400 Nm**

Answer: D

Step 1: find the angular acceleration.

$$\alpha = \frac{\Delta\omega}{\Delta t} = \frac{2000\ \mathrm{rad/s}}{3.0\ \mathrm{s}} \approx 666.7\ \mathrm{rad/s}^2$$

Step 2: apply the rotational form of Newton's second law.

$$\tau = I\alpha = 0.6\ \mathrm{kg\ m}^2 \times 666.7\ \mathrm{rad/s}^2 = 400\ \mathrm{Nm}$$

The answer is D. Option A (670 Nm) is a trap: it is the angular acceleration value, not the torque.

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

16. What do you call the sound wave that is heard after reflection from a hard surface? (1)

A. Loudness
B. Timber
C. ✓ **Echo**
D. pitch

Answer: C

An **echo** is a sound heard again after the sound wave reflects from a hard surface such as a cliff, a wall, or a mountain. The reflected wave reaches your ear a little later than the original sound, so you hear the sound twice.

The other options are properties of a sound, not reflected sounds. Loudness describes how strong the sound is (its amplitude). Pitch describes how high or low it is (its frequency). Timbre is the quality that lets you tell two instruments apart even when they play the same note.

The answer is C.

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

17. The angular momentum of a rotating object is defined as the product of its (1)

A. mass and the angular velocity.

B. moment of inertia and the square of the angular velocity.

C. ✓ **moment of inertia and angular velocity.**

D. mass and one-half of the square of the angular velocity.

Answer: C
Angular momentum is the rotational partner of linear momentum. Linear momentum is $p = mv$; replacing mass with moment of inertia and velocity with angular velocity gives

$$L = I\omega$$

So angular momentum is the product of the **moment of inertia and the angular velocity**, which is option C.

Option B, $I\omega^2$, is close to rotational kinetic energy ($KE = \frac{1}{2}I\omega^2$), not momentum. Option D looks like linear kinetic energy. Option A mixes mass with angular velocity, which does not even have the units of angular momentum.

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

18. Which one of the following waves is identified as longitudinal wave? (1)

A. Deep water wave

B. Wave on a vibrating string

C. ✓ **Sound wave**

D. S-wave of Earthquake

Answer: C
In a longitudinal wave the particles of the medium vibrate *parallel* to the direction the wave travels, forming compressions and rarefactions. Sound in air works exactly this way: air particles push together and spread apart along the line of travel. So the answer is C.

The others are not longitudinal. A wave on a vibrating string moves the string up and down while the wave runs along the string, so it is transverse. The S-wave of an earthquake is also transverse; that is why it cannot pass through liquids. Deep water waves move particles in circles, a mix of motions, not a pure longitudinal wave.

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

19. Which of the following statements is correct about the components of the velocity of a ball projected up at an angle of θ with the horizontal? Neglecting the air resistance, (1)

A. the vertical component of the velocity remains constant throughout its journey.

B. the vertical component of velocity increases while the horizontal component of velocity decreases.

C. ✓ **the horizontal component of the velocity remains constant throughout its journey.**

D. the horizontal velocity of the ball is equal to zero at the maximum

Answer: C
Once the ball is in flight, the only force on it is gravity, and gravity acts straight down. There is no horizontal force at all.

With no horizontal force, the **horizontal component of velocity stays constant** for the whole flight: $v_x = v_0 \cos\theta$ throughout. This is option C.

The vertical component does change: gravity slows it on the way up, makes it zero for an instant at the top, then speeds it up downward. So option A is wrong. Option B is wrong because the horizontal component does not decrease. Option D is wrong because at maximum height it is the *vertical* velocity that is zero; the ball is still moving horizontally there.

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

20. Which one of the following statements is correct about the electric field due to a charged spherical solid conductor? (1)

A. ✓ **It is zero inside the sphere.**

B. It is non-zero constant outside th sphere.

C. It is non-zero constant inside the sphere.

D. It is parallel to the surface of the sphere.

Answer: A

In a charged conductor at equilibrium, the free electrons rearrange themselves until they feel no net force. All the excess charge ends up on the outer surface, and the electric field **inside the conductor is exactly zero**. This is option A.

If any field existed inside, it would push the free electrons, and charges would keep moving; equilibrium means that motion has stopped.

Outside the sphere the field is not constant: it falls off as $1/r^2$, as if all the charge sat at the center. So option B fails. Option C fails because the inside field is zero, not a non-zero constant. Option D fails because just outside the surface the field is perpendicular to the surface, never parallel to it.

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

21. A metal wire made of coefficient of linear expansion a is heated so that its temperature is changed by ΔT. If the length of the wire before heating is L_0, which one of the following expressions is correct for the final length of the wire after heating? (1)

A. L_(0) ∝ ΔT

B. (L_(0))/ (1 + ∝ΔT)

C. ✓ **L_(0)(1 + ∝ΔT)**

D. (L_(0))/ (1 - ∝ΔT)

Answer: C

When a wire is heated, its length grows by

$$\Delta L = \alpha L_0 \Delta T$$

where α is the coefficient of linear expansion, L_0 is the original length, and ΔT is the temperature change.

The final length is the original length plus the growth:

$$L = L_0 + \Delta L = L_0 + \alpha L_0 \Delta T = L_0(1 + \alpha \Delta T)$$

This is option C. Options B and D divide instead of multiply, which would make the wire shrink or blow up incorrectly, and option A is not even an equation for a length.

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

22. What amount of heat energy is required to completely melt 200g of ice at 0°C ? (Take specific latent heat of melting for ice, L_f = 3.3x10^5 J/kg) (1)

A. 1.65 x 10^(7) J

B. Zero

C. ✓ **6.60x10^4 J**

D. 1.65x 10^3 J

Answer: C

The ice is already at its melting point (0°C), so all the heat goes into changing its state, not raising its temperature. Use the latent heat formula:

$$Q = mL_f$$

Convert the mass: $200\ \mathrm{g} = 0.2\ \mathrm{kg}$. Then

$$Q = 0.2\ \mathrm{kg} \times 3.3 \times 10^5\ \mathrm{J/kg} = 6.6 \times 10^4\ \mathrm{J}$$

The answer is C. Option A comes from forgetting to convert grams to kilograms. Option B is tempting because the temperature stays at 0°C during melting, but melting still needs energy to break the bonds between water molecules.

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

23. The orbital speed of a satellite at a height of 780km from the surface of the earth is 7, 465m/s. what is the period of the satellite? (1)

A. 6.04 x 10^2 s

B. ✓ **6.04 x 10^3 s**

C. 6.60 x 10^3 s

D. 6.60 X 10^2 s

Answer: B

In one full orbit the satellite travels the circumference $2\pi r$ at speed v, so the period is

$$T = \frac{2\pi r}{v}$$

The orbital radius is measured from the center of the Earth, so add the Earth's radius to the height:

$$r = 6.4 \times 10^6 \text{ m} + 0.78 \times 10^6 \text{ m} = 7.18 \times 10^6 \text{ m}$$

Now substitute:

$$T = \frac{2\pi \times 7.18 \times 10^6}{7465} = \frac{4.51 \times 10^7}{7465} \approx 6.0 \times 10^3 \text{ s}$$

The answer is B (about 100 minutes). The common mistake is using only the height 780 km as the radius; the orbit circles the Earth's center, not its surface.

Textbook: Physics Grade 12, Unit 2 Two-dimensional motion, section 2.4 Planetary motion and Kepler's laws (page 54).

24. The charge of 20.0μ is stored on the capacitor when a potential difference between its two parallel plates is 200.0 V, what is the capacitance of the capacitor? (1)

A. 1.0 x 10^{-6} F

B. 10.0 x 10^{-6} F

C. ✓ **0.1 x 10^{-6} F**

D. 4.0 x 10^{-6} F

Answer: C

Capacitance is the charge stored per volt:

$$C = \frac{Q}{V}$$

Substitute $Q = 20.0\ \mu\text{C} = 20.0 \times 10^{-6}\text{ C}$ and $V = 200.0\text{ V}$:

$$C = \frac{20.0 \times 10^{-6}}{200.0} = 0.1 \times 10^{-6}\text{ F} = 0.1\ \mu\text{F}$$

The answer is C. Watch the powers of ten: dividing by 200 shifts the value two places down, which trips students into picking A or B.

Textbook: Physics Grade 11, Unit 6 Electrostatics and Electric Circuit, section 6.6 Capacitors and Capacitance (page 270).

25. An air filled parallel plate capacitor is connected to a potential difference 'v' to store electric charge. If the area of the plates is and the separation between the plates is 'd', then the electrical energy stored on the capacitor is (1)

A. 1/2(ε₀ dv^(2))/A

B. (ε₀ Av^(2))/d

C. (ε₀ dv^(2))/A

D. ✓ **(1/2)(ε₀ Av^(2)/d**

Answer: D

Two formulas combine here. The energy stored in a capacitor at voltage v is

$$U = \frac{1}{2}Cv^2$$

and the capacitance of a parallel plate capacitor with plate area A and separation d is

$$C = \frac{\varepsilon_0 A}{d}$$

Substitute the second into the first:

$$U = \frac{1}{2} \cdot \frac{\varepsilon_0 A}{d} \cdot v^2 = \frac{1}{2}\frac{\varepsilon_0 A v^2}{d}$$

This is option D. Option B forgets the factor of one half, and options A and C put the area and separation in the wrong places.

Textbook: Physics Grade 11, Unit 6 Electrostatics and Electric Circuit, section 6.6 Capacitors and Capacitance (page 270).

26. When a force F is applied to a wire of length 'L' fixed at one end, the wire extends by x. The tensile strain of the wire is (1)

A. ✓ **the extension divided by the length L.**

B. the length L divided by the extension x

C. the applied force F divided by the extension.

D. the product of the force F and then extension x .

Answer: A

Tensile strain measures how much a material stretches compared to its original length:

$$\text{strain} = \frac{x}{L}$$

where x is the extension and L is the original length. It is a pure ratio with no unit. So the answer is A: the extension divided by the length.

Option C (force divided by extension) is the stiffness of the wire, as in Hooke's law. Force divided by cross-sectional area would be the *stress*, a different quantity. Options B and D do not correspond to any standard quantity.

Textbook: Physics Grade 10, Unit 3 Elasticity and rigid body in static equilibrium, section 3.3 Stress and Strain.

27. Which one of the following factors does NOT affect the moment of inertia of an object? (1)

A. The axis about which the object is rotating

B. The size of the object

C. ✓ **The angular speed of the object**

D. The mass of the object

Answer: C

The moment of inertia measures how hard it is to change an object's rotation. For a collection of particles it is

$$I = \sum mr^2$$

so it depends on the object's mass, on how that mass is spread out (its size and shape), and on which axis it rotates about, since r is measured from the axis.

The **angular speed** does not appear anywhere in this definition. A disk has the same moment of inertia whether it spins fast, slow, or not at all, just as mass does not change when an object speeds up. So the answer is C.

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

28. Which of the following describes the difference between static and dynamic equilibrium? In static equilibrium, (1)

A. ✓ **an object is at rest, whereas in dynamic equilibrium, the object moves with constant velocity.**

B. an object moves with constant acceleration, whereas in dynamic equilibrium, the object is at rest.

C. acceleration is zero, whereas in dynamic equilibrium the acceleration increases uniformly.

D. an object moves with constant velocity, whereas in dynamic equilibrium an object is at rest.

Answer: A

Both kinds of equilibrium mean the net force (and net torque) on the object is zero, so the acceleration is zero. The difference is the state of motion.

- **Static equilibrium:** the object is at rest and stays at rest, like a book lying on a table.
- **Dynamic equilibrium:** the object moves with constant velocity, like a car cruising at a steady speed on a straight road.

Option A states exactly this. Option D swaps the two. Options B and C mention acceleration that is constant or increasing, but any nonzero acceleration means the object is not in equilibrium at all.

Textbook: Physics Grade 10, Unit 3 Elasticity and rigid body in static equilibrium, section 3.5 Static equilibrium.

29. About an axis of rotation perpendicular to a plane of a couple, the forces in a couple produce (1)

A. no torque.

B. non-zero resultant force.

C. torques in opposite direction.

D. ✓ **torques in the same direction.**

Answer: D

A couple is a pair of forces that are equal in size, opposite in direction, and act along different parallel lines. Think of two hands turning a steering wheel: one pushes up on the left side, the other pushes down on the right side.

The *forces* point in opposite directions, so the resultant force is zero. But look at the turning effect of each force about the axis through the center: both forces turn the wheel the **same way** (say, clockwise). Their torques are in the same rotational direction, so they add up to a net torque $\tau = Fd$, where d is the distance between the two lines of action.

So the answer is D. Option C is the trap: it confuses the opposite directions of the forces with the directions of their torques. If the two torques really were opposite, they would cancel and a couple could never rotate anything, yet turning things is exactly what a couple is for. Options A and B fail because a couple gives zero net force but a nonzero net torque.

30. Which one of the following statements describes the difference between heat and temperature? (1)

A. ✓ Heat is a transfer of energy due to temperature difference, whereas temperature is a measure of the average kinetic energy.

B. Heat is measured with a thermometer in Kelvin, whereas temperature is measured with a Calorimeter in Joule.

C. Heat is a measure of the average kinetic energy, whereas temperature is a flow of energy from hotter to colder object.

D. Heat is an energy that flows spontaneously from colder to hotter object, whereas temperature is the degree of hotness and coldness.

> **Answer:** A
>
> Heat and temperature are related but they are not the same thing.
>
> - **Heat** is energy in transfer: it flows from a hotter object to a colder one because of the temperature difference between them. It is measured in joules.
> - **Temperature** is a measure of the average kinetic energy of the particles in an object. It tells how hot or cold the object is.
>
> Option A states both correctly. Option B swaps the instruments and units. Option C swaps the two definitions. Option D is wrong because heat never flows spontaneously from cold to hot; that direction would need outside work, as in a refrigerator.
>
> **Textbook:** Physics Grade 11, Unit 5 Heat Conduction and Calorimetry, section 5.1 The Concept of Heat (page 176).

31. Which one of the following statements does NOT describe the relationship of physics with biology? (1)

A. Physics and biology are interrelated to each other in the study of vision and color detection.

B. Physics and biology used to study how air vibrates in vocal cords.

C. ✓ Both physics and biology are mainly concerned in the interaction of large number of particles.

D. Newtonian mechanics and biology are used to explain why chectah is fastest animal.

> **Answer:** C
>
> The question asks for the statement that does **NOT** describe a real link between physics and biology.
>
> Options A, B and D are genuine links. The physics of light and lenses explains vision and color detection (A). The physics of vibration and sound explains how vocal cords produce speech (B). Newton's laws of motion help explain how a cheetah's body reaches its top speed (D).
>
> Option C claims that both subjects are mainly concerned with interactions of large numbers of particles. That describes only one branch of physics (the statistical study of gases and matter), and it is not the main concern of biology, which studies living things such as cells and organisms. Since the statement is false as a description of the two subjects, C is the answer.
>
> **Textbook:** Physics Grade 12, Unit 1 Application of physics in other fields, section 1.1 Physics and other sciences (page 2).

32. Which one of the following is a correct relation of physics with medicine? (1)

A. Modern medical imaging instrument are developed with knowledge of medicine and later used by physics.

B. Medicine is a branch of physics dealing with nuclear reaction.

C. Physics is a branch of medicine that sets standards during medical diagnosis.

D. ✓ A discipline called medical physics deals with principles of physics in medical diagnosis.

> **Answer:** D
>
> **Medical physics** is a recognized discipline that applies the principles of physics to medical diagnosis and treatment. X-ray imaging, ultrasound, CT scans, MRI and radiotherapy all come from physics applied to medicine. This is option D.
>
> The other options get the relationship backwards. Option A: imaging machines were developed from physics knowledge and are used by medicine, not the other way around. Options B and C wrongly make one subject a branch of the other; physics and medicine are separate fields that cooperate.
>
> **Textbook:** Physics Grade 12, Unit 1 Application of physics in other fields, section 1.3 Medical physics (page 12).

33. A glass tube of radius 30 mm is inserted in a bowl which contains methyl iodide of density 2.28 kg^3 m^3. If the contact angle of the methyl iodide in the tube is 30° and the surface tension is 0.26 N/m, how much height does the methyl iodide rises through the tube? (1)

A. 0.52 m

B. 6.6 m

C. ✓ **0.66 m**

D. 0.066 m

Answer: C

Capillary rise is given by

$$h = \frac{2T\cos\theta}{\rho g r}$$

where T is the surface tension, θ the contact angle, ρ the density, g gravity, and r the tube radius.

Substitute the values as given in the question: $T = 0.26\ \mathrm{N/m}$, $\cos 30^\circ = 0.866$, $\rho = 2.28\ \mathrm{kg/m^3}$, $g = 10\ \mathrm{m/s^2}$, $r = 30\ \mathrm{mm} = 0.03\ \mathrm{m}$.

Numerator: $2 \times 0.26 \times 0.866 = 0.45$. Denominator: $2.28 \times 10 \times 0.03 = 0.684$.

$$h = \frac{0.45}{0.684} \approx 0.66\ \mathrm{m}$$

The answer is C. Remember to convert the radius from millimeters to meters before substituting.

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

34. Three resistors are connected between points a and b as shown in the figure below. The effective resistance of the circuit is (1)

Question Diagram

A. 1.0Ω

B. 11.0Ω

C. ✓ **1.0KΩ**

D. 11.0KΩ

Answer: C

The figure shows the 3 kΩ, 6 kΩ and 2 kΩ resistors all connected between the same two points a and b, so they are in parallel.

For parallel resistors:

$$\frac{1}{R} = \frac{1}{3\ \mathrm{k\Omega}} + \frac{1}{6\ \mathrm{k\Omega}} + \frac{1}{2\ \mathrm{k\Omega}}$$

Use a common denominator of 6:

$$\frac{1}{R} = \frac{2+1+3}{6\ \mathrm{k\Omega}} = \frac{6}{6\ \mathrm{k\Omega}} = \frac{1}{1\ \mathrm{k\Omega}}$$

So $R = 1.0\ \mathrm{k\Omega}$, which is option C. Keep the units with the numbers: the resistors are in kilo-ohms, so the result is in kilo-ohms too, not in plain ohms (option A). As a check, the parallel combination must be smaller than the smallest branch (2 kΩ), and 1 kΩ is.

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

35. In an experiment to determine the direction of the magnetic field around a long straight current-carrying wire, a student placed a small compass at point P, as shown in the diagram. If the direction of the current in the wire is directed out-of the page, then the magnetic needle of the compass will point (1)

Question Diagram

A. to the right.
B. to the left.
C. ✓ **downward.**
D. upward.

Answer: C

The magnetic field around a straight current-carrying wire forms circles centered on the wire. Use the right-hand rule: point the thumb along the current (out of the page) and the fingers curl in the field direction, which is counterclockwise as seen on the page.

Now follow that counterclockwise circle: to the right of the wire the field points upward, above the wire it points to the left, to the left of the wire it points **downward**, and below the wire it points to the right.

In the figure, point P is on the *left* side of the wire. So the field there, and the compass needle that lines up with it, points downward. The answer is C.

Option B (to the left) is the field direction at a point directly *above* the wire, not at P.

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

36. A small ball of mass m tied to a rope of length 1 is moving along a vertical B circle about a point O as shown in the figure. If A, B, C, and D are points on the path, then which one of the following is correct about the force exert on the ball at these points? (1)

Question Diagram

A. At point C , the radial force and the tension on the rope are in opposite direction.
B. ✓ **At point D , the radial force is equal to the tension on the rope.**
C. At point A, the radial force is in opposite direction to the gravitational force on a ball.
D. At point B, the radial force is equal to the gravitational force on the ball.

Answer: B

In the figure, A is at the top of the circle, C at the bottom, and B and D at the two ends of the horizontal diameter. Two forces act on the ball: the tension along the rope (always pointing toward the center O) and gravity (always pointing straight down). The net radial (centripetal) force must point toward O at every moment.

At the side points B and D, the rope is horizontal, so the tension is fully radial, while gravity is vertical and therefore purely tangential there. The radial force is supplied by the tension alone: **radial force = tension**. That is exactly option B (at point D).

The other options fail. At C (bottom), the tension points up toward O and the radial force $(T - mg)$ also points up, the same direction as the tension, so A is wrong. At A (top), the radial direction is downward toward O, the same direction as gravity, so C is wrong. At B the radial force equals the tension, not the gravitational force, so D is wrong.

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

37. The velocity-time graph of an object moving along a straight line toward east is described by the figure shown below. What is the total displacement moved by the object? (1)

Question Diagram

A. 600 m EastR

B. 375 m East

C. ✓ **525 m East**

D. 450 m East

Answer: C

On a velocity-time graph, displacement is the area under the graph.

The graph has two parts:

- From 0 to 15 s the velocity is constant at 30 m/s. This area is a rectangle:

$$d_1 = 30 \times 15 = 450 \text{ m}$$

- From 15 s to 20 s the velocity falls in a straight line from 30 m/s to 0. This area is a triangle:

$$d_2 = \frac{1}{2} \times 5 \times 30 = 75 \text{ m}$$

Total displacement:

$$d = 450 + 75 = 525 \text{ m}$$

The velocity never goes negative, so the object keeps moving east the whole time. The answer is C: 525 m East.

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

38. A 200 N force is required to be applied at one end ofa 1 m long lever, 80 cm from its fulcrum, in order to lift a load of 600 N placed at the other end as shown the figure below. (1)

What is the efficien, of the lever?

Question Diagram

A. 25%

B. ✓ **75%**

C. 17%

D. 83%

Answer: B

The lever is 1 m long. The effort acts 80 cm from the fulcrum, so the load sits on an arm of $100 - 80 = 20$ cm.

Efficiency compares the useful work output with the work input. When the lever turns, each arm moves a distance proportional to its length, so:

$$\text{efficiency} = \frac{\text{load} \times \text{load arm}}{\text{effort} \times \text{effort arm}} = \frac{600 \times 0.20}{200 \times 0.80} = \frac{120}{160} = 0.75$$

That is 75%, option B.

The same result comes from comparing advantages: actual mechanical advantage $= 600/200 = 3$, velocity ratio $= 80/20 = 4$, and efficiency $= \frac{MA}{VR} = \frac{3}{4} = 75\%$.

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

39. A substance with a mass of 2 kg has a volume of 2.5×10^{-3} m^3. What is the relative density of the substance? (1)

A. 80
B. ✓ **0.8**
C. 8.0
D. 1.25

Answer: B

Step 1: find the density of the substance.

$$\rho = \frac{m}{V} = \frac{2 \text{ kg}}{2.5 \times 10^{-3} \text{ m}^3} = 800 \text{ kg/m}^3$$

Step 2: divide by the density of water (1000 kg/m^3).

$$\text{relative density} = \frac{800}{1000} = 0.8$$

Relative density is a pure number with no unit. The answer is B. Since 0.8 is less than 1, this substance would float on water.

Textbook: Physics Grade 10, Unit 3 Elasticity and rigid body in static equilibrium, section 3.2 Density and Specific Gravity.

40. The gauge pressure at a point in a fluid at rest is defined as (1)

A. the actual pressure at a given point relative to absolute vacuum.
B. the sum of absolute pressure and atmospheric pressure.
C. ✓ **the pressure difference between the absolute pressure and the atmospheric pressure.**
D. the atmospheric pressure difference between sea level and the local area at which the fluid exists.

Answer: C

Pressure can be quoted in two ways. Absolute pressure is measured from a perfect vacuum. Gauge pressure is measured from the local atmospheric pressure:

$$P_{gauge} = P_{absolute} - P_{atm}$$

So gauge pressure is the difference between the absolute pressure and the atmospheric pressure, which is option C. A tire gauge, for example, reads zero in open air even though the absolute pressure there is one full atmosphere.

Option A describes absolute pressure, not gauge pressure. Option B adds the two pressures instead of subtracting, and option D talks about a difference in atmospheric pressure between places, which is unrelated.

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

41. How do we use manometer to measure pressure of a given gas? We use in such a way that (1)

A. ✓ **the principle of the hydrostatic equilibrium is considered to measure the pressure of unknown gas.**
B. the pressure at the surface of open end manometer is the same as the gas pressure in closed tube.
C. the gauge pressure equals the atmospheric pressure.
D. the gauge pressure in a fluid in the open end equals the gas pressure in closed tube.

Answer: A

A manometer is a U-shaped tube holding a liquid, with one side connected to the gas and the other side open to the air. It works on the **principle of hydrostatic equilibrium**: in a connected liquid at rest, points at the same height have the same pressure.

Comparing the two liquid levels gives

$$P_{gas} = P_{atm} + \rho g h$$

where h is the height difference between the two arms. Measuring h therefore measures the unknown gas pressure. This is option A.

Option B is wrong because the open end feels atmospheric pressure, not the gas pressure. Options C and D force equalities that hold only in special cases, not as the working principle of the instrument.

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

42. Consider two balls A and B are projected with the same velocity, v_0 at angle θ_1 and θ_2, respectively, $0 < \theta_1 < 45°$ and $45° < \theta_2 < 90°$, Which one of the following statements is correct about the motion of the balls? (1)

A. The range of ball A is smaller than its maximum height.

B. Ball A takes longer time than ball B to reach its maximum height.

C. Both balls have equal speed at their respective maximum height.

D. ✓ The two balls cover equal ranges when θ_1 + θ_(2) = 90°

Answer: D

The range of a projectile is

$$R = \frac{v_0^2 \sin 2\theta}{g}$$

Since $\sin(180° - x) = \sin x$, two launch angles give the same range whenever $2\theta_1$ and $2\theta_2$ add up to $180°$, that is when

$$\theta_1 + \theta_2 = 90°$$

For example, $30°$ and $60°$ give equal ranges. This is option D.

The others fail. Option B: time to the top is $t = v_0 \sin\theta / g$, so the *larger* angle (ball B) takes longer, not ball A. Option C: at maximum height the speed is the horizontal component $v_0 \cos\theta$, which differs for the two angles. Option A: $R = 4h_{max} / \tan\theta$, so the range is smaller than the height only for very steep angles above about $76°$, which is not given.

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

43. A car initially traveling at speed of 20 m/s undergoes a constant deceleration of magnitude 1.5 m/s^2. If the radius of each tire is 0.3 m , how many revolutions does each tire make, without slipping, before the car comes to rest? (1)

A. 444.4 rev

B. 44.44 rev

C. ✓ 70.77 rev

D. 133.33 rev

Answer: C

Step 1: find the stopping distance.

$$v^2 = u^2 - 2as \quad \Rightarrow \quad 0 = (20)^2 - 2(1.5)s$$

$$s = \frac{400}{3} \approx 133.3 \text{ m}$$

Step 2: convert distance to revolutions. Rolling without slipping means each full turn of a tire covers one circumference:

$$2\pi r = 2\pi(0.3) \approx 1.885 \text{ m}$$

$$N = \frac{s}{2\pi r} = \frac{133.3}{1.885} \approx 70.7 \text{ revolutions}$$

The answer is C. Option D (133.33) is the stopping distance in meters, and option A (444.4) is the angle in radians; both stop one step too early.

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

44. A constant tangential force is applied on a rim of uniform solid disk of mass 50 kg and radius r = 0.5m. If the angular speed of the disk changes by lrev s within 2.0s, what is the magnitude of the torque produced by the force? (moment of inertia of disk I = m^2/2) (1)

A. ✓ **19.6Nm**

B. 3.125 Nm

C. 39.3 Nm

D. 8.25 Nm

Answer: A

Step 1: moment of inertia of the solid disk.

$$I = \frac{1}{2}mr^2 = \frac{1}{2}(50)(0.5)^2 = 6.25 \text{ kg m}^2$$

Step 2: angular acceleration. The angular speed changes by 1 rev/s, and 1 revolution is 2π radians:

$$\alpha = \frac{\Delta\omega}{\Delta t} = \frac{2\pi \text{ rad/s}}{2.0 \text{ s}} = \pi \text{ rad/s}^2$$

Step 3: torque.

$$\tau = I\alpha = 6.25 \times \pi \approx 19.6 \text{ Nm}$$

The answer is A. Option B (3.125 Nm) comes from forgetting to convert revolutions to radians.

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

45. A loop of 0.1 m wide in diameter is placed in xy-plane in uniform magnetic field of 0.6 T that is perpendicular to the plane of the loop. What is the net magnetic flux through the coil? (1)

A. 1.9 x 10^(-2) Wb

B. ✓ **4.7 X 10^(-3) Wb**

C. 5.6 x 10^(-2) Wb

D. 9.4 x 10^(-2) Wb

Answer: B

Magnetic flux through a flat loop is

$$\Phi = BA\cos\theta$$

Here the field is perpendicular to the plane of the loop, meaning it is along the loop's normal, so $\cos\theta = 1$ and $\Phi = BA$.

The loop's diameter is 0.1 m, so the radius is 0.05 m:

$$A = \pi r^2 = \pi(0.05)^2 = 7.85 \times 10^{-3} \text{ m}^2$$

$$\Phi = 0.6 \times 7.85 \times 10^{-3} = 4.7 \times 10^{-3} \text{ Wb}$$

The answer is B. The usual slip is squaring the diameter instead of the radius, which gives an answer 4 times too big (option A).

Textbook: Physics Grade 12, Unit 4 Electromagnetism, section 4.4 Electromagnetic Induction (page 126).

46. A 12 V voltage source is connected across the primary coil of a transformer having 600 turns. If the secondary coil of a transformer has 1000 turns, what voltage appears across the secondary coil? (1)

A. 72.0 V

B. 12.0 V

C. 7.2 V

D. ✓ **20.0 V**

Answer: D

Use the transformer equation:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

Solve for the secondary voltage:

$$V_s = V_p \times \frac{N_s}{N_p} = 12 \times \frac{1000}{600} = 20 \text{ V}$$

The answer is D. The secondary has more turns than the primary (1000 against 600), so this is a step-up transformer and the output must be larger than 12 V; that rules out B and C at a glance. Option C (7.2 V) comes from writing the turns ratio upside down.

Textbook: Physics Grade 12, Unit 4 Electromagnetism, section 4.6 Transformers (page 131).

47. The following table shows the density of different objects at 20°C. (1)

Based on the information given in the table, if we identify substances that sink and float with respect to other substance,

Question Diagram

A. ✓ **bone, iron and seawater will sink in water.**

B. water, gasoline and ice will sink into seawater.

C. gasoline, ice and blood floats on the surface of water.

D. gold, blood and copper floats in gasoline.

Answer: A

An object (or a liquid) sinks in a fluid when its density is greater than the density of that fluid, and floats when its density is smaller.

Water has a density of 1000 kg/m^3. From the table: bone is 1800, iron is 7860, and seawater is 1025. All three are denser than water, so all three sink in water. Option A is correct.

Checking the others against the table: option B fails because water (1000), gasoline (680) and ice (916) are all less dense than seawater (1025), so they float on it. Option C fails because blood (1060) is denser than water and sinks. Option D fails because gold (19300) and copper (8920) are far denser than gasoline (680) and sink in it.

Textbook: Physics Grade 12, Unit 3 Fluid Mechanics, section 3.3 Archimedes' principle (page 96).

48. Which one of the following statements differentiates emitter, collector and base of a transistor? (1)

A. The collector region is heavily doped as compared with emitter and base.

B. ✓ **The emitter region is heavily doped as comparsd with base and collector.**

C. The three parts; emitter, base and coliector are equally doped.

D. The base regrion is heavily doped as compared with base and collector.

Answer: B

A transistor has three regions, and they are deliberately doped differently:

- **Emitter:** heavily doped, so it can inject a large number of charge carriers into the base.
- **Base:** very thin and lightly doped, so almost all carriers pass through it to the collector instead of recombining.
- **Collector:** moderately doped and physically the largest region, so it can collect the carriers and get rid of heat.

So the emitter is the heavily doped region, which is option B. Options A and D name the wrong region, and option C is wrong because equal doping would defeat the whole design; the three regions must differ for the transistor to amplify.

Textbook: Physics Grade 12, Unit 5 Basics of electronics, section 5.4 Transistors and their application (page 154).

— END OF MARKING KEY —