QCAA PHYSICS EXTERNAL EXAM – 2024

MULTIPLE CHOICE QUESTIONS - SOLUTIONS AND EXPLANATIONS

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Note: *NCPQ* refers to *New Century Physics for Queensland*, U3 & 4, 2020, OUP.

Percentages (%) indicate the overall choice by students (QCAA Subject Report 2025)

Q		**%**	**Solutions**
1	A		Incorrect. Refers to electrons.
	B*		Correct. Definition of a baryon in QCAA syllabus 2019, p 65: “composite subatomic particles made up of three quarks” (Tipler & Mosca 2003, Giancoli 2008) or NCPQ p 354 for similar. Wikipedia says “type of composite subatomic particle that contains an odd number of valence quarks, conventionally three” (Gell-Mann, M. (1964). "A schematic model of baryons and mesons". Physics Letters. 8 (3): 214–215). Who could argue. Either way it is the best answer.
	C		Incorrect. Refers to quark or lepton
	D		Incorrect. Refers to quarks u, c, b with +2/3 e^- charge
2	A		Incorrect. E ∞ f not E ∞ 1/f (Planck)
	B		Incorrect. Velocity is constant in a given medium (based on 2^{nd} postulate by Einstein).
	C*		Correct. Special relativity, second postulate (NCPQ p 251)
	D		Incorrect. Snell’s law asserts that the frequency doesn’t change when light changes medium but the velocity and wavelength do.
3	A		Incorrect. Used $F = \frac{Gr^2}{Mm}$
	B		Incorrect. Used $F = GMm$
	C		Incorrect. Used $F = \frac{GMm}{r}$
	D*		Correct. $F = \frac{GMm}{r^2} = \frac{6.626\times10^{-11}\times65.0\times75.0}{1.50^2} = 1.445\times10^{-7}\text{ N}$
4	A		Incorrect. Wave theory can explain diffraction (Experiment 1) but not the photoelectric effect (Experiment 2)
	B		Incorrect. This refers to refraction. The wave model does support refraction but is not related to Experiment 1. The particle model does support Newton’s particle model but has refraction the wrong way around, and is not related to Experiment 2 anyway.
	C*		Correct. Experiment 2 correctly shows particle model but not wave model.
	D		Incorrect. This is irrelevant to Experiment 1 and 2. Gravitational waves can travel in a vacuum, but this is irrelevant to both experiments.
5	A*		Correct. A statement of Coulomb’s law $F = \frac{kQq}{r^2}$
	B		Incorrect. Misreading of Coulomb’s law. The force actually decreases as the distance increases.

	C		Incorrect. Misreading of Coulomb's law. The force is actually inversely proportional to square of the distance.
	D		Incorrect. Coulomb's law actually says that it is inversely related.
6	A		Incorrect. Calculated gradient correctly but said gradient was 1/g not g. Had g = 1.600/80 = 0.02 m s^{-1}.
	B		Incorrect. Didn't convert mass in g to kg.
	C		Incorrect. Used grams in for mass and also had gradient as 1/g giving g = 1600/80 = 20 m s^{-1}.
	D*		Correct. $g = \frac{F}{m} = gradient$ $gradient = \frac{100-20}{2.000-0.400} = 50\,\text{m}\,\text{s}^{-1}$
7	A*		Correct. $F_{net} = F_g \sin\theta = 50.0 \times \sin 40° = 32.14$ N
	B		Incorrect. Used $F_{net} = F_g \sin\theta - F_g/g = (50.0 \times \sin 40°) + (50.0/9.8) = 37.3$ N
	C		Incorrect. Used $F_{net} = F_g \cos\theta$
	D		Incorrect. $F_{net} = F_g \tan\theta$
8	A		Incorrect. Uses F_H as 120cos θ = 103.9 = 100 to 1 s. f.
	B		Incorrect. Uses $F_{net} = F_H + 30$ = 120cosθ + 30 = 90 to 1 s. f. (or just uses 120 – 30 = 90 N)
	C		Incorrect. Uses F_H = 120sin θ − 30 = 73.9 = 70 to 1 s. f.
	D*		Correct. $F_{net} = F_H - 30$ $= F_g \cos 60° - 30$ $= 60 - 30 = 30$ N
9	A*		Correct. To 'stationary' observer who sees the train moving, the back of the train will move towards the light beam and catch up whereas the front will move away and take longer to catch up. The word 'stationary' is a bit misleading here but the elaboration 'who sees the train moving' clears it up. Motion is relative so 'the stationary observer' has to state what they are stationary to. The passenger is stationary to the train, and the outside observer is stationary to the ground. Needs careful reading but the question is well presented. This is called "The Flashlight on the train paradox".
	B		Incorrect. Front is moving away. See note in comment about option D.
	C		Incorrect. Light is not instantaneous even to the passenger on the train.
	D		Incorrect. Not for observer watching the train go by. The passenger would see the light reach both ends simultaneously as the passenger is at rest to the event and the light is equidistant from both front and back. Note that the passenger is also at the centre of the train next to the light. This is important and without that condition the passenger may see option (B) if sitting near the front of thetrain.
10	A		Incorrect. Used correct formula but didn't convert 86 cm to m.
	B*		Correct.

			$F = BIL\sin\theta = 0.0306\sin\theta$ $BIL = 0.0306$ $B = \frac{0.0306}{2.4\times 0.85} = 0.015\,\text{T}$ $=1.5\times 10^{-2}$ T O.M.$=10^{-2}$ T
	C		Incorrect. Used correct formula and result of 0.015 T, and correctly said you had to multiply the answer by 10^2 to make it 1.5 but assumed that 10^2 was OM.
	D		Incorrect. Used correct formula but didn't convert 86 cm to m and had a result of 0.00015 T. Correctly said you had to multiply that answer by 10^4 to make it 1.5 but assumed that 10^4 was OM.
11	A		Incorrect.
	B		Incorrect.
	C*		Correct. The required formula is in the QCAA *Formula and data book* otherwise you can develop it from first principles, thus: $\frac{GMm}{r^2} = \frac{mv^2}{r}$ $\frac{GM}{r} = v^2$ $\frac{GM}{r} = (\frac{2\pi r}{T})^2$ $\frac{GM}{r} = \frac{4\pi^2 r^2}{T^2}$ $M = \frac{4\pi^2 r^3}{T^2 G}$ [Formula book has: $\frac{T^2}{r^3} = \frac{4\pi^2}{GM}$] $= \frac{4\pi^2 (6.4\times 10^{14})^3}{(1.5\times 365\times 24\times 60\times 60)^2 \times 6.67\times 10^{-11}}$ $= \frac{1.0349\times 10^{46}}{1.49\times 10^5}$ $= 6.9\times 10^{40}\,\text{kg}$
	D		Incorrect.
12	A		Incorrect.
	B		Incorrect.
	C		Incorrect.
	D*		Correct. $1.0\,\text{m}$ horizontal displacement $\rightarrow \cos\theta = 0.12$ $\theta = \cos^{-1} 0.12$ $= 83.1^\circ$ Alternatively (longer method):

			$s_x = u\cos\theta$ $\text{gradient} = \frac{\Delta s_x}{\Delta\cos\theta} = \frac{6.9-0.20}{1.0-0.0} = 6.70\,\text{m}$ trendline $y = 6.7x + 0.2$ $1.0 = 6.7\times\cos\theta + 0.2$ $\cos\theta = \frac{1.0-0.2}{6.7} = 0.119$ $\theta = \cos^{-1}0.119$ $= 83.1^\circ$ (83° to 2 s. f.)
13	A		Incorrect.
	B*		Correct. $E_{k(max)} = hf - W$ $W = hf - E_{k(max)}$ $= 6.626\times10^{-34}\times9.4\times10^{15} - 5.6\times10^{-18}$ $= 6.28\times10^{-19}\,\text{J}$ $= \frac{6.28\times10^{-19}}{1.6\times10^{-19}}\,\text{eV}$ =3.9 eV
	C		Incorrect.
	D		Incorrect.
14	A		Incorrect. Says $B \propto \frac{\Delta\phi}{A}$
	B*		Correct. Formula $B \propto \frac{\phi}{A}$
	C		Incorrect. Flux density is for 2-D area, not a 3-D space like volume
	D		Incorrect. This is the ratio used for interpreting deflections of a particle in a magnetic field. It is used in mass spectroscopy. Good examples in QCAA website Sample EA paper 2020 Paper 1 Q25, or 2020 EA Paper 2 Q6.
15	A*		Correct. "Centripetal" is "centre seeking" so points towards the centre of motion.
	B		Incorrect. This would be -F_c
	C		Incorrect. This would be -v
	D		Incorrect. This would be v
16	A		Incorrect. Photons experience only the EM force
	B		Incorrect. Leptons don't experience the SNF, but do experience the WNF. The EM force box is left unchecked which implies they don't experience it. However, the charged leptons (electrons, muons, and tau) do experience the EM force, but the neutrinos do not. So, the EM force applies to only some of the leptons and is left unchecked but should have a tick.
	C		Incorrect. Quarks experience the WNF so that box should have a tick in it.
	D*		Correct. Mesons are a quark-antiquark composite so experience the SNF and the WNF. They can have an electric charge, π^+ and π^-, or be neutral, π^0, depending on their quark

			antiquark composition, so some can experience the EM force. They tick all 3 boxes and this is correct.
17	A		Incorrect. Didn't square the *v*. Used $t_0 = 15\sqrt{1-0.7}$
	B*		Correct. This is not the Twins paradox as the spaceship passenger is not necessarily returning to Earth to compare clocks. This is just a person on Earth noting the passage of time on their clock but not measuring the time aboard the spaceship. The question doesn't ask that. It merely asks how much time has elapsed on the spaceship relative to its own clock (hence t_0) compared to a clock the spaceship sees as moving (on Earth, *t*). $t = \frac{t_0}{\sqrt{1-v^2/c^2}}$ $t_0 = t\sqrt{1-v^2/c^2}$ $= 15\sqrt{1-0.7^2}$ $= 10.7\text{ y} (11\text{ y to2 s. f.})$
	C		Incorrect. Identified *t* and t_0 the wrong way around. $t = \frac{t_0}{\sqrt{1-v^2/c^2}}$ $t = \frac{15}{\sqrt{1-0.7^2}}$ $= 21\text{ y}$
	D		Incorrect. Identified *t* and t_0 the wrong way around, but also forgot to square *v*
18	A		Incorrect. They are not parallel but are perpendicular
	B		Incorrect. Have the same wavelength and thus same frequency and speed for each component
	C*		Correct. Definition in syllabus is "synchronised oscillations"
	D		Incorrect. Intersect at the base or equilibrium position of their components
19	A		Incorrect. Probably said $OM = \frac{10^{-8}}{10^{-6}} = 10^{-2}$
	B*		Correct. $V = \frac{\Delta U}{q} = \frac{W}{q} = \frac{1.5\times10^{-8}}{7\times10^{-6}} = 2.14\times10^{-3}$ $OM = 10^{-3}\text{ V}$ Could also estimate by converting to OM first: $V(OM) = \frac{W}{q} = \frac{10^{-8}}{10^{-5}} = 10^{-3}\text{ V}$
	C		Incorrect. Didn't use microcoulomb $V = \frac{W}{q} = \frac{1.5\times10^{-8}}{7} = 2.14\times10^{-9}$ $OM = 10^{-9}\text{ V}$
	D		Incorrect. Used $V = Wq$ and identified OM as 10^{-13} V
20	A*		Correct. Definition of blackbody – see QCAA 2019 syllabus p 65

	B		Incorrect. Related to spectrum of light with two orbital transitions
	C		Incorrect. Related to the failure of wave theory in explaining photoelectric effect
	D		Incorrect. Related to Wein's displacement graph but is wrong anyway.

Whew! For other worked solutions to EA past papers see seniorphysics.com/ncpq