QCAA PHYSICS EXTERNAL EXAM – 2025
ALTERNATIVE SEQUENCE

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		Incorrect. It is 9.8 m s^{-2} at sea level.
	B*		Correct. To one decimal place it is mostly 9.8 m s^{-2} on or near the Earth’s surface.
	C		Incorrect. Because the poles are closer to Earth’s centre of mass than at the equator, acceleration due to gravity is greater at the poles.
	D		Incorrect. It decreases with elevation. Newton’s law of Universal Gravitation shows an inverse square relationship between gravitational force (or field) and the distance between centres of mass. Thus, as the distance from the surface of the Earth increases, the field, and hence acceleration due to gravity, decreases.
4	A		Incorrect. Nuclear fusion is a nuclear reaction in which two or more atomic nuclei combine to form one or more different, heavier atomic nuclei and subatomic particles. The reaction in this question has the heavy nucleus Co-59 being produced but doesn’t show a subatomic particle being released - as fusion requires. Note: this option would have been chosen by students who make the incorrect assumption that fusion is simply ‘two particles joining together’ (a fairly common mistake).
	B		Incorrect. Fission is the splitting apart of a nucleus. The reaction is the combining together of two particles, not splitting apart.
	C*		Correct. Artificial transmutation is the process in which an isotope is intentionally caused to change by nuclear processes into an isotope of another element (distinct from natural radioactivity). In this case a Co-59 nucleus is artificially transmuted into Ni-60 by intentional (human induced) bombardment with a proton (the nuclear particle).

	D		Incorrect. Radioactive decay is the process where an unstable atomic nucleus loses energy by emitting radiation (like alpha, beta, or gamma rays) to become more stable. The reaction in the question shows a nucleus absorbing a proton.

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*		Correct. A decay series is a sequence of steps and that an unstable nucleus has to undergo before reaching a stable state.
	B		Incorrect. Adding excess energy to a radionuclide can either cause it to undergo radioactive decay and emit radiation, or, if the energy is added to a stable nucleus, it can make it unstable and cause it to become a radionuclide.

	C		Incorrect. It is true that a decay series involves unstable nuclei emitting radiation in the form of alpha particles, beta particles, gamma rays and/or electrons. However, the main point is that it leads to the formation of stable nuclei at the end of the series.
	D		Incorrect. This refers to beta negative decay and could be a part of a decay series but is only one of many types of emission. It misses the point that a decays series ends with a stable nucleus.
8	A*		Correct. Speed is distance travelled per unit of time, irrespective of direction. Both students have average speeds of 80 m per minute, but they are travelling in different directions, so their velocities are different.
	B		Incorrect. Velocity is displacement over time, therefore takes direction into account. As the two students are walking in different directions, their velocities are different.
	C		Incorrect. One travels 160 m, the other travels 240 m.
	D		Incorrect. Both the change in position (displacement) is different for both (180 m vs 240 m), and the direction of travel is different, so their displacements are different in both magnitude and direction.
9	A		Incorrect. The boson that mediates the gravitational force is the hypothetical graviton. Alternatively, there is no boson identified 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. Half-life is the average time for half the atoms in a sample to decay, not the time for an individual atom to decay.

	B		Incorrect. Half-life is a measure of the time for half the atoms in a sample to decay and not about the decay process itself.
	C*		Correct.
	D		Incorrect. Half-life doesn't specify the type of reaction, but just decay in general. This is a fusion reaction, not decay.
12	A*		Correct. The mass numbers (top) are conserved as 238 = 234 + 4, the atomic numbers are conserved (92 = 90 + 2) and the symbol is correct for atomic number 92.
	B		Incorrect. The atomic numbers are not conserved: 92 ≠ 91 + 2.
	C		Incorrect. The mass numbers are not conserved: 238 ≠ 238 + 4.
	D		Incorrect. The mass numbers are not conserved: 238 ≠ 242 + 4.
13	A		Incorrect. The horizontal component is the *cos* of the angle not *sin*. This answer used *sin*. They incorrectly said $u_x = usin\theta = 31 \times sin28° = 15$ m s^{-1}
	B		Incorrect. This answer used the wrong trigonometric formula. They incorrectly used $u_x = utan\theta = 28 \times tan31° = 17$ m s^{-1}
	C		Incorrect. This answer has the angle and velocity mixed up. They incorrectly said $u_x = \theta cos\ u = 28 \times cos31° = 24$ m s^{-1}
	D*		Correct. $u_x = ucos\theta = 31 \times cos28° = 27$ m s^{-1}
14	A*		Correct. $v_y^2 = u_y^2 + 2gs_y$ $0 = (usin\theta)^2 + 2gs_y$ [at maximum height $v_y = 0$ m s^{-1}] $s_y = \frac{-(usin\theta)^2}{2g} = \frac{-(31sin28°)^2}{2 \times -9.8} = 11$ 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		Incorrect. Impulse is the product of force and time (Impulse = *Ft*) whereas work is the product of force and distance (*W* = *Fs*).
	B*		Correct. Impulse is also defined as the change in momentum of an object thus: Impulse $= Ft$ $= ma \times t$ $= m(\frac{v-u}{t})t$ $= mv - mu$ $= \Delta p$
	C		Incorrect. Impulse is not *F/t* but *Ft.*
	D		Incorrect. This probably means the net force F_{net} but impulse is the product of $F_{net} \times t$.
16	A		Incorrect. This is the gradient of the line which would be $\frac{8-0}{8-0} = 1$ N s^{-1}
	B		Incorrect. This is the change in force over the 8 seconds.

	C*		Correct. Impulse is equal to the area under an *F*-*t* graph. In this case it is $\frac{8\times8}{2} = 32$ N s.
	D		Incorrect. This is the product of the initial force (8 N) and time (8 s), not the product of average force (4 N) and time (8 s).
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		Incorrect. This is just the difference in their initial speeds. The 'left' direction is irrelevant.
	B*		Correct. There are two ways to solve this question. The simple way is to realise the masses are the same so in an elastic collision the velocities are reversed. This is known as the 'pool player's result' [see Oxford *Physics for Queensland*, Module 11.4 and Worked Example 11.4 B, page 431]. For a 1-mark MCQ this is likely to be the way the QCAA item writer approached this question. There is also a complex way to solve it, and this is done below. Momentum is conserved in all collisions. As this collision is also elastic, kinetic energy is also conserved. Considering conservation of momentum: $p_i = p_f$ $mu_A + mu_B = mv_A + mv_B$ $u_A + u_B = v_A + v_B$ [as $m_A = m_B$] $0.75 + -0.43 = v_A + v_B$ $0.32 = v_A + v_B$ $v_B = 0.32 - v_A$ [Equation 1] Considering conservation of kinetic energy:

			$\Sigma E_{k(i)} = \Sigma E_{k(f)}$ $E_{k(i)A} + E_{k(i)B} = E_{k(f)A} + E_{k(f)B}$ $\frac{1}{2} m_A u_A^2 + \frac{1}{2} m_B u_B^2 = \frac{1}{2} m_A v_A^2 + \frac{1}{2} m_B v_B^2$ $u_A^2 + u_B^2 = v_A^2 + v_B^2$ [as $m_A = m_B$] $0.75^2 + (-0.43)^2 = v_A^2 + v_B^2$ $0.7474 = v_A^2 + v_B^2$ $v_B^2 = 0.7474 - v_A^2$ [Equation 2] Substituting Equation 1 into Equation 2: $(0.32 - v_A)^2 = 0.7474 - v_A^2$ $0.32^2 - 0.64 v_A + v_A^2 = 0.7474 - v_A^2$ $2v_A^2 - 0.64 v_A - 0.645 = 0$ $v_A^2 - 0.32 v_A - 0.3225 = 0$ Solve quadratic: $v_A = +0.75\,\text{m s}^{-1}\ or -0.43\,\text{m s}^{-1}$ $v_A = -0.43\,\text{m s}^{-1}$ $v_A = 0.43\,\text{m s}^{-1}$ to the left [CORRECT ANSWER] Check if answer makes sense: $v_B = 0.32 - v_A$ $= 0.32 - (-0.43) = +0.75\,\text{m s}^{-1}$ (to the right) This makes sense as the balls collide and bounce back in opposite directions. Now check alternative answer for v_A (= +0.75 m s^{-1}). $v_B = 0.32 - v_A$ $= 0.32 - (+0.75) = -0.42\,\text{m s}^{-1}$ (to the left) This couldn't happen as A would be travelling to the right and B travelling to the left. This is impossible as they would have to pass through each other.
	C		Incorrect. This is just the average of their initial speeds.
	D		Incorrect. This speed for A (v_A = 0.75 m s^{-1}) is solution to the quadratic equation, but the sign is positive indicating that the ball travels to the right.
20	A		Incorrect. The graph appears to be approaching zero atoms on the x-axis but that is only a rough estimate.
	B		Incorrect. That is the half-lie in days.
	C*		Correct. Reading off the graph – when the number of atoms remaining (y-axis) is half the initial number, one half life is said to have passes. This happens at 4 days. $n = \frac{t}{t_{1/2}} = \frac{36}{4} = 9$ half lives $N = N_0 (\frac{1}{2})^n$ $= 10 \times 10^5 \times (\frac{1}{2})^9$ $= 1953$ atoms ≈ 2000 atoms

	D		Incorrect. That is just the number of atoms remaining after one half life.

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