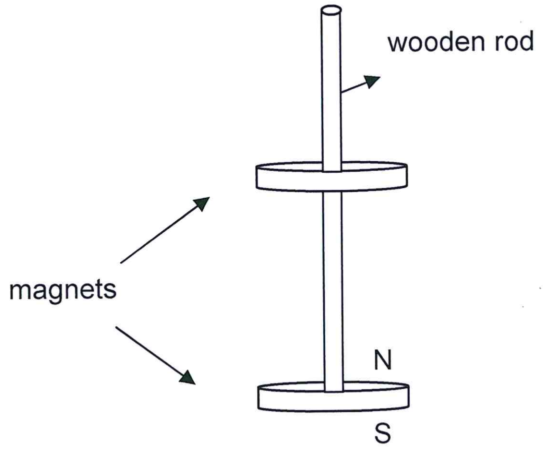
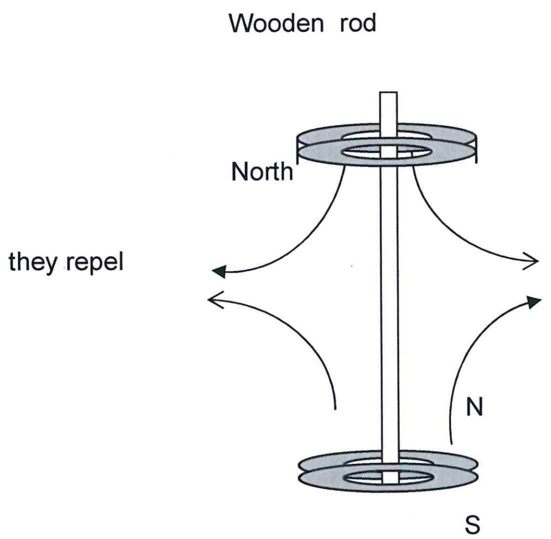
Exam Answers
Chapter 5·2 - Generators
Answer 1 2010:1:13

(4 marks)

Below is a diagram of a wooden rod on which there are two powerful magnets, one 'floating' above the other.



(a) Indicate the north pole of the floating magnet and draw the magnetic field lines between the magnets. (2 marks)



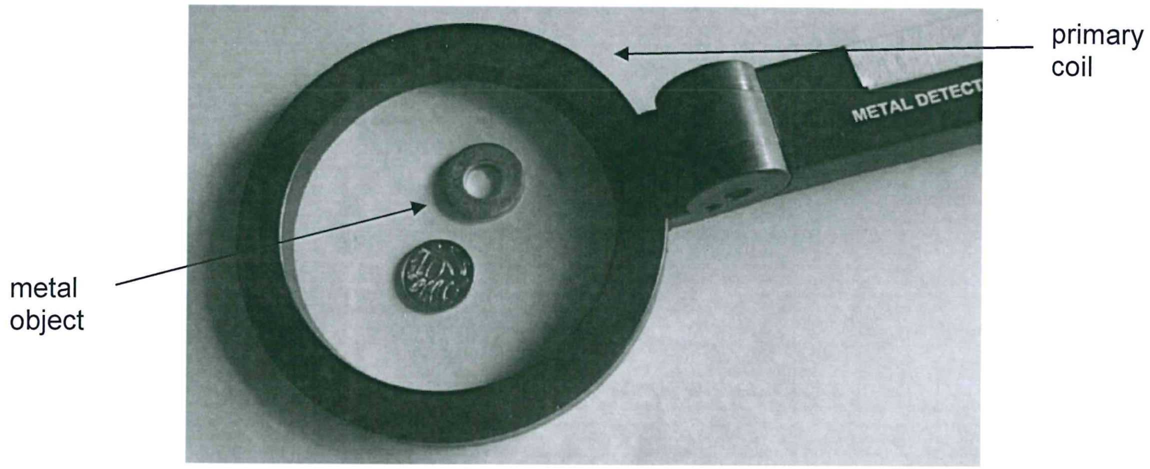
Description	Marks
North pole clearly marked on top magnet. Lines between poles show field lines repelling and so diverge (could have labels and arrows reversed).	1
Arrows on field lines N → S.	1
	Total 2

(b) Explain why the top magnet 'floats'. (2 marks)

Description	Marks
Two equal sized and opposite forces;	1
forces are magnetic repulsion and gravitational attraction.	1
	Total 2

Exam Answers
Chapter 5·2 - Generators
Answer 2 2010:2:15

(12 marks)



Above is a picture of a metal detector and a metal object. A ten cent coin has been added to give a sense of scale. The detector consists of a DC battery connected to a primary coil. There is a secondary coil connected to a buzzer that makes a sound when the primary coil moves over a metal object.

(a) Explain the principle of operation of this metal detector. In your answer, explain why the coil has to be moved whilst locating metal objects. (4 marks)

Description	Marks
Field produced in primary coil due to battery and coil	1
This field sweeps over the metal object so the field exposed to the object is changing.	1
This changing magnetic field in the object induces a voltage (currents) in the object and this produces a field in the secondary.	1
The current in the secondary flows through the buzzer producing a sound.	1
	Total 4

(b) What type of metal can the detector find? Circle the correct answer. (1 mark)

copper and tin　　　iron and steel　　　any metal

Description	Marks
Any metal	1
	Total 1

EXAM ANSWERS
Chapter 5·2 - Generators
Answer 2 continued

(c) Use the following data to **estimate** the voltage in the secondary buzzer circuit. (5 marks)

Magnetic field strength within primary coil = 0.0500 Wb

Number of turns in secondary coil = 10

Time of sweep = 0.5 s

Description	Marks
Students may interpret the magnetic field information as either field strength or as enclosed flux. Estimate for change in field (or flux) due to small coin. Since r_{coin} =1cm then area of coin $A_{coin} = \pi\times(0.01)^2 = 0.0003\ m^2$.	1
Radius of the coil seems about 5 cm or 0.05 m (plus or minus 1 cm) Thus $A_{coil} = \pi\times(0.05)^2 = 0.008\ m^2$ which is about 25 times the area of the coil. Thus $\Delta\Phi_{coin}$ is 1/25th of flux through coil.	1
Estimate of time to move across coin. Estimate that a "sweep" covers a distance of about 1m in 0.5s thus a speed of 2m/s so time to traverse coin of diameter 2cm is about 0.02m/2m/s = 0.01s.	1
$\text{emf} = -N\frac{\Delta\Phi}{t}$ $= -N\frac{A\Delta B}{t}$	1
Assume maximum change occurs in 0.01s and there is 100% flux linkage(in reality much less) so $\text{emf} = -10\left(\frac{0.0003\times0.05}{0.01}\right)\ V$ $= 0.0015\ V$ (accept smaller or larger values as long as assumptions reasonable)	1
Or using value as flux $\text{emf} = -N\frac{\Delta\Phi}{t}$ $= -10\frac{0.05/25}{0.01}\ V$ $= 2\ V$	1 1
Note maximum of two if only plug numbers given into Faraday's Law (1V) Other 3 marks for comments and estimates of how the rate of flux changes due to presence of coin/metal 1 mark if state Wb should be T and nothing else	
	Total 5

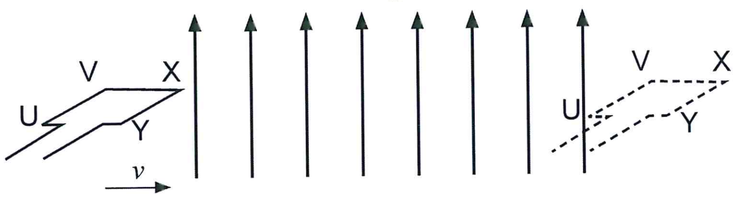
(d) How would the sound change if the metal detector was held stationary near a nail? Give a brief reason for your answer. (2 marks)

Description	Marks
No sound, because no induced voltage.	1–2
	Total 2

Exam Answers
Chapter 5·2 - Generators
Answer 3   2014:2:17

(17 marks)

As a rectangular coil loop (UVXY) is moved from left to right, it enters a uniform magnetic field, B, as shown in the diagram below. The plane of the loop is perpendicular to the magnetic field lines. According to Faraday's law, an emf must be induced in the loop. Assume that the emf induced in the U-V-X-Y direction is negative, while in the Y-X-V-U direction the emf is positive.



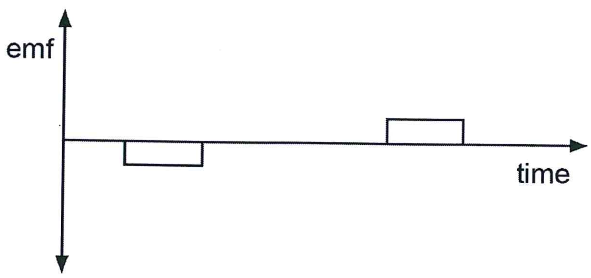
(a) A meter is connected to the loop to measure the emf generated in the circuit during one movement through the field. Fill in the following details of the meter: (2 marks)

Description	Marks
Type: Voltmeter or galvanometer (or one to measure the potential difference)	1
Units: Volts	1
Total	**2**

(b) During a second movement through the field, a light globe is attached between U and Y, making a circuit. Explain why the loop requires a force when entering and leaving the magnetic field. (4 marks)

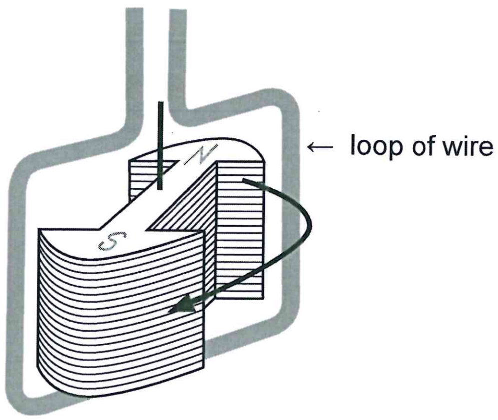
Description	Marks
The loop of wire experiences a change in magnetic flux and therefore induces current that opposes the change in flux (or relates to emf=-BΔA/Δt)	1–2
While the loop is partly in the magnetic field (entering), only the current in the Y-X segment experiences a force to the left (F=IℓB),	1
Similarly when the Y-X segment has left the field, the changing flux produces a current in the other direction, and the U-V segment experiences a force to the left.	1
Total	**4**

(c) Given that the velocity of the loop is constant, complete the graph below for the emf induced in the loop over the time that it moves into and out of the field. (4 marks)

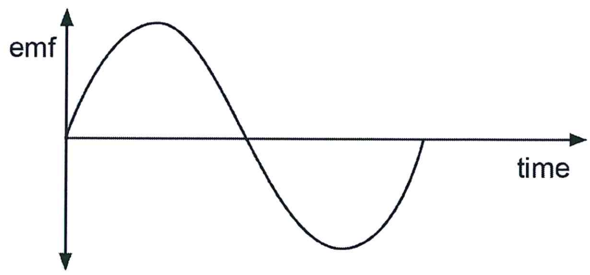
Description	Marks
 Graph shows the following features: • Negative to start • Two generations that are opposite to each other • Large gap in the middle • Two rectangular shapes that are the same	1–4
Total	**4**

Exam Answers
Chapter 5·2 - Generators
Answer 3 continued

(d) Another method of generating an emf is to move the magnet in a circular motion as shown in the diagram below.



(i) Complete the graph below for the current induced in the loop over one complete rotation of the magnet. (3 marks)



Description	Marks
Sinusoidal wave (arbitrary starting point)	1
One complete cycle	1
Has positive and negative components	1
Total	**3**

(ii) The loop of wire above is a square 5.00 × 5.00 cm. If the magnet rotates once every 1.00 s and has a magnetic field strength of 0.789 T, calculate the magnitude of the maximum emf generated. Assume that the field is completely reversed in the loop during the magnet's rotation. Show **all** workings. (4 marks)

Description	Marks
emf = $2NB\ell v$	1
where $v = \frac{2\pi r}{T} = 2\pi r f = 2\pi \times 0.025 \times 1 = 0.157\ \text{m s}^{-1}$	1
$\therefore$ emf = $2 \times 1 \times 0.789 \times 0.05 \times 0.157$	1
$= 1.24 \times 10^{-2}$ V (units not needed)	1
or	
emf = $2\pi BANf$	1–2
$= 2\pi \times (0.789) \times 0.0025 \times 1 \times 1$	1
$= 1.24 \times 10^{-2}$ V (units not needed)	1
or, if **average** emf calculated, max 3 marks as shown below.	
$A = 0.05 \times 0.05 = 2.5 \times 10^{-3}\ \text{m}^2$	1
For maximum $\frac{1}{4}T = t = \frac{1}{4} \times 1 = 0.25$ s	1
emf $= -NBA/t = -1(0.789)(2.5 \times 10^{-3})/0.25$ emf $= 7.89 \times 10^{-4}$ V (units not needed)	1
Total	**4**