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Physics, 2015 EC, natural science, entrance exam

Grade 12 · Physics · 2015 E.C.

MARKING KEY — CONFIDENTIAL

Time allowed: 120 minutes | **Questions:** 30 | **Total marks:** 30

1. An object is placed 25.0 cm in front of a concave mirror having focal length of 10.0cm. The magnification of the mirror is (1)

A. 2.5
B. 16.7
C. ✓ **0.67**
D. 1.5

Answer: C

Start with the mirror equation: $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$, where $f = 10.0$ cm and the object distance $d_o = 25.0$ cm.

$\frac{1}{d_i} = \frac{1}{10} - \frac{1}{25} = \frac{5-2}{50} = \frac{3}{50}$, so $d_i = \frac{50}{3} \approx 16.7$ cm.

The magnification is $m = -\frac{d_i}{d_o} = -\frac{50/3}{25} = -\frac{2}{3} \approx -0.67$. Its size is 0.67, so the image is smaller than the object, and the minus sign tells us the image is inverted.

Option B (16.7) is a trap: that is the image distance in cm, not the magnification.

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

2. Which of the following statements distinguishes between random and systematic errors? (1)

A. Systematic error can be minimized by taking several readings and averaging; whereas random error cannot be minimized.

B. ✓ **Systematic error makes measured values to be always above or always the true value; whereas random error causes measured vales to be sometimes above and sometimes below the true value.**

C. Random error makes measured values to be always above or always below the true value; whereas systematic error causes measured values to be sometimes above and sometimes below the true value.

D. Random error is biased, whereas systematic error does not show bias.

Answer: B

A systematic error is a bias built into the experiment, for example a scale that always reads a little high or a stopwatch that runs slow. It pushes every reading in the same direction, so the results sit always above or always below the true value. Taking more readings and averaging does not remove it.

A random error comes from small unpredictable changes between readings. It scatters the results on both sides of the true value, so repeating the measurement and averaging does reduce it.

Option B states exactly this, so it is correct. Option A is backwards: averaging helps against random error, not systematic error. Option C swaps the two definitions, and option D swaps which one is biased.

3. The unit vector the direction A = 3i + 4j is (1)

A. ✓ **(3/5)i + (4/5)j**
B. 2i - j
C. (3/2)i - (4/2)j
D. i + j

Answer: A

A unit vector has length 1 and points in the same direction as the given vector. To find it, divide the vector by its own magnitude: $\hat{u} = \frac{\vec{A}}{|\vec{A}|}$.

The magnitude of $\vec{A} = 3\hat{i} + 4\hat{j}$ is $|\vec{A}| = \sqrt{3^2 + 4^2} = \sqrt{9 + 16} = \sqrt{25} = 5$.

So $\hat{u} = \frac{3}{5}\hat{i} + \frac{4}{5}\hat{j}$. Check: $\sqrt{(3/5)^2 + (4/5)^2} = \sqrt{9/25 + 16/25} = 1$, so its length really is 1.

Textbook: Physics Grade 11, Unit 2 Vectors, section 2.1 Vectors and Types of Vectors.

4. Which of the following pair of vectors are collinear? (1)

A. 2i - 3j and -4i - j

B. i + j and -i + j

C. 2i + 3j and -4i + 6j

D. ✓ **2i + 3j and -4i - 6j**

Answer: D

Two vectors are collinear when they lie along the same line. That happens when one is a number times the other, in the same or the exactly opposite direction.

Look at option D: $-4\hat{\imath} - 6\hat{\jmath} = -2\,(2\hat{\imath} + 3\hat{\jmath})$. The second vector is -2 times the first, so the pair is collinear (they point in opposite directions along one line).

You can also test with the cross product, which is zero for collinear vectors: $(2)(-6) - (3)(-4) = -12 + 12 = 0$.

For the other pairs no single multiplier works. In option C, for example, the $\hat{\imath}$ parts need a factor of -2 but the $\hat{\jmath}$ parts need $+2$, so those vectors are not collinear.

Textbook: Physics Grade 11, Unit 2 Vectors, section 2.4 Product of Vectors.

5. For an object moving in straight line, (1)

A. If the displacement changes by equal amount in equal time interval,the displacement-time graph is horizontal line.

B. The area of the region under the displacement-time graph and the slope of velocity-time graph are, respectively, the acceleration and displacement of the object.

C. ✓ **If the velocity increases by equal amount in equal time interval, the velocity -time graph is straight line with positive slope and the acceleration-time graph is horizontal.**

D. The slope of displacement-time graph and the area of the region under acceleration-time graph are, respectively, the acceleration and velocity of the object

Answer: C

Remember what each graph tells you for straight line motion:

- The slope of a displacement-time graph is the velocity.
- The slope of a velocity-time graph is the acceleration.
- The area under a velocity-time graph is the displacement.
- The area under an acceleration-time graph is the change in velocity.

If the velocity grows by equal amounts in equal time intervals, the acceleration is constant. Then the velocity-time graph is a straight line with positive slope, and the acceleration-time graph is a horizontal line. That is option C.

Option A is wrong because equal displacement in equal time means constant velocity, which gives a sloped straight line, not a horizontal one. Options B and D mix up which quantity comes from a slope and which comes from an area.

Textbook: Physics Grade 11, Unit 3 Motion in one and two dimensions, section 3.3 Graphical Representation of Uniformly Accelerated Motion.

6. Which of the following is true about satellite motion? (1)

A. A satellite moving closer to the Earth takes longer time to complete one revolution than a satellite farther from the Earth.

B. For two satellites moving around the Earth at equal orbital radius, a heavier satellite has larger speed than a lighter one.

C. For equal orbital radius, a satellite moving around the Earth has smaller speed than a satellite moving about moon.

D. ✓ **A satellite closer to Earth is faster than a satellite farther from the As Earth.**

Answer: D

For a satellite in a circular orbit, gravity supplies the centripetal force: $\frac{GMm}{r^2} = \frac{mv^2}{r}$. Solving gives the orbital speed $v = \sqrt{\frac{GM}{r}}$, where M is the mass of the body being orbited and r is the orbital radius.

The formula shows that a smaller r gives a larger v. So a satellite closer to the Earth moves faster than one farther away, which is option D.

The other options fail on the same formula. A: a closer satellite has a shorter path and a higher speed, so its period is shorter, not longer. B: the satellite mass m cancelled out, so a heavy and a light satellite at the same radius move at the same speed. C: at equal radius the speed depends on the central mass M, and the Earth is far heavier than the Moon, so the satellite around the Earth is the faster one.

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

7. According to the work- energy theorem, (1)

A. work done by tension on an object tied to a string and moving a horizontal circle is negative.

B. work done by gravity on an object downward is negative.

C. ✓ **work done by gravity on an object thrown upward and moving upward is negative.**

D. work done by gravitational force on a satellite moving around the earth in a circular is positive

Answer: C

Work is $W = Fd\cos\theta$, where θ is the angle between the force and the displacement. The sign of the work comes from that angle.

For a ball thrown upward and still moving upward, gravity points down while the displacement points up, so $\theta = 180^\circ$ and $W = Fd\cos 180^\circ = -Fd$. The work done by gravity is negative, which is option C. This is why the ball loses kinetic energy on the way up.

The others are false. B: for an object moving downward, gravity and displacement point the same way, so the work is positive, not negative. A and D: in circular motion the tension (or gravity, for a circular orbit) points toward the center, at 90° to the motion, so it does zero work, neither negative nor positive.

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

8. A young double slit experiment consists of two narrow slits separated by 0.06 mm and 1.2m away from a screen. If the slits arel illuminated with a light of wavelength 563nm, the location of the fourth bright fringe on the screen is (1)

A. 0.0394cm

B. 0.45cm

C. 3.94cm

D. ✓ **4.5cm**

Answer: D

In Young's double slit experiment, the bright fringes sit at $y_m = \frac{m\lambda L}{d}$, where m is the fringe order, λ the wavelength, L the slit to screen distance, and d the slit separation.

Here $m = 4$, $\lambda = 563 \times 10^{-9}$ m, $L = 1.2$ m, and $d = 0.06$ mm $= 6 \times 10^{-5}$ m.

$$y_4 = \frac{4 \times 563 \times 10^{-9} \times 1.2}{6 \times 10^{-5}} = \frac{2702.4 \times 10^{-9}}{6 \times 10^{-5}} \approx 4.5 \times 10^{-2}\ \mathrm{m} = 4.5\ \mathrm{cm}$$

So the fourth bright fringe is about 4.5 cm from the central bright fringe, option D. Option B (0.45 cm) comes from slipping one power of ten in the unit conversion.

9. The electric potential at a distance of 2 cm from -1.6 x 10^{-9}C point charge is (1)

A. -14.4 v

B. 720 v

C. 4.4 v

D. ✓ **-720 v**

Answer: D

The electric potential of a point charge is $V = \frac{kQ}{r}$, with $k = 9 \times 10^9\ \mathrm{N\ m^2/C^2}$. Potential is a scalar, so it keeps the sign of the charge.

Here $Q = -1.6 \times 10^{-9}$ C and $r = 2$ cm $= 0.02$ m.

$$V = \frac{(9 \times 10^9)(-1.6 \times 10^{-9})}{0.02} = \frac{-14.4}{0.02} = -720\ \mathrm{V}$$

So the potential is -720 V, option D. Option A (-14.4 V) is the value of kQ before dividing by the distance, and option B has the wrong sign for a negative charge.

Textbook: Physics Grade 11, Unit 6 Electrostatics and Electric Circuit, section 6.3 Electric Potential.

10. Consider a long and tightly wound solenoid carrying current l, havinglength L and N turns of winding. If n is the number of turns per unit length, which of the following describes the magnetic field produced by the solenoid? (1)

A. The magnetic field inside the solenoid is zero, whereas the field outside is perpendicular to the length of the solenoid.

B. ✓ **The magnetic field inside the solenoid is constant and is parallel to the solenoid's axis, whereas the field outside is negligible.**

C. The magnetic field inside the solenoid is uniform and perpendicular to the axis of the solenoid.

D. The magnetic field outside the solenoid is as strong as the field inside it.

Answer: B

A long, tightly wound solenoid behaves like a bar magnet made of current loops. Inside it, the fields of all the turns add up to give a strong, nearly uniform field that runs parallel to the axis of the solenoid: $B = \mu_0 n I$, where $n = N/L$ is the number of turns per unit length.

Outside a long solenoid the fields of the turns nearly cancel, so the field there is negligible. Option B states both facts correctly.

Option A puts the zero field in the wrong place, option C gives the inside field the wrong direction (it is along the axis, not perpendicular to it), and option D wrongly makes the outside field as strong as the inside one.

Textbook: Physics Grade 12, Unit 4 Electromagnetism, section 4.3 Current and Magnetism.

11. According to the law of electromagnetic induction, (1)

A. ✓ the magnitude of emf induced in a circuit is directly proportional to the rate of change the magnetic flux crossing any surface bounded by the circuit.

B. a changing magnetic field parallel to the plane of a circuit induces an emf in it.

C. a constant magnetic flux crossing the surface of a circuit induced an emf in the circuit.

D. an emf is induced in a circuit when a constant magnetic field crosses its surface.

> **Answer:** A
>
> Faraday's law of electromagnetic induction says an emf is induced in a circuit only when the magnetic flux through it changes, and the size of the emf is proportional to how fast the flux changes: $\varepsilon = -\frac{\Delta\Phi}{\Delta t}$.
>
> Option A says exactly this, so it is correct.
>
> The others all miss the key word: change. C and D describe a constant flux or a constant field, which induces nothing. B fails for a different reason: a field parallel to the plane of the circuit passes no flux through the circuit at all, so even when that field changes, the flux stays zero and no emf appears.
>
> **Textbook:** Physics Grade 12, Unit 4 Electromagnetism, section 4.5 Faraday's Law of electromagnetic Induction.

12. According to the Heisenberg's uncertainty principle, (1)

A. the larger the position uncertainty, the larger the momentum uncertainty.

B. if the uncertainty in position decreases, the momentum uncertainty decreases, too.

C. ✓ the more precisely we measure the position of a particle; we become less precise of its momentum and vice versa.

D. we can measure both the position and momentum of a particle simultaneously with unlimited precision.

> **Answer:** C
>
> Heisenberg's uncertainty principle says the uncertainties in position and momentum are linked: $\Delta x \, \Delta p \geq \frac{h}{4\pi}$. Their product can never fall below a fixed limit.
>
> So the two uncertainties trade against each other. If you pin down the position very precisely (small Δx), the momentum uncertainty Δp must grow, and the other way round. That is option C.
>
> Option D is the exact opposite of the principle. Options A and B claim the two uncertainties rise and fall together, but the principle only sets a floor on their product: making one small forces the other large.

13. The graph of nuclear binding energy per nucleon (BE/A) versus mass number (A) has its peak near an atomic weight A = 56. Which of the following statements is true about the graph? (1)

A. Uranium (A = 235), which has larger binding energy than iron (A = 56), is more stable than iron.

B. Nucleus with larger number of neutron is more stable than nucleus of the same atom with smaller number of neutron.

C. ✓ For heavier nuclei (A > 56), the binding energy per nucleon decreases with the increase of mass number; implying that heavier atoms can increase their stability by increasing their proton's number.

D. For smaller atoms (A < 56), the biding energy per nucleon generally increases with the increase of mass number; indicating that lighter atoms can increase stability through nuclear fission.

> **Answer:** C
>
> The binding energy per nucleon (BE/A) measures how tightly each proton and neutron is held in the nucleus. The curve rises for light nuclei, peaks near iron (A = 56), and slowly falls for heavier nuclei. A nucleus is more stable when its BE/A is higher.
>
> Two facts follow. For heavy nuclei (A above 56), BE/A falls as A grows, so a heavy nucleus can release energy and become more stable by splitting into smaller pieces (fission). For light nuclei (A below 56), BE/A rises with A, so light nuclei release energy by joining together (fusion).
>
> Option A is wrong because stability is judged by binding energy per nucleon, and iron sits at the peak, so uranium is less stable than iron. Option B is not a general rule. Option D correctly describes the rising part of the curve but then names fission, where fusion is the process that makes light nuclei more stable.
>
> Option C is the recorded answer and correctly describes the falling part of the curve for heavy nuclei. Note, though, that its final phrase is faulty as printed: adding protons makes a heavy nucleus heavier and less stable; heavy nuclei actually gain stability by fission.
>
> **Textbook:** Physics Grade 11, Unit 7 Nuclear Physics, section 7.1 The nucleus.

14. Which of the following statements is NOT correct about reflection and refraction of sound waves and their applications? (1)

A. In pre-natal scanning, reflection and refraction of sound allows doctors to monitor the progress of a developing baby.

B. ✓ Reflection of sound (echo) is formed when sound enters a medium of varying densities.

C. Reflection and refraction of sound are used to detect flaws in metals and to help people park their cars.

D. Refraction of sound is the change in its direction as it travels through a medium having different densities.

> **Answer:** B
>
> The question asks for the statement that is NOT correct.
>
> An echo is the reflection of sound: the sound wave hits a large hard surface, such as a cliff or a wall, and bounces back through the same medium. It does not need to enter a new medium at all. Option B describes an echo as sound entering a medium of varying densities, which is actually the condition for refraction, so B is the incorrect statement.
>
> The other options are all true. D gives the correct meaning of refraction: the direction of sound changes as it passes through regions of different density. A and C list real applications: ultrasound scanning of a developing baby, flaw detection in metals, and parking sensors all work by sending out sound and reading what comes back.
>
> **Textbook:** Physics Grade 9, Unit 6 Mechanical Oscillation and Sound Wave.

15. A torque t rotates an object of mass m and moment of inertia I through an angle 9. The work done on the object by the torque is (1)

A. Iθ

B. mθ

C. ✓ **τθ**

D. τI

Answer: C

Rotational motion has the same shape of formulas as straight line motion. In straight line motion, work is force times displacement: $W = Fd$. In rotation, the torque τ plays the role of force and the angle θ (in radians) plays the role of displacement.

So the work done by a torque turning an object through an angle θ is $W = \tau\theta$, which is option C.

The mass m and the moment of inertia I do not enter this formula directly. They matter for how fast the object ends up spinning, not for the work done by the torque.

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

16. One of the following statements is a correct description of the charging processes? (1)

A. During charging a neutral object by induction using a negatively charged rod, charge flows from the rod to the object

B. When a neutral metallic sphere is charged by induction using a negatively charged rod, the sphere acquires a net negative charge.

C. ✓ **When a positively charged object is momentarily brought into contact with a neutral metallic sphere, the sphere acquires a net positive charge.**

D. When a plastic rod is rubbed with wool, the two objects acquire a net charge of the same region.

Answer: C

Charging by contact (conduction) transfers charge of the same sign. When a positively charged object touches a neutral metal sphere, electrons flow from the sphere into the object. The sphere is left short of electrons, so it ends up with a net positive charge. That is option C.

Option A is wrong because charging by induction works without any charge passing from the rod: the rod only pushes the sphere's own electrons around. Option B is wrong for the same reason: with a negative rod nearby, grounding lets electrons escape from the sphere, so the sphere ends up positive, not negative. Option D is wrong because rubbing separates charge, leaving the plastic rod and the wool with opposite signs, not the same sign.

Textbook: Physics Grade 10, Unit 4 Static and Current Electricity, section 4.2 Methods of Charging a Body.

17. A parallel plate capacitor is charged with a battery. The battery is then disconnected, and a dielectric material is inserted between the plates of the capacitor. Which of the following is correct about the effect of the dielectric? (1)

A. The potential difference between the plates remains the energy stored increases.

B. The charge on the plates decreases and the energy stored increases

C. ✓ **The electric field between the plates and the energy stored decrease.**

D. he capacitance remains the same and the electric field between the plates increases.

Answer: C

The battery is disconnected, so the charge Q on the plates is trapped: it cannot change. Everything else follows from that.

Inserting a dielectric of constant $\kappa > 1$ raises the capacitance to $C' = \kappa C$. Then:

- Voltage: $V' = \frac{Q}{\kappa C} = \frac{V}{\kappa}$, so it decreases.
- Electric field: $E' = \frac{V'}{d} = \frac{E}{\kappa}$, so it decreases (the dielectric's induced charges partly cancel the field).
- Stored energy: $U' = \frac{Q^2}{2\kappa C} = \frac{U}{\kappa}$, so it decreases (the capacitor pulls the dielectric in, doing work on it).

Both the field and the energy decrease, which is option C. The other options either keep a quantity fixed that must change, or change one in the wrong direction.

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

18. Which one of the following statements is correct about the resistance of a conductor with a circular cross-section? (1)

A. At a given temperature, the resistance of copper and silver wires of the same length and diameter is the same.

B. ✓ The resistance of the conductor increases as its length increases and its diameter decreases.

C. The resistance of the conductor increases as its length and diameter increases.

D. The resistance of the conductor decreases as it is heated.

Answer: B

The resistance of a wire is $R = \frac{\rho L}{A}$, where ρ is the resistivity of the material, L the length, and A the cross-sectional area. For a circular wire $A = \frac{\pi d^2}{4}$, so a smaller diameter means a smaller area.

From the formula, resistance grows when the wire gets longer (larger L) and when it gets thinner (smaller d, so smaller A). That is option B.

Option A fails because copper and silver have different resistivities, so equal size does not give equal resistance. Option C has the diameter effect backwards. Option D is also backwards: the resistance of a metal conductor rises as it is heated, because the vibrating lattice scatters the electrons more.

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

19. The primary coil of a transformer has 250 turns and its secondary coil consists of 1500 turns. If 220V is applied to its primary coil, the voltage induced in the secondary coil, respectively, are (1)

A. ✓ 1320V and 6

B. 1330V and 6

C. 1220V and 60

D. 1320V and 60

Answer: A

For an ideal transformer, the voltages are in the same ratio as the numbers of turns: $\frac{V_s}{V_p} = \frac{N_s}{N_p}$.

The turns ratio is $\frac{N_s}{N_p} = \frac{1500}{250} = 6$. Since the secondary has more turns, this is a step-up transformer.

The secondary voltage is $V_s = V_p \times \frac{N_s}{N_p} = 220 \times 6 = 1320$ V.

So the two values are 1320 V and 6, which is option A. Option D pairs the right voltage with a wrong ratio of 60.

Textbook: Physics Grade 12, Unit 4 Electromagnetism, section 4.6 Transformers.

20. A diode is an electronic component that (1)

A. is useful to covert a DC voltage to AC voltage.

B. ✓ allows electric current to pass through it in one direction.

C. allows the flow of current when its p-type region is connected to the negative terminal of a cell.

D. allows current to mass through it either from cathode to anode or from anode to cathode.

Answer: B

A diode is a p-n junction that conducts electric current in one direction only. It conducts when it is forward biased, that is, when its p-type side is connected to the positive terminal of the supply. When the connection is reversed, almost no current flows.

Option B states this one-way behavior, so it is correct.

Option C describes reverse bias (p-type to the negative terminal), which blocks the current. Option D says current can pass both ways, which is the opposite of what a diode does. Option A is also backwards: because a diode passes only one direction of current, it is used to convert AC to DC (rectification), not DC to AC.

Textbook: Physics Grade 12, Unit 5 Basics of electronics, section 5.2 Diodes and their Functions.

21. A student throws a ball vertically upward with a speed of 20m/s. The maximum height reached by the ball and its velocity 30s after it was thrown are, respectively (1)

A. 20m and 30m/s upward.

B. 15m and 10m/s downward.

C. 105m and 50m/s upward.

D. ✓ **20m and 10m/s downward.**

> **Answer:** D
>
> Take $g = 10\ \mathrm{m/s^2}$ and up as positive, with launch speed $u = 20$ m/s.
>
> **Maximum height:** at the top the velocity is zero, so from $v^2 = u^2 - 2gh$ with $v = 0$: $h = \frac{u^2}{2g} = \frac{20^2}{2\times 10} = \frac{400}{20} = 20\ \mathrm{m}$.
>
> **Velocity at t = 3 s** (the options show the printed 30 s is a misprint for 3 s): $v = u - gt = 20 - 10 \times 3 = -10\ \mathrm{m/s}$. The minus sign means the ball is already past the top and moving downward at 10 m/s.
>
> So the answers are 20 m and 10 m/s downward, option D.
>
> **Textbook:** Physics Grade 11, Unit 3 Motion in one and two dimensions, section 3.4 Vertical Motion.

22. Which one of the following statements describes the difference between different types of friction? (1)

A. ✓ **For an object at rest on a horizontal surface, static friction increases with the increase of the applied force and reaches a maximum value just before sliding occurs.**

B. Limiting friction is the minimum value of static friction that keeps an object stationary.

C. If there is a constant force applied to a stationary object on a horizontal surface, the static friction becomes equal to the limiting friction.

D. Limiting and kinetic frictions exist at the same time between two surfaces sliding over each other.

> **Answer:** A
>
> Static friction is a self-adjusting force. While the object stays at rest, the friction exactly matches the applied force. As you push harder, the static friction grows with you, up to a maximum value called the limiting friction ($f_{max} = \mu_s N$). The moment the applied force passes that limit, the object starts to slide and kinetic friction takes over. Option A describes this correctly.
>
> Option B is wrong because limiting friction is the maximum of static friction, not the minimum. Option C is wrong because static friction equals the limiting value only at the point of slipping, not for any constant applied force. Option D is wrong because limiting (static) friction acts just before sliding, while kinetic friction acts during sliding; they do not act at the same time.
>
> **Textbook:** Physics Grade 11, Unit 4 Dynamics, section 4.2 Frictional Force.

23. The apparent weight of a 60kg student standing inside a lift is (1)

A. 600N when the lift accelerates with acceleration equal to gravitational acceleration.

B. 600N when the lift accelerates upward with 2m/s^2

C. ✓ **480N when the lift accelerates downward with 2m/s^2**

D. 720N when the lift is at rest.

> **Answer:** C
>
> The apparent weight in a lift is the normal force N from the floor. Applying Newton's second law with $g = 10\ \mathrm{m/s^2}$ and $m = 60$ kg:
>
> - Lift at rest or moving at constant velocity: $N = mg = 60 \times 10 = 600\ \mathrm{N}$.
> - Accelerating upward with a: $N = m(g + a) = 60 \times 12 = 720\ \mathrm{N}$.
> - Accelerating downward with a: $N = m(g - a) = 60 \times (10 - 2) = 480\ \mathrm{N}$.
>
> Option C matches: accelerating downward at $2\ \mathrm{m/s^2}$ gives 480 N. Option B should be 720 N, option D should be 600 N, and in option A (accelerating downward with $a = g$, free fall) the apparent weight would be zero.
>
> **Textbook:** Physics Grade 11, Unit 4 Dynamics, section 4.1 The Concept of Force and Newton's Laws.

24. Which of the following statements describe the use of energy resources? (1)

A. ✓ Solar energy produced by photovoltaic cells in free of greenhouse gases and has a very low running cost

B. Hydroelectric power generates a large a large amount of energy using small dam with little environmental impact and cheap initial cost of consstruction.

C. Geothermal energy is the most accessible, environmental friendly and inexpensive source of energy.

D. Wind energy, which is due to the pressure difference in space as the result of uneven sun heat, is a consistent and economical source of energy.

> **Answer:** A
>
> Photovoltaic (solar) cells turn sunlight directly into electricity. While they operate they release no greenhouse gases, and since sunlight is free, the running cost is very low once the panels are installed. Option A is correct.
>
> The other options each contain a false claim. B: hydroelectric power on a large scale needs a large dam, which is expensive to build and changes the river environment and the land behind it. C: geothermal energy is clean, but it is not the most accessible source; it can only be tapped at particular sites where hot rock is near the surface. D: wind does come from uneven solar heating of the Earth, but it is not consistent; the wind changes with weather and season.

25. According to the law of floatation, an object must displaces a volume of fluid (1)

A. equal to the weight of undisplaced fluid.

B. equal to its apparent weight.

C. less than its own weight.

D. ✓ equals to its own weight.

> **Answer:** D
>
> By Archimedes' principle, the buoyant force on an object equals the weight of the fluid it displaces.
>
> For a floating object, the buoyant force must balance the object's weight. Putting the two together gives the law of flotation: a floating object displaces an amount of fluid whose weight equals the object's own weight. That is option D.
>
> Option C describes a sinking object, not a floating one: if the displaced fluid weighed less than the object, the buoyant force could not hold it up. Option B confuses apparent weight (which is zero for a floating object) with the weight of displaced fluid.
>
> **Textbook:** Physics Grade 12, Unit 3 Fluid Mechanics, section 3.3 Archimedes' principle.

26. Which one of the following statements describes the unusual behavior of expansion of water? (1)

A. ✓ The density of water at 0°C is less than its density at 4°C, since water molecules move further apart and form a second hydrogen bond with other water molecules.

B. As a temperature of water increases above 4°C, its density increases since water molecules move further apart to form a second hydrogen bond with other molecules.

C. At 0°C, water has larger density and smaller volume than its density and volume at 4°C.

D. As a temperature of water increases from 0°C to 4°C, its density increases since one molecule of water forms one hydrogen bond with another molecule.

> **Answer:** A
>
> Most liquids shrink steadily as they cool, but water behaves unusually below 4 degrees Celsius. Water is densest at 4 degrees Celsius. As it cools from 4 to 0 degrees Celsius it expands instead of shrinking, because the molecules move slightly apart to build the open, ordered structure held by extra hydrogen bonds (the structure that becomes ice).
>
> So the density of water at 0 degrees Celsius is lower than its density at 4 degrees Celsius, which is what option A says. This is why ice floats and why ponds freeze from the top down while fish survive below.
>
> Option C is the exact opposite: at 0 degrees Celsius water has the larger volume and the smaller density. Option B is wrong because above 4 degrees Celsius water expands normally, so its density decreases, not increases.

27. An FM radio signal is transmitted from a radio station at a frequency of 1.5×10^8 Hz. If the wavelength of the radio wave is 2.00m, the speed of the FM signal is (1)

A. 6.00 x 10^8 m/s
B. 1.33 x 10^(-8) m/s
C. ✓ **3 x 10^(8) m/s**
D. 0.75 x 10^(8) m/s

> **Answer:** C
>
> For any wave, speed equals frequency times wavelength: $v = f\lambda$.
>
> $$v = (1.5 \times 10^8 \text{ Hz}) \times (2.00 \text{ m}) = 3.0 \times 10^8 \text{ m/s}$$
>
> The answer is option C. The result also makes sense physically: a radio signal is an electromagnetic wave, and all electromagnetic waves travel through air at about 3×10^8 m/s, the speed of light.
>
> Option B comes from dividing instead of multiplying, and option D from dividing the frequency by the wavelength squared or a similar slip.
>
> **Textbook:** Physics Grade 10, Unit 6 Electromagnetic wave and geometrical optics, section 6.1 Electromagnetic Waves.

28. Which one of the following statements is correct about transformation of mechanical energy into other forms and the law of conservation of total energy? (1)

A. ✓ **Due to dissipative force, the mechanical energy of a wooden block sliding on a rough horizontal surface is not conserved.**
B. Mechanical energy of a wooden block sliding on a rough horizontal surface is conserved.
C. Neglecting air resistance, an object moving vertically downward gains potential energy and loses an equal amount of kinetic energy.
D. Neglecting air resistance, an object moving vertically upward gains kinetic energy and loses an equal amount of gravitational potential energy

> **Answer:** A
>
> Mechanical energy (kinetic plus potential) is conserved only when no dissipative force, such as friction or air resistance, acts on the object.
>
> A block sliding on a rough surface feels friction. Friction converts some of the block's kinetic energy into heat, so the mechanical energy decreases. The total energy is still conserved, because the lost mechanical energy shows up as heat, but the mechanical energy alone is not. Option A says this correctly, and option B contradicts it.
>
> Options C and D swap the energy changes. Falling: the object loses potential energy and gains kinetic energy. Rising: it loses kinetic energy and gains potential energy. Both options state the reverse.
>
> **Textbook:** Physics Grade 11, Unit 4 Dynamics, section 4.5 Conservation of mechanical energy.

29. A wheel rotating at angular speed of 20 rev/s is brought to rest after 40 rev under a constant angular acceleration. The angular acceleration of a point on the wheel is (1)

A. 5 rev/s^2
B. ✓ **-5 rev/s^2**
C. -0.5 rev/s^2
D. 0.25 rev/s^2

> **Answer:** B
>
> Use the rotational equation $\omega^2 = \omega_0^2 + 2\alpha\theta$. The wheel comes to rest, so $\omega = 0$, with $\omega_0 = 20$ rev/s and $\theta = 40$ rev. Working in revolutions keeps the units consistent with the options.
>
> $$0 = (20)^2 + 2\alpha(40)$$
>
> $$\alpha = -\frac{400}{80} = -5 \text{ rev/s}^2$$
>
> The answer is option B. The minus sign matters: the wheel is slowing down, so the angular acceleration acts against the rotation. Option A has the right size but the wrong sign, which would mean the wheel is speeding up.
>
> **Textbook:** Physics Grade 12, Unit 2 Two-dimensional motion, section 2.2 Rotational Motion.

30. Tensile stress is the (1)

A. parallel component of the applied force divided by the cross sectional area of an object.

B. ratio of change in length of an object to the original length

C. ✓ **perpendicular component of the applied force divided the cross sectional area of an object.**

D. ratio of original to the change in length of the object.

Answer: C

Stress is force divided by area. Which force component you use decides the kind of stress.

Tensile stress uses the force component perpendicular (normal) to the cross-sectional area, the pull along the length of the object that stretches it: $\sigma = \frac{F_\perp}{A}$. That is option C.

Option A, the parallel component over the area, defines shear stress, which slides layers of the material past each other. Option B, change in length over original length, is the definition of strain, not stress. Option D is the inverse of strain and has no standard meaning.

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

— END OF MARKING KEY —