Level 2 Physics: Electricity – Electromagnetism - Answers

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<tr><th>Question</th><th>Evidence</th><th>Achievement</th><th>Merit</th><th>Excellence</th></tr>
<tr><td>2020 (3)
(a)</td><td>$V = BvL = 40\times10^{-6}\times236\times68.4 = 0.646\text{ V}$</td><td>This is a show question.</td><td></td><td></td></tr>
<tr><td>(b)</td><td><table>
<tr><th>Action</th><th>Effect on size of induced voltage</th><th>Which colour wing is positive</th></tr>
<tr><td>Speed of plane increases</td><td>Voltage increases</td><td>Red</td></tr>
<tr><td>Plane is flown in opposite direction at the same speed</td><td>Voltage stays the same
No effect/ no change etc</td><td>Red</td></tr>
<tr><td>Plane flies vertically upwards from the Earth</td><td>No voltage (accept lowers)</td><td>None
Accept neutral or equivalent not both</td></tr>
</table></td><td>TWO correct entries.</td><td>FOUR correct entries.</td><td>FIVE correct entries.</td></tr>
<tr><td>(c)</td><td>$I = \frac{28}{5} = 5.6$ and $F = BIL = 4\times10^{-5}\times5.6\times5.9 = 1.32\times10^{-3}\text{ N}$
Direction is left.</td><td>Force OR direction given.</td><td>Force AND direction given.</td><td></td></tr>
<tr><td>(d)</td><td>The wire is cutting through the magnetic field, and there is voltage inducedon the wire, which is equal to the voltage induced on the wings. This makes the red wing tip and the “red” end of the wire positive and no current flows, meaning the lamp will never go, so the arrangement would be no good as a speed-warning device.</td><td>Accept if speed increases induced voltage on plane increases. Or opposite.</td><td>Voltage induced on wire increases as speed increases or explains how there is a voltage on the wire.</td><td>The lamp won’t go –with correct reason</td></tr>
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2019 (3) (a)	$V = BvL = 4.73\times10^{-6}\times13.5\times0.42$ $= 2.68\times10^{-4}$ V Show question.	Show question. Accept use of 42		
(b)	The electrons are cutting the magnetic field as the handlebars move. There isa force on the electrons that causes a charge separation. The two ideas are movement across field and charge separation.Not "**in or entering** a magnetic field"	ONE of: **Movement** across B. Charge separation.	Both.	
(c)(i) (ii)	Voltage is less. Because the component of the velocity at 90° to the magnetic field hasdecreased. Must refer to movement.	Induced voltage is less.	Correct answer to (i)and a valid reason. E.g. horizontal speedless. Crosses field linesslower. OR similar.	
(d)	$V = BvL = 0.8\times1.2\times3.1 = 2.976$ $V = IR$ so $I = 0.5952$ and $F = BIL = 0.8\times0.5952\times1.2 = 0.571$ N	Correct voltage OR Uses 1.5m twice (0.89N)	One error, uses L = 1.5 once (0.714N)	Correct answer.0.571N
2018 (2) (a)	AB: Down BC: No force DE: Up	TWO of three.	All three	

(b)	$F = BIL \rightarrow L = \frac{F}{BI} = \frac{0.60}{0.20 \times 2.5} = 1.2\text{ m}$ $L_{AB} = \frac{1}{2}L_{total} = \frac{1}{2} \times 1.2 = 0.60\text{ m}$	1.2 m (7.5 calculator error no brackets on denominator.)	0.60 m	
(c)	V = BvL V = 3.5 x 7.5 x 0.16 x 4.2 V End A is positive.	Correct voltage OR Correct end.	Both.	
(d) (i) (ii)	Yes, a voltage is induced in both cases. In Experiment 1, as one conductor is outside the B-field, no voltage is induced in this wire. A voltage is induced in the moving rod moving across a magnetic field ($V = BvL$), so a current would flow (clockwise). In Experiment 2, both conductors are the same length, moving at the same speed in the same magnetic field, creating the same induced voltage in both lengths of wire, causing no current to flow. In Experiment 3, as one conductor is not moving, no voltage ($V = BvL$) is induced in this rod, but a voltage is induced in the second moving wire so a current does flow (in a clockwise direction).	Yes, to one voltage (no rubbish). OR One current correct with reason	ONE voltage statement correct, with **linked** correct, **justified** current statement. OR THREE current statements, two of which are justified.	One voltage statement correct. AND THREE current statements, TWO of which are **justified**. OR for Max E7 One voltage statement correct. AND TWO current statements justified.

2017 (3) (a)	$I = \frac{V}{R} = \frac{12}{2.4} = 5\text{ A}$ $F = BIL = 30\times10^{-6}\times5.0\times1.6$ $F = 2.4\times10^{-4}\text{ N to the left}$	Correct current AND Correct direction OR Correct force.	Correct force AND Correct direction.	
(b)	• The force on the wire connected to the positive terminal is **equal and opposite** the force on the wire connected to the negative terminal. • As the magnetic force has no effect (no net force), it will not change the time to complete the flying fox. • Also, the force is so small, even if it was not cancelled out it would be negligible.	1 bullet point from evidence.	2 bullet points from evidence. Must state force on each wire will be equal in magnitude and opposite in direction, so no effect.	
(c)	$V = Bvl = 30\times10^{-6}\times12.0\times1.6$ $V = 5.76\times10^{-4}\text{ V}$	Correct answer		

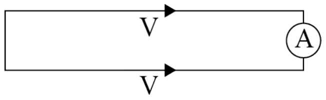
(d)	The wires Sam has used to connect the light are composed of free-to-move charges, which are moving across (90° to) a magnetic field. From $F = Bqv$, these charges experience a force. Positive charges experience a force to the top of the wire, and negative charges to the bottom of the wire. Work is done to separate these charges, creating a voltage. Although a voltage is induced, the polarity is the same in both wires (positive at the top), meaning no current will flow, so the bulb cannot glow. <u>Components of answer:</u> • Charges experience a force. • Because moving 90° to B-field. • Top is positive; bottom is negative. • Effect is same in both wires. • No current will flow; bulb can't glow.	2 bullet points from evidence.	3 bullet points from evidence.	Well linked answer
2016 (3) (a)	The rod moves to left.	Correct answer.		
(b)	$I = \frac{V}{R} = \frac{12}{20} = 0.6$ A $F = BIL$ $= 1.5 \times 10^{-3} \times 0.6 \times 0.16$ $= 1.44 \times 10^{-4}$ N	Correct current value or incorrect current but consequently correct force.	Correct force.	
(c)	The electrons in the conducting rod experience a force and move creating an induced voltage.	Partial explanation.	Complete explanation.	

(d)	$V = BvL$ $= 1.5 \times 10^{-3} \times 3.0 \times 0.16$ $= 7.2 \times 10^{-4}$ V $I = \frac{V}{R} = \frac{7.2 \times 10^{-4}}{20} = 3.6 \times 10^{-5}$ A Conventional current is down (A to B).	ONE of: • correct direction of conventional current • correct workings for induced voltage • correct workings for induced current.	TWO of: • correct direction of conventional current • correct workings for induced voltage • correct workings for induced current.	Comprehensive answer.
2015(2) (a)	Down.	Correct answer.		
(b)	$V = Bvl$ $v = \frac{V}{Bl} = \frac{0.15 \times 10^{-3}}{(3.0 \times 10^{-3}) \times (6.0 \times 10^{-2})} = 0.83 \text{ m s}^{-1}$	Correct except for wrong length OR wrong unit conversion.	Correct answer.	
(c)	$V = Bvl$ So if the speed doubles, the voltage doubles. Assuming the resistance is constant, this will cause the current to double.	Current doubles.	Correct answer and reason.	
(d)	The current is zero. Both sides of the loop are cutting across the magnetic field. Both sides of the loop have the same voltage induced. One voltage pushes the charges clockwise. The other voltage pushes the charge anticlockwise. The net voltage is zero (OR voltages cancel).	The current is zero.	The current is zero AND a reason (e.g. both wires are cutting the field and have an induced voltage).	Correct answer showing understanding of connection between concepts.

2014(4) (a)	*F* = *Bqv* $= 0.65 \times 1.6 \times 10^{-19} \times 4.8 \times 10^{3}$ $= 4.992 \times 10^{-16}$ N	*F* = *Bqv* $0.65 \times 1.6 \times 10^{-19} \times 4.8 \times 10^{3}$ $= 4.992 \times 10^{-16}$ N		
(b)	Conventional current will be anticlockwise (up the rod).	Conventional current will be anticlockwise (up the rod).		

(c)	• The magnetic force on the electrons causes charge separation. • Charge separation results in the formation of an electric field. • This results in an induced voltage across the ends of the wire. • Since it is a complete circuit, there will be a current. OR (Alternate answer) • The motion of the rod causes electrons in the rod to move to the bottom of the rod. • Top of rod is positive and bottom of rod is negative. • This means there is a voltage. • This causes electrons to flow around the loop (or causes a current to flow around the loop).	• The magnetic force on the electrons causes charge separation. • Charge separation results in the formation of an electric field. OR (Alternate answer) • The motion of the rod causes electrons in the rod to move to the bottom of the rod.	• The magnetic force on the electrons causes charge separation. • Charge separation results in the formation of an electric field. • This results in an induced voltage across the ends of the rod. OR (Alternate answer) • The motion of the rod causes electrons in the rod to move to the bottom of the rod. • Top of rod is positive and bottom of rod is negative. • This means there is a voltage.	• The magnetic force on the electrons causes charge separation. • Charge separation results in the formation of an electric field. • This results in an induced voltage across the ends of the wire. • Since it is a complete circuit, there will be a current. OR (Alternate answer) • The motion of the rod causes electrons in the rod to move to the bottom of the rod. • Top of rod is positive and bottom of rod is negative. • This means there is a voltage. This causes electrons to flow around the loop (or causes a current to flow around the loop).

(d)	$V = BvL$ $V = 0.85 \times 0.40 \times 4.6$ = 1.564 V $I = \frac{V}{R} = \frac{1.564}{0.68}$ I = 2.3 A $F = BIL$ $F = 0.85 \times 2.3 \times 0.40 = 0.782$ N F = 0.78 N	$V = BvL \rightarrow$ $V = 0.85 \times 0.40 \times 4.6$ = 1.564 V	$I = \frac{V}{R} \rightarrow \frac{1.564}{0.68}$ $I = 2.3$ A	$F = BIL$ $F = 0.85 \times 2.3 \times 0.40$ = 0.782 N F = 0.78 N
2013(3) (a)	Out of the page Towards the top of the page.	One correct.	Both correct.	
(b)	$F = BIL$ $B = \frac{F}{IL} = \frac{0.013}{35 \times 5} = 7.4 \times 10^{-5}$ T	Correct.		
(c)	$I = \frac{V}{R}$, so first calculate the voltage across the wire $V = BvL$ $V = (3.1 \times 10^{-5}) \times 3.0 \times 5.0$ $V = 4.65 \times 10^{-4} V$ $I = \frac{V}{R} = \frac{4.65 \times 10^{-4}}{1.5} = 3.1 \times 10^{-4}$ A	One correct equation and substitution.	Correct working except for one error.	Correct working and answer.

(d)	The current in the wire will become zero. There are now two wires cutting across the field in the same direction. Each wire has the same voltage induced across it. The two voltages are in opposite directions, so they cancel out. OR total voltage = zero.  	One correct statement.	Two correct statements.	Correct answer AND explanation.

Question	Achievement	Merit	Excellence
2012(1) (a)	The rod will move to the right.	The rod will move to the right because the current through the rod which is in the magnetic field will cause the electrons in the rod to experience a force to the right causing the rod itself to move. OR Power supply causes electrons to move through the rod. The electrons are cutting across a magnetic field, so have a force on them.	
(b)	$I = V / R \rightarrow I = 12.0 / 35.4 \rightarrow 0.34$ A	$I = V / R \rightarrow I = 12.0 / 35.4 \rightarrow 0.34$ A $F = BIL \rightarrow$ $F = 0.85 \times 10^{-3} \times .34 \times 18.5 \times 10^{-2}$ OR $= 0.85 \times 10^{-3} \times .34 \times 25 \times 10^{-2}$ $F = 7.2 \times 10^{-5}$ N	$I = V / R \rightarrow I = 12.0 / 35.4 \rightarrow 0.34$ A $F = BIL \rightarrow F$ $= 0.85 \times 10^{-3} \times .34 \times 18.5 \times 10^{-2}$ $F = 5.4 \times 10^{-5}$ N
(c)	$V = BvL \rightarrow$ $V = 0.85 \times 10^{-3} \times 2.5 \times 25 \times 10^{-3} \rightarrow$ $V = 5.3 \times 10^{-4}$ V		
(d)	The rod slows down and stops.	The rod slows down and stops because the induced current in the rod causes an electromagnetic force.	The rod slows down and stops because the induced current in the rod causes an electromagnetic force. This force is in the opposite direction to the movement, causing the rod to slow down and stop.

Question	Evidence	Achievement	Merit	Excellence
2011(1) (a)	Electrons flow from the negative terminal in the direction X→Y These electrons are cutting across a magnetic field that is towards the bottom of the page. Each electron experiences a force in the direction "A". This causes the wire to experience a force and to swing in direction "A" OR can explain in terms of conventional current.	[1] The loop swings in direction "A".	[1] Direction of charge flow and loop movement correct. OR Current direction and wire perpendicular/crossing/cutti ng (not in) field.	[1] Full explanation. Loop movement + Current flow + perpendicular / cutting / across (not in).
(b)	$V = IR$ $I = \frac{V}{R}$ $I = \frac{6.0}{1.8} = 3.33 \text{ A}$ $F = BIl$ $l = \frac{F}{BI} = \frac{0.25}{2.0 \times 3.33}$ $l = 0.038 \text{ m}$	[1] ONE correct calculation.	[2] All correct except for ONE error. Stops at 0.038 m.	[2] Correct answer. Must have = 3.8 cm.
(c)	Electron – direction "C" (or left).	[1] Correct answer.		

(d)	$V = Bvl$ $v = \frac{V}{Bl}$ $v = \frac{11\times10^{-3}}{2\times0.0375}$ $v = 0.1467 = 0.15 \text{ m s}^{-1}$	[1]Correct except for one error.	[2]Correct answer.	
2010(3) (a)	A motor is used in fans, cars, etc. A generator is used in a bicycle dynamo, power stations to produce electricity. A motor works on the principle that a **wire carrying current in a magnetic field** experiences a force. A generator works on the principle that a **moving conductor in a magnetic field (or electromagnetic induction)** will have an induced voltage. A motor converts electrical energy to mechanical / kinetic energy. Whereas a generator converts mechanical energy to electrical energy or chemical energy (battery of the sub).	[1]Any sensible use of a motor **AND** generator.	[1]Achieved **AND** States ONE correct energy transformation or ONE correct principle.	[1]Achieved **AND** states THREE of: The TWO energy conversions. The TWO principles involved.
(b)	$I = \frac{V}{R} = \frac{12}{4.5} = 2.67 \text{ A}$ $F = BIL$ $F = 0.75 \times 2.67 \times 12 \times 10^{-2}$ $F_{1 \text{ turn}} = 0.24 \text{ N}$ $F_{100 \text{ turns}} = 0.24 \times 100 = 24 \text{ N}$	[2]Correct answer to current. **2.67** OR Correct use of F= BIL with incorrect value of current.	[2]Correct answer for force on a single turn. OR One mistake in calculation, e.g. missing cm conversion.	[2]Correct answer.

(c)	Wire AD is parallel to the magnetic field. OR The wire does not cut the field. Or equivalent.	[1]Correct answer.		
(d)	Increase strength of magnetic field. Increase current/voltage/batteries. Increase length of **coil** or have more turns of wire. **Not increase the length.**	[1]Any TWO correct answers.		
2009(3) (a)	To the right.	[1] Correct answer.		
(b)	$I = \frac{V}{R} = \frac{12}{18} = 0.666\text{ A}$ $F = BIl = (4 \times 10^{-4}) \times 0.66 \times 8$ $F = 2.1 \times 10^{-3}\text{ N}$	[2] Correct current.	[2]Correct answer except for one error. E.g. no unit.	[2]Correct answer
(c)	No. The two wires carry current in opposite direction. The force on the two wires is in the opposite direction. The forces are equal and so they cancel.	[1]No force. Except if because yachts are stationary.	[1]Currents are equal and opposite.	[1]No. Currents opposite, forces equal and opposite.
(d)	Yes there is a voltage induced because the two wires are **cutting** across a magnetic field. This causes an induced voltage.		[1]Correct answer. Must convey **movement** at 90 degrees to/across field.	

(e)	$F = Bvq$ $F = 4\times10^{-4}\times3.0\times1.6\times10^{-19}$ $F = 1.9\times10^{-22}$ N	[2] Correct answer.		
2008(3) (a)	$V = BvL = 0.75\times0.20\times0.146\times2$ $V = 0.044$ V	[2]Correct except for one mistake. Either incorrect unit conversion (4.4) or missing x2 (0.022)	[2]Correct answer. 0.044	
(b)	**Stronger magnetic** field, **longer** length of **wire** in the field, **increasing the speed** with which the wire is made to move in the magnetic field.	[1]Correct answer.		
(c)	The induced voltage depends on the speed that the wire cuts across the magnetic field. The maximum induced voltage is produced when the coil is moving perpendicular to the direction of the magnetic field. The size of the induced voltage is minimum when the coil is moving parallel to the direction of the magnetic field. Hence the induced voltage changes from a maximum to a minimum every quarter cycle.	[1]Max when coil is flat or moving at 90 deg to field OR Min when coil is upright/vertical at 90 deg to field or moving along field.	[1] States the condition for both maximum and minimum voltage to be induced.	[1] Full and correct explanation e.g. linking changing velocity perpendicular to the field to voltage. OR Voltage must change from max to min (must state when min and max occur)

(d)	$I = \frac{V}{R} = \frac{12}{4.5} = 2.66\ \text{A}$ $F = BIl = 0.75 \times 2.66 \times 0.146 \times 100$ $F = 28\ \text{N}$	[2] Correct current. **2.66 A**	[2]Correct answer except for number of turns. OR Unit conversion (2800 N)	[2]Correct answer. 28N (29 N)
2007(3) (a)	Battery causes electrons to flow in axle. These electrons are moving perpendicular to a magnetic field. The electrons experience a force perpendicular to the axle and the field. The electrons are trapped in the axle so the whole axle experiences a force.	[1] one idea [1] Charge moving through a field experiences a force [1] Current flowing makes magnetic field.	[1] Force on charges. moving in magnetic field results in **force** on the **axles**. [1] The two magnetic fields interact and produce force (on axle).	
(b)	In / (arrow indicating left to right)	[1] Correct answer.		
(c)	$F = BIl$ $F = \frac{0.052}{2}$ $I = \frac{F}{Bl} = \frac{0.026}{0.25 \times 35 \times 10^{-3}}$ $I = 2.97\ \text{A}$ battery current $= 5.94\ \text{A}$ $V = IR$ $V = 5.94 \times 0.55$ $V = 3.3\ \text{V}$	[2] Correct equation and calculation of current. **2.97 or rounded** **OR 5.94**	[2] Correct process for calculating voltage but with one error. E.g. does not double = 1.6 / allow incorrect length conversion but **not 35.**	[2] Correct working and answer. **Accept any rounding e.g. 3.2, 3.27 etc.**

(d)	$V = Bvl$ $V = 0.25 \times 0.29 \times 35 \times 10^{-3}$ $V = 2.5\ \text{mV}$ **Only penalise the same incorrect length conversion once from c and d**	[2] Correct answer except for one error e.g. for unit conversion of either length or to mV **OR** incorrect length **OR** combining both axles.	[2] Correct answer.	
(e)	As the carriage rolls, the axles (and the electrons) cut across the magnetic field, the electrons in the wire get pushed to one end of the wire. This causes a build-up of negative charge at one end of the axle.	[1] One correct idea. [1] **Force /push** on electrons [1] Charge moving through mag field	[1] Full and clear explanation clearly linking ideas. [1] electrons then move / shift towards one end.	
(f)	The axle has an induced voltage across it, but the connecting wire is also cutting across the magnetic field. It also has an induced voltage. The two voltages oppose each other, so the induced current is zero.	[1] No current flows, [1] Induced voltage in axle [1] Induced voltage in wire	[1] Idea of two induced voltages. [1] lamp does not operate. **Contradictory statements will not negate achievement.**	[1] Full and clear explanation clearly linking ideas. [1] Two opposite induced Voltages cancel. [1] No change in flux as entire circuit / loop in field will mean no light / current.
2006(3) (a)	The moving electrons would experience a force and move towards A, leaving end B positive.	[1] ***Moving*** charge experiencing a force. • Electrons move up the rod. • End A negative. • End B positive.	[1] ***Moving*** electron experiences an upward force and either A negative or/and B positive.	

(b)	Since the circuit is now complete, the induced voltage would cause an anticlockwise current in the circuit (or would cause electrons to flow in a clockwise direction).	[1] Current produced. • Voltage produced. • Electron flow.	[1] Voltage causes a current/ electron flow. • Anticlockwise current. • Clockwise electron flow.	[1] Voltage causes an ***anticlockwise current*** in the circuit. Voltage causes a ***clockwise electron*** flow.
(c)	$V = BvL$ $V = 0.8 \times 4.0 \times 10 \times 10^{-2}$ $V = 0.32$ V $I = \frac{V}{R}$ $I = \frac{0.32}{2}$ $I = 0.16$ A	[2] Induced voltage calculated (*ignore std form).* • 32	[2] Correct Voltage • 0.32 • 16	[2] Correct current • 0.16
(d)	Arrow going from N to S. →	[1] Correct answer. →		
(e)	Up ↑	[1] Correct answer. ↑ • Up		
(f)	When a conducting wire carrying current is placed perpendicularly in a magnetic field, the electrons moving in the wire experience a force causing the wire itself to move in a direction that is perpendicular to both the direction of the magnetic field, and the current. The charge is cutting across the field.	[1] Charge moving in the magnetic field. • Current in the rod. • Rod perpendicular to the magnetic field. • Magnetic field around the rod.	[1] Electrons travelling across the magnetic field. • Current carrying rod across the magnetic field. • The magnetic **fields** add / subtract.	[1] Explanation of the magnetic flux difference.

2005(3) (a)	$V = BvL \times 2 \times 45$ $= 0.070 \times 12 \times 0.085 \times 90$ $= 6.4\ \text{V}$	[2] Correct equation and substitution of correct side. (Ignore length unit)	[2]Calculates voltage using the correct side. (Forgets to multiply by 45 turns **or** by 2 sides).	[2] Correct answer.
(b)	V = 0 Coil is moving parallel to the field.	[1]V = 0 [1]Parallel to magnetic field	[1]Correct answer **and** reason.	

The Mess that is NCEA Assessment Schedules….

Level 2 Physics: **AS 91173** replaced **AS 90257.**

In 90257, from **2004 to 2011**, there was an Evidence column with the correct answer and Achieved, Merit and Excellence columns explaining the required level of performance to get that grade. Each part of the question (row in the Assessment Schedule) contributed a single grade in either Criteria 1 (Explain stuff) or Criteria 2 (Solve stuff). From 2003 to 2008, the NCEA shaded columns that were not relevant to that question (Sorry haven't had time to do 2004 yet).

In 91173, from **2012 onwards**, the answers/required level of performance are now within the Achieved, Merit and Excellence columns. Each part of a question contributes to the overall Grade Score Marking of the question and there are no longer separate criteria. There is no shading anymore. At least their equation editor has stopped displaying random characters over the units.

And **in 2013-2015**, with 91173, we are back to an Evidence column with the correct answer and Achieved, Merit and Excellence columns explaining the required level of performance to get that part. Each part of a question contributes to the overall Grade Score Marking of the question. And now in **2014 - 2017**, we have the Evidence column back……