QCAA PHYSICS EXTERNAL ASSESSMENT 2022

ALTERNATIVE SEQUENCE

Worked solutions and explanations to Alternative Sequence Paper 1 Multiple choice

- from Dr Richard Walding, author *New Century Physics for Queensland* (OUP)

Note: I have included worked solutions and explanations to the multiple choice questions to other QCAA Physics EA papers on my website at seniorphysics.com/ncpq. See the bottom of that page for links.
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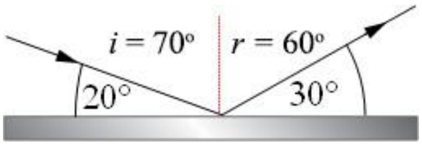
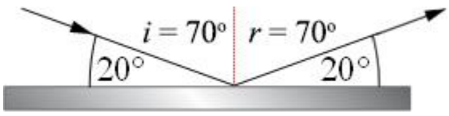
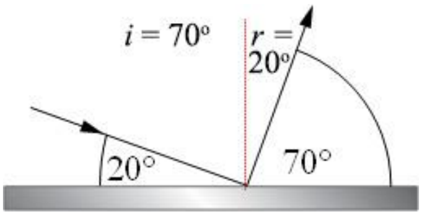
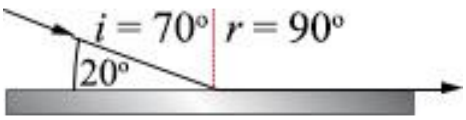
Option	Solutions and explanations (validity statements and distractor justification)
1	***Electromotive force is…etc***
A	Incorrect. This is the definition of electromagnetic induction and not electromagnetic force. See Syllabus Glossary page 73 and NCPQ p215.
*B	Correct. See Syllabus Glossary page 73 and NCPQ p 215.
C	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	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 photon is described as... etc***
A	Incorrect. This refers to electromagnetic radiation. See Glossary: *electromagnetic radiation - electromagnetic waves, propagated at the speed of light in a vacuum*
B	Incorrect. Photons do not require a medium for their propagation. See NCPQ U3&4 p302
*C	Correct. Glossary p 86 and NCPQ p315 and 316.
D	Incorrect. This refers to a gluon. See Glossary in NCPQ page 415.
3	***The energy available for electrical charges…etc***
*A	Correct. Potential difference is *the change in potential energy per unit (1 coulomb) charge between two defined points in a circuit.* Note: the syllabus definition is under the heading for 'electrical potential difference' page 73. In NCPQ U1&2 I have called it just 'potential difference' and said it is *the change in potential energy per unit charge between two defined points in an electric field*. This is a more general definition.
B	Incorrect. This is neither correct nor a syllabus term. Capacitance is a measure of the ability to store electric charge anyway. You do not have to know about this for the EA.
C	Incorrect. Resistance is the ratio of the voltage applied to the electric current that flows through it.
D	Incorrect. Current is the rate of movement of electric charge carriers from one part of a conductor to another.

4	***One kilogram of an unknown substance is heated…etc***
A	Incorrect. Out by a factor of 100 somewhere
B	Incorrect. Forgot to convert minutes to seconds.
C	Incorrect. Possibly misread the graph and used a time of 5 minutes.
*D	Correct. Total energy used is 1000 W (1000 J/s) for 8 minutes ($8 \times 60\ s$) $$P = \frac{W}{t}$$ $$W = Pt = 1000 \times (38 - 30) \times 60 = 4.8 \times 10^5\ J$$ $$W = Q\ (energy) = mL_v$$ $$L_v = \frac{W}{m} = \frac{4.8 \times 10^5\ J}{1\ kg} = 5 \times 10^5\ J\ (1\ sf)$$
5	***Which option accurately depicts the reflection…etc***
A	Incorrect. Angle of incidence ≠ angle of reflection. 
*B	Correct: $\angle i = \angle r$ 
C	Incorrect: $\angle i \neq \angle r$ 
D	Incorrect: $\angle i \neq \angle r$ 

6	***After coherent light has been passed through a double slit…etc***
*A	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	Incorrect. The width of the slits will affect the pattern but not the phenomena of interference and the banding. See NCPQ p 301.
C	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	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	***Which change would produce the greatest increase in magnetic …etc]***
A	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	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	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	Incorrect. Alternating current passes through a $V = 0$ during each cycle so this will reduce the average B value in a cycle.
8	***Determine the wavelength of an electromagnetic wave...etc***
A	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	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	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	Incorrect. Has formula upside down. Rearranges $E = \frac{hc}{\lambda}$ to $\lambda = \frac{E}{hc} = 1.2 \times 10^{2}$ m

9	***An experiment was conducted to determine the resistance…etc***
A	Incorrect. Calculated gradient which is the reciprocal of the resistance. $$Gradient = \frac{I}{V} = \frac{(6-0)\times 10^{-3}}{12-0} = 5\times 10^{-4}$$
B	Incorrect. Calculated gradient but didn't take reciprocal. Also left current in mA instead of A. $$Gradient = \frac{I}{V} = \frac{(6-0)}{12-0} = 5\times 10^{-1}$$
C	Incorrect. Didn't convert current from mA to A. $$Gradient = \frac{I}{V} = \frac{(6-0)}{12-0} = 0.5$$ $$R = \frac{V}{I} = \frac{1}{gradient} = \frac{1}{0.5} = 2\times 10^{0}\ \Omega$$
*D	Correct. $$Gradient = \frac{I}{V} = \frac{(6-0)\times 10^{-3}}{12-0} = 5\times 10^{-4}$$ $$R = \frac{V}{I} = \frac{1}{gradient} = \frac{1}{5\times 10^{-2}} = 2\times 10^{3}\ \Omega$$
10	***Electric field strength refers to the...etc***
*A	Correct. See definition in Glossary page 73, NCPQ p 164.
B	Incorrect. This is about change in potential energy ΔU, and not electric field strength.
C	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	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	***The maximum kinetic energy of an electron ejected…etc***
A	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	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	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 model. Learn this. See NCPQ p 314.
*D	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 lightbulb produces 360 J of light energy and 1580 J...etc***
A	Incorrect. Calculated ratio of outputs. $$\frac{1580}{360} = 4$$
B	Incorrect. Calculate ratio of total input over light output. $$= \frac{1920}{360} = 5$$
*C	Correct. $$\eta = \frac{W_{out}}{W_{in}} \times 100\%$$ $$= \frac{360}{360 + 1580} \times 100\%$$ $$= 19\%$$
D	Incorrect. Used the 1580 J of heat out as total heat in. $$\frac{360}{1580} \times 100 = 23\%$$
13	***A rectangular coil of 3000 turns and dimensions...etc***
A	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	Incorrect. May have miscalculated the area: $$\Delta t = -\frac{3000 \times (2 \times 10^{-3}) \times (0.1 + 0.2)}{6} = 0.33 \text{ s}$$ $$\text{f} = \frac{1}{T} = \frac{1}{0.33} = 3 \text{ rps}$$
*C	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:

	$$= -n\frac{\Delta(BA\cos\theta)}{\Delta t}$$ $$= -n\frac{BA\,\Delta(\cos\theta)}{\Delta t}$$ $$\Delta t = -n\frac{BA\,\Delta(\cos\theta)}{emf}$$ Now $\Delta(\cos\theta) = -1$ given that θ goes from 0° to 90° in ¼ of a turn. Thus: $$\Delta t = n\frac{BA}{emf}$$ $$= \frac{3000 \times (2 \times 10^{-3}) \times (0.1 \times 0.2)}{6}$$ $$= 0.02\ s\ (for\ ¼\ turn)$$ $$= 0.08\ s\ (for\ 1\ turn)$$ $$f = \frac{1}{T} = \frac{1}{0.08}$$ $$= 12.5\ s^{-1} \approx 13\ rps\ (C)$$
D	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. $$T = 0.02\ s\ for\ 1\ cycle$$ $$f = \frac{1}{T} = \frac{1}{0.02}$$ $$= 50\ rps$$
14	***Which option shows the refraction of light passing…etc***
A	Incorrect. At the left-hand face the ray is passing from low to high refractive index media, so it correctly refracts towards the normal. However, at the right face it is passing from high to low RI so it should bend towards from the normal but is incorrectly shown as bending away from the normal.
B	Incorrect. The ray should be refracted at the left hand face as it is passing from air to glass. It does not refract (bend) at all. Secondly, at the right hand face the ray is perpendicular to the face so there will be no refraction. However, the diagram shows the ray bending away from the normal.
*C	Correct. At the left-hand face the ray is passing from low to high refractive index media, so it correctly refracts towards the normal. At the right face it is passing from high to low RI so correctly bends away from the normal.
D	Incorrect. At the left-hand face the ray is passing from low to high refractive index media, so it correctly refracts towards the normal. However, at the right interface the ray passes through unchanged whereas it should refract away from the normal.
15	***Which option is a property of mechanical waves...etc***
*A	Correct. They can't propagate in a vacuum like electromagnetic waves can.
B	Incorrect. This is a property of electromagnetic waves. See NCPQ U1&2 p378.
C	Incorrect. This is a property of electromagnetic waves. See NCPQ U1&2 p 436
D	Incorrect. This is a property of electromagnetic waves. See NCPQ U1&2 p436, U3&4 p230

16	***The graph shows the temperature of an insulated vessel***
A	Incorrect. Calculated gradient as 8.3 × 10^{-2} and selected option with 8.3 in it. $$gradient\ = \frac{(50-30)}{(6-2)\times 60} = 8.3\times 10^{-2}$$
*B	Correct. $$\begin{aligned} P &= \frac{W}{t} \\ W &= P\times t\ (=Q) \\ Q &= mc\Delta T \\ P\times t &= mc\Delta T \\ gradient &= \frac{\Delta T}{t} = \frac{P}{mc} \\ P &= gradient\ \times mc \\ &= \frac{(50-30)}{(6-2)\times 60}\times 5\times 4180\ [Note\text{: } time\ is\ in\ seconds] \\ &= 0.0833\times 5\times 4180 \\ &= 1741 \\ &= 1.7\times 10^3\ W \end{aligned}$$
C	Incorrect. Forgot to convert minutes to seconds. $$\begin{aligned} P &= gradient\ \times mc \\ &= \frac{(50-30)}{(6-2)}\times 5\times 4180 \\ &= 5\times 5\times 4180 \\ &= 1.0\times 10^5\ W \end{aligned}$$
D	Incorrect. Possibly calculated gradient upside down and chose option with closest value. $$gradient\ = \frac{(6-2)\times 60}{(50-30)} = 0.12\ [wrong]$$ $$\begin{aligned} P &= gradient\ \times mc \\ &= 0.12\times 5\times 4180 = 2.5\times 10^5\ \mathrm{W} \end{aligned}$$
17	*Three kilograms of ice at 0 °C is added to an*
*A	$$\lvert Q_L\rvert = \lvert Q_G\rvert$$ $$Q_{water\ cooling} = Q_{ice\ melting} + Q_{cold\ water\ warming}$$ A negative sign on the left is needed when there is a $(T_f - T_i)$ involved for energy loss: $$-m_w c_w (T_f - T_i) = mL_f + m_w c_w (T_f - T_i)$$ $$-20\times 4180\times (T_f - 25) = 3\times 3.34\times 10^5 + 3\times 4180\times (T_f - 0)$$ $$-83600T_f + 2090000 = 1.00\times 10^6 + 12540T_f$$ $$-96140T_f = -1090000$$ $$= 11.3\ ℃$$
B	Incorrect. Omitted the final temperature of the cold water warming on the right.

	$$\lvert Q_L \rvert = \lvert Q_G \rvert$$ $$Q_{water\ cooling} = Q_{ice\ melting} \cancel{+ Q_{cold\ water\ warming}}$$ $$-m_w c_w(T_f - T_i) = mL_f \cancel{+ m_w c_w(T_f - T_i)}$$ $$-20 \times 4180 \times (T_f - 25) = 3 \times 3.34 \times 10^5 + \cancel{3 \times 4180 \times (T_f - 0)}$$ $$-83600T_f + 2090000 = 1.00 \times 10^6 \cancel{+ 12540T_f}$$ $$-83600T_f = -1090000$$ $$= 13.0\ °\mathrm{C}$$
C	Incorrect. Two mistakes: neglected the negative sign on the left; and omitted the initial temperature of the water. $$\lvert Q_L \rvert = \lvert Q_G \rvert$$ $$Q_{water\ cooling} = Q_{ice\ melting} + Q_{cold\ water\ warming}$$ $$+m_w c_w(T_f \cancel{- T_i}) = mL_f + m_w c_w(T_f - T_i)$$ $$+20 \times 4180 \times (T_f \cancel{- 25}) = 3 \times 3.34 \times 10^5 + 3 \times 4180 \times (T_f - 0)$$ $$+83600T_f = 1.00 \times 10^6 + 12540T_f$$ $$+71060T_f = 1.00 \times 10^6$$ $$= 14.0\ °\mathrm{C}$$
D	Incorrect. Neglected the negative sign on the left. Assumed value was positive (+). Ignored negative sign at end. $$\lvert Q_L \rvert = \lvert Q_G \rvert$$ $$Q_{water\ cooling} = Q_{ice\ melting} + Q_{cold\ water\ warming}$$ $$+m_w c_w(T_f - T_i) = mL_f + m_w c_w(T_f - T_i)$$ $$+20 \times 4180 \times (T_f - 25) = 3 \times 3.34 \times 10^5 + 3 \times 4180 \times (T_f - 0)$$ $$+83600T_f + 2090000 = 1.00 \times 10^6 + 12540T_f$$ $$+71060T_f = -1090000$$ $$= (-)15.4\ °\mathrm{C}$$
18	***The primary and secondary coils ...etc***
A	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	Correct. Current in the secondary is decreased. See NCPQ p 228. $$I_p V_p = I_s V_s$$ $$\frac{V_p}{V_s} = \frac{I_s}{I_p} = \frac{n_p}{n_s} = \frac{4}{6}$$ $$I_s = I_p \times \frac{4}{6}$$ $$\therefore I_s < I_p$$

C	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	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 current-carrying wire is placed perpendicular...etc***
A	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	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	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	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	***An 8.0 V battery is used to power a circuit...etc***
A	Incorrect. Omitted to square voltage. $$\mathrm{P} = \frac{V^2}{R} = \frac{8.0}{6.0} = 1.3\ \Omega$$
*B	Correct. $$R_t = R_1 + R_2$$ $$= 2.4 + 3.6 = 6.0\ \Omega$$ $$P = VI = \frac{V^2}{R}$$ $$= \frac{8^2}{6}$$ $$= 11\ W$$ Alternatively, calculate the current: $$I = \frac{V}{R} = \frac{8.0}{6.0} = 1.33\ A$$ $$P = VI = 8.0 \times 1.33 = 11\ W$$
C	Incorrect. Used the average value for resistance. $$R_{av} = \frac{2.4 + 3.6}{2} = 3\ \Omega$$

	$$P = \frac{V^2}{R} = \frac{8.0^2}{3} = 18\ \text{W}$$
D	Incorrect. Used P = VR $$P = VR\ = 8.0 \times\ 6.0 = 48\ W$$ Note: another common mistake is to use the resistors in parallel formula. $$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots \frac{1}{R_n}$$ $$\frac{1}{R_t} = \frac{1}{2.4} + \frac{1}{3.6}$$ $$R_t\ = 1.44\ \Omega$$ $$P = \frac{V^2}{R} = \frac{8.0^2}{1.4} = 44\ \text{W}$$