QCAA PHYSICS EXTERNAL EXAM – 2022

MULTIPLE CHOICE QUESTIONS - SOLUTIONS AND EXPLANATIONS

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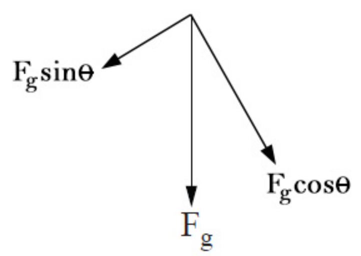
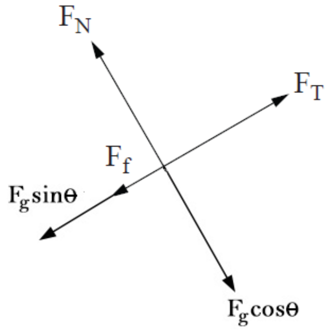
Note: *NCPQ* refers to *New Century Physics for Queensland*, U3 & 4, 2020, OUP.
Glossary refers to the QCAA Physics Syllabus 2019.
Percentages (%) indicate the overall choice by students (QCAA Subject Report 2023)

Q		%	Reasoning
1	A	64.44	Incorrect. This is the definition of electromagnetic induction and <u>not</u> electromagnetic force. See Glossary page 73 and NCPQ p215.
	B	25.14	Correct. See Glossary page 73 and NCPQ p 215.
	C	6.96	Incorrect. This is the definition for electrostatic repulsion. See Glossary page 73: *the repulsion experienced by two like charged particles.* See also NCPQ p 155.
	D	3.21	Incorrect. Electromotive force (EMF) is not one of the four fundamental forces, which are strong nuclear force, electromagnetic force, weak nuclear force, and gravitational force. EMF is generated by the dynamic interaction (relative motion) of a conductor with a magnetic field. This interaction is mediated by the electromagnetic force (a fundamental force) which produces the EMF (also known as 'voltage'). See Glossary page 73 and NCPQ p 358.
2	A	18.32	Incorrect. This refers to electromagnetic radiation. See Glossary: *electromagnetic radiation - electromagnetic waves, propagated at the speed of light in a vacuum*
	B	8.66	Incorrect. Photons do not require a medium for their propagation. See NCPQ U3&4 p302
	C	63.1	Correct. Glossary p 86 and NCPQ p315 and 316.
	D	9.62	Incorrect. This refers to a gluon. See Glossary in NCPQ page 415.
3	A	52.23	Correct. Constant speed means no acceleration and thus no net force. Forces along (parallel to) the plane must be equal and opposite. As the object is said to be moving up the plane, the frictional force F_f must act down the plane, and the tension in the rope by which the object is pulled must act up the inclined plane. However, to the frictional force down the plane, we must add the parallel component of the weight. The weight, F_g, can be resolved into two vectors at right angles, thus:  So, to the friction (acting down the plane) we can add $F_g\sin\theta$ and this combination must be equal and opposite to F_T acting up the plane. Only option (A) satisfies this criterion.

			As well, (A) correctly has the normal force F_N acting upwards at right angles to the plane. If we compare F_N and $F_g\cos\theta$ we see that they are equal and opposite as well, and this is to be expected. 
	B	37.61	Incorrect. It is partly correct in that the object must be moving at constant speed because the tension (in the rope) F_T pulling the object up the inclined plane is equal to the frictional force F_f acting down the plane. However, when we add the component of the weight $F_g\sin\theta$ to F_F, the sum is greater than F_T so the object will accelerate down the incline.
	C	7.66	Incorrect. The object must be moving down the plane. The tension in the pulling force F_T acts down the plane and is equal to the frictional force up the plane. You would think that as the two forces are equal there is no acceleration so it will travel at constant speed down the plane. However, the questions states that the object is moving up the plane so friction must act down.
	D	2.33	Incorrect. Friction F_f is greater than tension F_T and this cannot happen. It is always less than, or equal to, the tension force. F_T less than F_f so the object cannot be moving up the plane (at constant speed, or accelerating) anyway.
4	A	13.87	Incorrect. Forgot to square the $T = 5.6 \times 10^3$ value. See equation below.
	B	66.88	Correct. Apply the formula derived from Kepler's and Newton's laws. See NCPQ p 141 and Worked Example 5.1C p 142. $\frac{T^2}{r^3} = \frac{4\pi^2}{GM}$ $r^3 = \frac{T^2 GM}{4\pi^2} = \frac{(5.6 \times 10^3)^2 \times 6.67 \times 10^{-11} \times 5.97 \times 10^{24}}{4\pi^2}$ $= 3.163 \times 10^{20}$ $r = 6.8 \times 10^6 \text{m}$
	C	13.02	Incorrect. Took the square root of $r^3 = 3.163 \times 10^{20}$ instead of the cube root.
	D	5.63	Incorrect. Used $\frac{T^3}{r^2} = \frac{4\pi^2}{GM}$ instead of the correct formula.
5	A	3.33	Incorrect. Tau are not bosons but are leptons. Bosons are the mediating particle that carry forces. See NCPQ p 358.
	B	85.35	Correct. Tau are leptons along with muons and electrons, and the associated neutrinos.
	C	6.39	Incorrect. Mesons are composite particles made up of a quark and an antiquark pair. See NCPQ p 355.

	D	4.71	Incorrect. Baryons are particles made up of 3 quarks. See NCPQ p 355. Note: some sources define baryons as being composed of an odd number of quarks greater than 1. This is not the syllabus definition, nor the one in NCPQ. Baryons have 3 quarks.
6	A	86.95	Correct. It is an interaction between waves caused by constructive and destructive interference. This phenomenon can only occur with waves. Note that 'coherent' is not defined in the syllabus but is in NCPQ p 301. It is essential to understand its meaning.
	B	2.33	Incorrect. The width of the slits will affect the pattern but not the phenomena of interference and the banding. See NCPQ p 301.
	C	5.98	Incorrect. 'Discrete packets of photons' is a characteristic of the particle model of light. Hence, it cannot explain the interference (a wave phenomenon). NCPQ p 310.
	D	4.55	Incorrect. The distance will affect the spacing in the pattern but not the phenomena of interference and the banding. Further reading see NCPQ U1&2, p 362.
7	A	4.41	Incorrect. Decreasing the thickness would increase the resistance and allow a smaller current to flow. The equation $B = \mu_0 \frac{N}{L} I$ says that B is proportional to current, so decrease I and you will decrease B. See NCPQ p 193.
	B	5.98	Incorrect. Increasing the length of the solenoid will decrease the magnetic field strength as shown by the equation: $B = \mu_0 \frac{N}{L} I$ which says that B is inversely proportional to length, so increase L and you will decrease B.
	C	79.75	Correct. The formula $B = \mu_0 \frac{N}{L} I$ shows that B is directly proportional to N so increase N and you will increase B.
	D	9.56	Incorrect. Alternating current passes through a $V = 0$ during each cycle so this will reduce the average B value in a cycle.
8	A	6.26	Incorrect. Used an incorrect formula. Used $E = \frac{\lambda}{c}$ as follows: $\lambda = E \times c = 2.4 \times 10^{-23} \times 3 \times 10^{8} = 7.2 \times 10^{-15}$ m
	B	21.35	Incorrect. Used an incorrect formula. Used $E = \frac{h}{\lambda}$ as follows: $$\lambda = \frac{h}{E} = \frac{6.625 \times 10^{-34}}{2.4 \times 10^{-23}} = 2.76 \times 10^{-11}\text{m}$$
	C	63.12	Correct. The question, in other words, is asking you to determine the wavelength of a photon with an energy of 2.4×10^{-23} J. This correct option uses the correct formula: $$E = hf = \frac{h\lambda}{c}$$ $$\lambda = \frac{hc}{E} = \frac{6.625 \times 10^{-34} \times 3 \times 10^{8}}{2.4 \times 10^{-23}} = 8.3 \times 10^{-3}\text{ m}$$ See QCAA Formula and Data Book, and NCPQ p 310. See also, Worked Example 11.4A p 312.
	D	8.23	Incorrect. Has formula upside down. Rearranges $E = \frac{hc}{\lambda}$ to $\lambda = \frac{E}{hc} = 1.2 \times 10^{2}$ m

9	A	39.98	Incorrect. The range is only 9.4 m. See method in Option (B) below. $$t = \frac{2 \times v \times sin\theta}{g}$$ $$= \frac{2 \times 12 \times sin\ 20°}{9.8} = 0.837\ s$$ $$s_x = u \times cos\theta \times t$$ $$= 12\ cos20° \times 0.837$$ $$= 9.4\ \text{m}$$
	B	57.79	Correct. The range is 12.3 m which is the largest of all options. See NCPQ p 51. $$s_y = v\ sin\theta\ t + \tfrac{1}{2}gt^2$$ $$v\ sin\theta = \tfrac{1}{2}\ gt$$ $$t = \frac{2 \times v \times sin\theta}{g}$$ $$= \frac{2 \times 11 \times sin\ 45°}{9.8} = 1.587\ s$$ $$s_x = ucos\theta t$$ $$= 12\ cos45° \times 1.587$$ $$= 12.3\ \text{m}$$ Note: you could eliminate Options C and D by considering the diagrams. For example, Options B & D have the same angle, but B has a greater velocity, so B will have a greater horizontal range. Thus, eliminate D. Likewise, eliminate C out of options A & C as it has a lower velocity. Just consider options A and B.
	C	1.2	Incorrect. The time is 0.698 s, and the range is only 6.56 m. Check to see if you agree.
	D	0.8	Incorrect. The time is 1.30 s, and the range is only 8.26 m. Check to see if you agree.
10	A	72.91	Correct. See definition in Glossary page 73, NCPQ p 164.
	B	7.44	Incorrect. This is about change in potential energy ΔU, and not electric field strength.
	C	9.16	Incorrect. This is about the rate of flow of electric charge – which is current: $I = \frac{Q}{t}$. See NCPQ U1&2, p 211.
	D	10.19	Incorrect. This option is about the force on a charged particle in an electric or magnetic field. It is not the physical property of the particle. Thus, this option is not about the property of the electric field but about forces acting due to the field. Note: the term 'electromagnetic field' does not appear in the syllabus, nor is it defined in the Glossary. This should make you wary. An electromagnetic field can be viewed as the combination of an electric field and a magnetic field. The electric field is produced by stationary charges, and the magnetic field by moving charges (electric currents); these two are often described as the sources of the field. See NCPQ p231.
11	A	8.56	Incorrect. This will decrease $E_{K(max)}$ as the electrons will have to overcome the electrostatic force of attraction to the positively charged metal.
	B	12.75	Incorrect. Using the formula $E_K = hf - W$, we see that a larger W means <u>less</u> energy is left over for the electron to gain as E_K. See Formula Book, and NCPQ p 316.
	C	33.17	Incorrect. An increase in intensity will increase the number of photoelectrons emitted but will not increase their $E_{K(max)}$. Note: this is a key part of the particle (photon) model

			for light, and one that distinguishes it from the wave mode;. Learn this. See NCPQ p 314.
	D	45.17	Correct. A decrease in wavelength of the light (photons) means an increase in the frequency and thus higher energy of these incident photons (*E* = *hf*). Some of this energy is used in overcoming *W* but there will be a greater amount left for E_K of the photoelectrons.
12	A	83.62	Correct. $v = \frac{2\pi r}{T}$, thus $r = \frac{vT}{2\pi} = \frac{8.0 \times 0.3}{2\pi} = 0.38\ m = 3.8 \times 10^1$m. NCPQ p 198.
	B	8.51	Incorrect. Has wrongly used $r = \frac{2\pi}{vT} = 15$ m $= 1.5 \times 10^1$m
	C	3.91	Incorrect. Has wrongly used $r = v \times 2\pi \times T = 216\ m = 2.16 \times 10^2$m
	D	3.58	Incorrect. Has wrongly used $r = \frac{2\pi \times v}{T} = 170$ m $= 1.7 \times 10^2$ m
13	A	7.54	Incorrect. May have omitted the area: $t = \frac{N \times \Delta B}{EMF} = \frac{3000 \times 2 \times 10^{-3}}{6}$ =1 s, thus 1 rps.
	B	22.79	Incorrect. May have miscalculated the area: $\Delta t = -\frac{3000 \times (2 \times 10^{-3}) \times (0.1 + 0.2)}{6} = 0.33$ s f $= \frac{1}{T} = \frac{1}{0.33} = 3$ rps
	C	28.62	Correct. The magnetic flux threading the rotating coil would be zero when the plane of the coil is parallel to the field, and a maximum when the plane is at right angles (90º) to the field. The change in flux for 90º (¼ turn) rotation can be used in Faraday's equation: $emf = -\frac{n\Delta(BA_\perp)}{\Delta t}$ $\Delta t = -\frac{n\Delta(BA)}{emf}$ $\Delta t = -\frac{n \times \Delta B \times A}{emf}$ $= -\frac{3000 \times (0 - 2 \times 10^{-3}) \times (0.1 \times 0.2)}{6}$ $= 0.02\ s\ (for\ ¼\ turn)$ $= 0.02 \times 4 = 0.08\ (for\ 1\ turn)$ $f = \frac{1}{T} = \frac{1}{0.08} = 12.5\ rps \approx 13\ rps\ (C)$ Note: see NCPQ p 201, Figure 15, and Question 8 CYL 8.2 p 219. See also the EMF diagram in Q18 p 238. Alternatively: Using Faraday's other two equations. Consider a loop rotating one-quarter of a turn:

			$= -n\dfrac{\Delta(BA\cos\theta)}{\Delta t}$ $= -n\dfrac{BA\,\Delta(\cos\theta)}{\Delta t}$ $\Delta t = -n\dfrac{BA\,\Delta(\cos\theta)}{emf}$ Now $\Delta(\cos\theta) = -1$ given that θ goes from 0° to 90° in ¼ of a turn. Thus: $\Delta t = n\dfrac{BA}{emf}$ $= \dfrac{3000 \times (2 \times 10^{-3}) \times (0.1 \times 0.2)}{6}$ $= 0.02\ s\ (for\ ¼\ turn)$ $= 0.08\ s\ (for\ 1\ turn)$ $f = \dfrac{1}{T} = \dfrac{1}{0.08}$ $= 12.5\ s^{-1} \approx 13\ rps\ (C)$
	D	39.81	Incorrect. Answer has used the 0.02 s calculated in option (C) as the time for 1 rotation instead of the time for ¼ rotation. $T = 0.02\ s\ for\ 1\ cycle$ $f = \dfrac{1}{T} = \dfrac{1}{0.02}$ $= 50\ rps$
14	A	4.16	Incorrect. The neutron *udd* is wrongly shown as staying a neutron *udd* but should turn into a proton *uud*.
	B	22.71	Incorrect. Shows a W+ decay when it should be a W– to conserve charge. The proton is +, so the W boson must be –.
	C	63.75	Correct. See diagram in QCAA Feynman diagram booklet, and NCPQ p 387.
	D	9.06	Incorrect. The neutron *udd* on the left is shown as staying a neutron *udd* on the right, and is not a proton *uud* as it should be.
15	A	41.21	Incorrect. An observer can measure an object's motion relative to any reference frame, fixed or otherwise.
	B	13.85	Incorrect. An observer can measure an object's velocity relative to the speed of light (eg 0.8 c) but doesn't have to. It can be measured relative to any object in any reference frame. NCPQ p 252.
	C	16.00	Incorrect. An observer can measure an object's motion relative to any reference frame, fixed or otherwise.
	D	28.55	Correct. An object's velocity can only be measured relative to an observer doing the measuring. The velocity relative to other objects can then be determined.
16	A	11.87	Incorrect. See reasoning below.
	B	4.43	Incorrect. The resultant is pointing the wrong way.
	C	10.42	Incorrect. The resultant is pointing the wrong way.

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<td>D</td>
<td>72.83</td>
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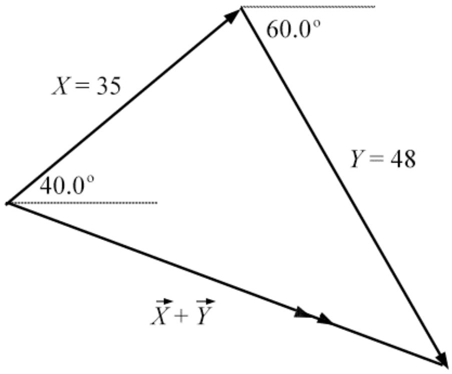
Correct. There are two main ways of doing this question. The first is the ‘components’ method. Thus, for addition, place the vectors head to tail and draw the resultant vector $\vec{X} + \vec{Y}$:



Determine the horizontal (h) and vertical (v) components of the original X and Y we get:

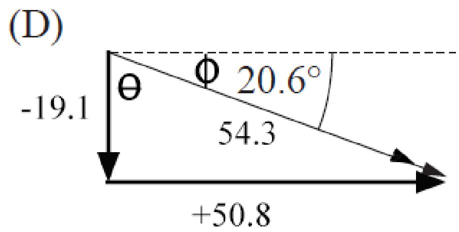
X_v = 35 sin40 = +22.5 X_h = 35 cos 40 = +26.8

Y_v = 48 sin 60 = – 41.6 Y_h = 48 cos 60 = +24

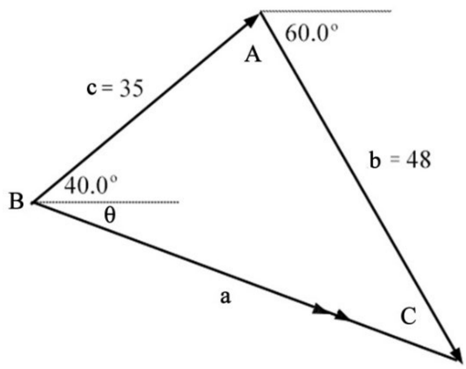
$(X+Y)_h$ = +22.5 + (– 41.6) = –19.1 m $(X+Y)_h$ = +26.8 + (+24) = +50.8

Hypotenuse = $\sqrt{19.1^2 + 50.8^2} = \mathbf{54.3}$

Angle $\theta = tan^{-1}\left(\frac{50.8}{19.1}\right) = 69.4°$. Angle ϕ = 90.0 – 69.4 = **20.6°**



The second method is the ‘cosine and sin’ method. Firstly, draw the diagram similar to above but with labels to suit the cos rule:



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			$a^2 = 48^2 + 35^2 - 2 \times 48 \times 35\ cos80°$ $= 3529 - 583.5$ $= 2945.5$ $a = \mathbf{54.3}$ $\frac{sinA}{A} = \frac{sinB}{B}$ $sinB = \frac{B\ sinA}{A} = \frac{48\ sin80}{54.3} = 0.871$ $B = sin^{-1}0.871 = 60.6°$ $\theta = B - 40 = 60.6 - 40 = \mathbf{20.6}°$ See NCPQ Worked Example 6.1C, 6.1D, 6.1E p 158-160. Note: more examples of these methods can also be found in *Oxford Study Buddy Revision and Exam Guide*, Volume 1, 2021. Question 13 solution p 292.
17	A	45.62	Correct. See NCPQ p 128 and Worked Example 4.3a p 128 $r_{orbit} = r_{earth} + r_{altitude}$ $= 6.4 \times 10^6 + 400 \times 10^3 = 6.8 \times 10^6$m $g = \frac{GM}{r^2}$ $= \frac{6.67 \times 10^{-11} \times 5.97 \times 10^{24}}{(6.8 \times 10^6)^2}$ $= \frac{3.98 \times 10^{14}}{4.624 \times 10^{13}}$ $= 8.6\ \text{m s}^{-2}$ Note: an alternative solution gives 8.7 m s^{-2} as the answer but (A) is still the closest. The solution is: $g_e = \frac{GM}{r_e^2}$ and $g_o = \frac{GM}{r_o^2}$ $g_o = g_e \times \left(\frac{6.4}{6.4 + 0.4}\right)^2$ $= 9.8 \times 0.886$ $= 8.7\ \text{m s}^{-2}$
	B	20.95	Incorrect. Forgot to add the altitude of 400 km.
	C	14.54	Incorrect Forgot to add the radius of the Earth. See NCPQ Worked Example 5.1C(a) p 142 for example.
	D	18.17	Incorrect. Forgot to square the radius of the orbit.
18	A	8.06	Incorrect. It is *lossless* which means the power in the secondary equals the power in the primary. Note: *lossless* is not a syllabus term and is not in the Glossary. However, it is logically interpreted. See NCPQ p 228.
	B	48.57	Correct. Current in the secondary is decreased. See NCPQ p 228. $I_pV_p = I_sV_s$ $\frac{V_p}{V_s} = \frac{I_s}{I_p} = \frac{n_p}{n_s} = \frac{4}{6}$ $I_s = I_p \times \frac{4}{6}$ $\therefore I_s < I_p$

	C	28.87	Incorrect. V_S will be <u>in</u>creased and not decreased. $$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$ $$\frac{V_p}{V_s} = \frac{4}{6}$$ $$V_s = V_p \times \frac{6}{4}$$ $$\therefore V_s > V_p$$
	D	14.19	Incorrect. There are more turns in the secondary, hence a longer length of wire, and thus the resistance would be increased in the secondary.
19	A	7.93	Incorrect. The gradient F/I is not related to potential difference. The gradient is constant, and the potential difference would need to increase during the experiment to increase the current (x-axis). Thus, gradient is constant, but the potential difference (V) must be increasing.
	B	12.94	Incorrect. The gradient F/I is not related to *EMF*. The gradient is constant, and the *EMF* would need to increase during the experiment to increase the current (x-axis). Thus, the gradient is constant, but the *EMF* must be increasing.
	C	6.94	Incorrect. Rearranging the equation $F = BIL\sin\theta$ to $F/I = BL\sin\theta$, if the angle is 90° we can say the gradient $F/I = BL$. If B was held constant, then $F/I \propto L$. However, resistance $R \propto 1/L$, thus $F/I \propto 1/R$. The gradient is <u>not</u> proportional to resistance, but <u>inversely</u> proportional to resistance.
	D	71.83	Correct. Gradient = F/I. Rearranging the equation $F = BIL\sin\theta$ to $F/I = BL\sin\theta$, if the angle is 90° and the length is held constant we can say: $F/I \propto B$ (the magnetic field strength).
20	A	11.97	Incorrect. The W and Z bosons both mediate the weak nuclear force, so they will be equal. That is, for strength: W boson = Z boson, but it is correct to say they will be they will be less than the photon. That is, in order of ascending strength it would be: W boson = Z boson < photon.
	B	15.37	Incorrect. Gluons mediate the strongest force which is the strong nuclear force so will be greater than the Z and W bosons (for which Z boson = W boson). That is, in order of ascending strength it would be: Z boson = W boson < gluon.
	C	24.14	Incorrect. The W boson mediates the weakest force (weak nuclear force) so will be weaker than the photon (electromagnetic force), which in turn is weaker than the gluon (strong nuclear force). That is, in order of ascending strength it would be: Z boson <photon < gluon.
	D	48.12	Correct. The three forces of the standard model that are mediated by gauge bosons are, in order of increasing strength, and their bosons are: weak nuclear force (W, Z bosons), electromagnetic force (photons), strong nuclear force (gluons). This option has them in the correct order of ascending (increasing) strength. Note: *ascending* is not a syllabus term but should be generally understood to mean 'increasing'. See NCPQ Table p 361.

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