QCAA PHYSICS EXTERNAL EXAM – 2025

MULTIPLE CHOICE QUESTIONS - SOLUTIONS AND EXPLANATIONS

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Q		**%**	**Solutions**
1	A		Incorrect. "Opposes" is correct but the force is not always vertical to the surface but is defined as perpendicular to the surface. As well, it is not just the weight (F_g = mg) of the object on the surface because there could be applied forces acting on the object in addition to its weight.
	B*		Correct. This is the definition of a normal force. It is perpendicular to the surface irrespective of whether the surface is horizontal or angled.
	C		Incorrect. Not parallel, but 'perpendicular'.
	D		Incorrect. The force that resists motion along a surface is friction. The normal force may be proportional to friction but is not 'friction' in itself.
2	A		Incorrect. This formula describes the gravitational force acting on an object of mass *m* in a gravitational field of strength *g*.
	B		Incorrect. The right-hand side is to do with orbital motion but is not equal to force. It is equal to Kepler's constant (see the Formula and data book).
	C*		Correct.
	D		Incorrect. This is the formula for centripetal force.
3	A*		Correct. Using Fleming's LH rule: index finger (*B*) into the page, middle finger (*I*) is the positive charge (akin to an electric current) which is across page to right; leaving the thumb (*F*) up the page. Using RH Palm Rule: Fingers (*B*) into page, thumb (*I*) to right, gives palm (*F*) up the page.
	B		Incorrect
	C		Incorrect. Probably used wrong hand or reversed the direction of either the magnetic field to be out of the page or the direction of the charge to be to the left.
	D		Incorrect
4	A		Incorrect. EM waves do not need a medium for propagation
	B		Incorrect. They move at this speed in a vacuum only. In another medium their speed will be reduced. For example, in glass they would move at 2×10^8 m s^{-1} or about two-thirds the speed in a vacuum.
	C		Incorrect. EM waves travel at right angles to the direction of oscillation of the charge, and at right angles to the direction of oscillation of the magnetic and electric fields produced by the oscillating charge.
	D*		Correct. This is a characteristic of EM waves.

5	A		Incorrect. A likely approach used by students to get an answer of "4" is to assume the velocity remains constant (which it doesn't). They then use the following incorrect logic: $$v = \frac{2\pi r_1}{T_1} = \frac{2\pi r_2}{T_2}$$ $$\frac{r_1}{T_1} = \frac{r_2}{T_2}$$ $$\frac{r_1}{T_1} = \frac{4r_1}{T_2}$$ $$\frac{r_1}{T_1} = \frac{4r_1}{T_2}$$ $$T_2 = 4T_1$$ Another mistake could be that in using Kepler's third law, the radius has only been squared instead of cubed. This also given an answer of "4".
	B*		Correct. Using Kepler's third law. Let the original satellite orbital period and radius be "a" and the final be "b": $$\frac{T_a^2}{r_a^3} = \frac{T_b^2}{r_b^3}$$ $$\frac{T_a^2}{r_a^3} = \frac{T_b^2}{(4r_a)^3}\ [because\ r_b = 4r_a]$$ $$\frac{T_a^2}{r_a^3} = \frac{T_b^2}{64(r_a)^3}$$ $$T_a^2 = \frac{T_b^2}{64}$$ $$T_b^2 = 64T_a^2$$ $$T_b = 8T_a$$
	C		Incorrect. Needs to consider Kepler's third law.
	D		Incorrect. Has calculated T_b^2 in second last line but hasn't taken square root.
6	A		Incorrect. Will be accelerating, unless at terminal velocity. A ball will initially accelerate when dropped (from rest) regardless of whether it reaches terminal velocity or not.
	B		Incorrect. The boat is slowing down so is undergoing a change of velocity.
	C*		Correct. An inertial frame of reference is one in which Newton's laws of inertia apply. This will happen when an object is travelling at constant velocity, that is, not accelerating. The plane in this case is stated to be at constant velocity.
	D		Incorrect. Even though the car is travelling at a constant speed its direction is changing so it is undergoing (centripetal) acceleration.
7	A		Incorrect. Both Rutherford and Bohr postulated this.
	B		Incorrect. Neutrons were not discovered until decades later. Neither Rutherford nor Bohr mentioned neutrons or even the existence of neutral particles in the nucleus.
	C*		Correct. This was the defining aspect of Bohr's model. He didn't use the word 'orbital' at first, but his revised model used this term within a few years.
	D		Incorrect. Rutherford proposed a cloud of electrons surrounding the nucleus but Bohr has them in separate orbitals.

8	A		Incorrect. There will be a net force if the electrons are free to move, so they will accelerate to the positive plate.
	B		Incorrect. There is no magnetic field present so no magnetic field lines can be shown. Note: this seems like an oddly worded option in the paper. Perhaps it is a mistake and should read "travel in the same direction as the electric field lines" which is still wrong but more consistent with the scenario. An electron would travel in the opposite direction to the electric field. Either way – it is incorrect.
	C*		Correct. Charged particles will experience an electric force when placed in an electric field. If they are free to move, as in this case, the net force will cause them to accelerate. As electrons are negative, they will be attracted to the positive plate. Another way of saying this is that the electric field direction is from positive to negative (from left to right) so the electrons will experience a net force in a direction opposite to that of the field.
	D		Incorrect. The attraction will be to the positive plate, and the repulsion will be away from the negative plate. That is, the forces will act to move the electron in the same direction (to the left).
9	A		Incorrect. The boson that mediates the gravitational force is the hypothetical graviton. Alternatively, there is no boson that mediates the gravitational force.
	B		Incorrect. The strong (nuclear) force is mediated by bosons called gluons
	C		Incorrect. Electromagnetism is mediated by bosons called photons
	D*		Correct. The weak force is mediated by W bosons (which can be either + or -) or by Z bosons.
10	A		Incorrect. The solution rearranged the equation incorrectly as shown below, but substituted correctly: $$v = \sqrt{\frac{F_c m}{r}}$$
	B*		Correct. $$F_c = \frac{mv^2}{r}$$ $$v = \sqrt{\frac{F_c r}{m}} = \sqrt{\frac{4.8 \times 0.60}{0.50}} = 2.4 \text{ m s}^{-1}$$
	C		Incorrect. Rearranged the equation incorrectly as shown below and substituted correctly but didn't take the square root at the end: $$v^2 = \frac{F_c m}{r} = \frac{4.8 \times 0.50}{0.60} = 4$$
	D		Incorrect. Selected correct equation but did faulty rearrangement: $$F_c = \frac{mv^2}{r}$$ $$v = (F_c m)^2 = (4.8 \times 0.50)^2 = 5.8 \text{ m s}^{-1}$$
11	A		Incorrect. $emf = -N\frac{\Delta(BA)}{\Delta t}$, therefore: $emf \propto \Delta A$ and thus not inversely proportional to the area.

	B		Incorrect. $emf = -N\frac{\Delta(BA)}{\Delta t}$, therefore: $emf \propto \Delta B$ and thus not inversely proportional to the strength of the magnet.
	C		Incorrect. $emf = -N\frac{\Delta(BA)}{\Delta t}$, therefore $emf \propto N$ and thus not inversely proportional to the number of coils, *N*.
	D*		Correct. $emf = -N\frac{\Delta(BA)}{\Delta t}$, therefore: $emf \propto \frac{1}{\Delta t}$
12	A		Incorrect. As there is a perpendicular component to the current relative to the magnetic field, the wire will experience a force. It would only be zero if the wire was parallel to the field.
	B*		Correct. The angle between the wire and the field is 90° and this does not change. The angle θ is not the angle between the wire and the field, but an angle of rotation in space perpendicular to the field. $F = BILsin90°$ $= 1.5 \times 10^{-3} \times 2.4 \times 0.2 \times sin\ 90°$ $= 7.2 \times 10^{-4}\text{N}$
	C		Incorrect. The solution assumes the wire starts at 0° to the field and increases to 90° to the field. The angle θ shown in the diagram is not the angle the wire makes with the field (which is always 90°). It is just an angle of rotation in space perpendicular to the field.
	D		Incorrect. The solution assumes the wire starts at 90° to the field and decreases to 0° to the field. The angle θ shown in the diagram is not the angle the wire makes with the field (which is always 90°). It is just an angle of rotation in space perpendicular to the field.
13	A		Incorrect. The horizontal component is the *cos* of the angle not *sin*. This answer used *sin*. They incorrectly said $u_x = usin\theta = 31 \times sin28° = 15\ \text{m s}^{-1}$
	B		Incorrect. This answer used the wrong trigonometric formula. They incorrectly used $u_x = utan\theta = 28 \times tan31° = 17\ \text{m s}^{-1}$
	C		Incorrect. This answer has the angle and velocity mixed up. They incorrectly said $u_x = \theta cos\ u = 28 \times cos31° = 24\ \text{m s}^{-1}$
	D*		Correct. $u_x = ucos\theta = 31 \times cos28° = 27\ \text{m s}^{-1}$
14	A*		Correct. $v_y^2 = u_y^2 + 2gs_y$ $0 = (usin\theta)^2 + 2gs_y$ [at maximum height $v_y = 0\ \text{m s}^{-1}$] $s_y = \frac{-(usin\theta)^2}{2g} = \frac{-(31sin28°)^2}{2 \times -9.8} = 11\ \text{m}$
	B		Incorrect. Forgot to divide by 2.
	C		Incorrect. Used *cos* instead of *sin*.
	D		Incorrect. Used the initial velocity as the vertical component of velocity: $s_y = \frac{-(u^2)}{2g} = -\frac{-(31^2)}{2 \times -9.8} = 49\ m$
15	A*		Correct. The gradient of a PE graph which has maximum kinetic energy in J on the y-axis, and frequency in Hz on the x-axis is equal to Planck's constant $h = 6.6 \times 10^{-34}$ J s.

	B		Incorrect. The gradient would have units J s not J.
	C		Incorrect. The calculation did not include the multiplier of 10^{14} on the x-axis. Note that the inverse of frequency $1/f$ could be written with units of 1/Hz or Hz^{-1} as in this option, it is more common to write the units for $1/f$ as $1/s^{-1}$ or, more preferred, as s.
	D		Incorrect. The gradient should include the unit J from the y-axis.
16	A		Incorrect. The work function for a metal is represented on this type of graph by the magnitude of the y-intercept. In this case it is not zero. Alternatively, the work function is proportional to the threshold frequency f_0 which is the value of the x-intercept ($W = hf_0$) when the kinetic energy $E_k = 0$. A smaller x-intercept value (Metal R) means a smaller work function.
	B*		Correct. The work function is represented by the magnitude of the y-intercept for each metal. Metal R has a smaller magnitude y-intercept than metal X.
	C		Incorrect. The work function is represented by the magnitude of the y-intercept for each metal. They are not equal.
	D		Incorrect. The work function is represented by the magnitude of the y-intercept for each metal. Metal R intercept is less in magnitude than metal X not greater.
17	A		Incorrect. They are both composites. Mesons are composed of a quark and an antiquark. Baryons are composed of three quarks.
	B		Incorrect. Baryons consist of three quarks.
	C		Incorrect. Mesons consist of two elementary particles, a quark and an antiquark.
	D*		Correct. Mesons are composed of a quark and an antiquark. Baryons are composed of three quarks, so, they both contain at least one quark.
18	A*		Correct. The equation for relativistic momentum includes a denominator that approaches zero as speed increases, so momentum approaches infinity as speed approaches the speed of light in a vacuum.
	B		Incorrect. This would mean that as speed approaches *c*, momentum stops increasing. The formula doesn't represent this.
	C		Incorrect. At non-relativistic speeds momentum is proportional to speed and this graph show it as being constant.
	D		Incorrect. This is the graph for non-relativistic motion.
19	A*		Correct. As the S-pole of the magnet approaches the solenoid, and induced S-pole appears at the left end of the solenoid to oppose it. To create this pole in the solenoid a current must flow down the front of the solenoid and so current flows from P to Q. As the magnet approaches, the flux from the magnet increases inside the solenoid as magnetic field strength is great closer to the magnet.
	B		Incorrect. The flux inside the coil must increase as a magnet is entering.
	C		Incorrect. To satisfy Lenz's law the current in the solenoid must oppose the change so a S-pole is induced at the left end of the solenoid. Ampere's rule shows this to be a current coming down the front of the solenoid, hence P to Q.
	D		Incorrect. A S-pole will be induced at the LH end of the coil – which requires a current down the front and then from P to Q. As the magnet enters the coil the magnetic field in the coil would increase just by the mere presence of the magnet.
20	A		Incorrect. It is true that light behaves as a wave in certain circumstances - such as diffraction, interference and polarisation, and therefore light has wavelike properties

			including wavelength. This graph shows the distribution of wavelengths of light emitted by a black body at a certain temperature. It does show that light has a wave nature (wavelength) but the question says it “can be used to demonstrate that light behaves as a wave”. The curve itself does not demonstrate this. This type of curve can be drawn for different temperatures which can only be explained if light behaves as a particle (not a wave).
	B		Incorrect. In this case as wavelength is changing (x-axis), frequency must be changing because the velocity of light stays constant ($v = f\lambda$).
	C*		Correct. It is true that ‘light is quantised into discrete values’ of energy related to their wavelength - as given by the Planck equation $E = \frac{hc}{\lambda}$. The question being asked is – can this curve be used to demonstrate that idea? This graph shows the distribution and peak wavelength for a black body at one particular temperature. However, it does not show how the distribution and peak wavelength changes with temperature so it doesn’t demonstrate the quantised nature of light but “can be used to demonstrate” this nature as the question states. Secondly, if you discounted A, B and D because they are wrong, this leaves only Option C, which we know is a true statement. Teachers are not fans of this reasoning, but Option C is the only answer that is not wrong, so it is the best choice.
	D		Incorrect. The peak wavelength is not proportional to the temperature but is inversely proportional according to Wien’s Law: $\lambda_{max} = \frac{b}{T}$. This eliminates Option D as a correct answer. Secondly, and incidentally, because the graph shows a single, unspecified temperature, you cannot demonstrate an inverse relationship using this graph alone. Had the graph shown multiple curves for different temperatures, then yes, the relationship could be determined. But this option is still wrong.

Whew, that was hard! My thanks to Michael Tomlin for his feedback on answers and wording.

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