3 **Fig. 3.1** shows a short bar magnet being dropped vertically through a small horizontal coil.

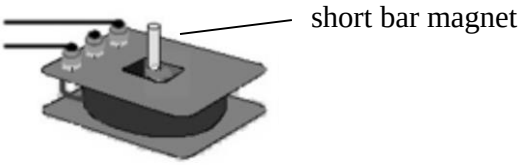

Fig. 3.1

Fig. 3.2 shows the graph of how the e.m.f. induced in the coil varies with time, as the magnet passes through the coil.

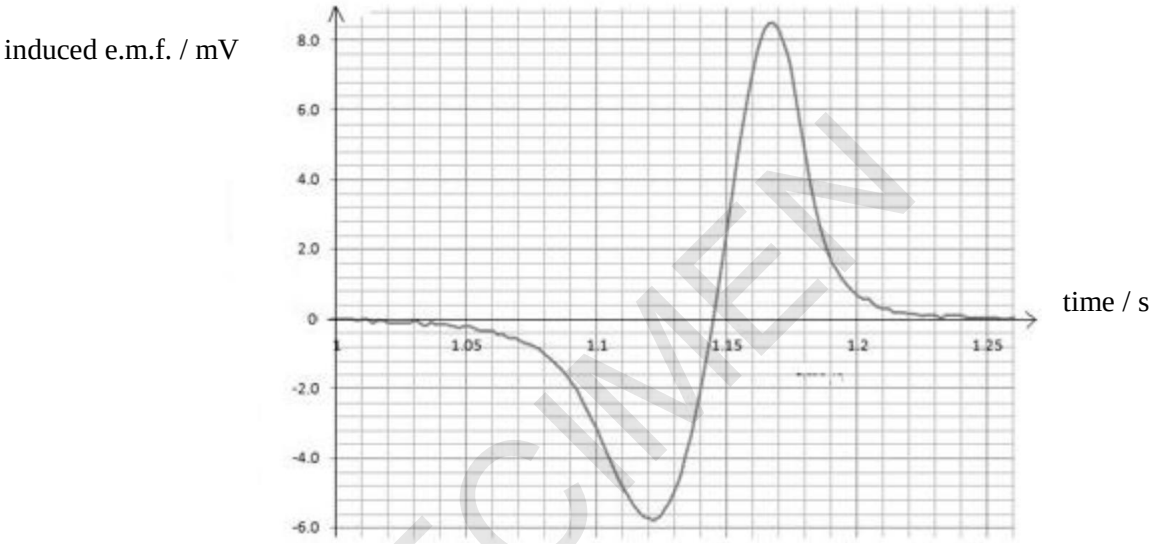

Fig. 3.2

(a)* Identify and explain the main features of the peaks of induced emf shown on **Fig. 3.2**, in terms of Faraday's law of electromagnetic induction. **[6]**

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Additional answer space if required.

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(b) An experiment is being planned for dropping a much longer bar magnet through the small coil of **Fig. 3.1** and measuring the induced emf.

Sketch and label an apparatus diagram.

State **one** aspect that would need to be controlled in order to obtain accurate data and explain how you would achieve this.

[3]

3 (c) Explain how the graph in **Fig. 3.2** would change if:

1 a much longer bar magnet replaced the short bar magnet.

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2 a much larger diameter coil replaced the small coil.

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[4]

(d) The data in **Fig. 3.2** were obtained using an 1100 turn coil.

Calculate the total flux linking the coil from when the magnet **enters** the coil to the point at which the magnet is central within the coil.

flux linked = **……**Wb **[2]**

Question			Answer	Marks	Guidance
3	(a)*		**Level 3 (5–6 marks)** All 3 features fully explained: sense and amplitude explained in terms of changes of flux linking coil. Explanations involve reference to Faraday's Law or $\varepsilon = (-) N \Delta\Phi / \Delta t$. **Sense:** increase in $N \Delta\Phi$ is + ve and decrease – ve. **Amplitude:** peak occurs when rate of change of flux linkage is greatest, may be mathematically expressed. **Area:** equated to total change of flux linkage with coil = $\Sigma \varepsilon \Delta t$ = (-) $N \Delta\Phi$ **or** sum of strips and same flux links coil on way in as unlinks from coil on way out. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** 2 or 3 features quite well explained: sense and amplitude explained in terms of changes of flux through coil. Explanation may involve reference to Faraday's Law or $\varepsilon = (-) N \Delta\Phi / \Delta t$. Area simply equated to change of flux and idea that increase = decrease in flux **or** both end points have zero flux through coil. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.*	6	**Indicative scientific points may include:** **Features of induced peaks to be explained** • Sense of each peak opposite • Amplitude of 2nd peak larger because greater speed or greater (-)$N \Delta\Phi / \Delta t$ • area under peaks is equal because $\Sigma \varepsilon \Delta t = (-) N \Delta\Phi$ **Vocabulary guidelines** • Level 3 in terms of changing flux linkage $N \Phi$ with coil • Level 2 in terms of changes of flux Φ through coil • Level 1 in terms of field lines B being cut by coil **Marking guidelines** • **accept** arguments using mathematical symbolism

Question			Answer	Marks	Guidance
			Level 1 (1–2 marks) 1 or 2 features explained at a low level in terms of cutting lines of magnetic field e.g. cut in opposite direction, cut at a different rate, total field cut on way in equals field cut on way out. Some attempt at $\Delta B / \Delta t$. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** No response or no response worthy of credit.		
	(b)		<u>Labelled sketch:</u> horizontal coil connected to data-logger **or** oscilloscope and vertical magnet ✓ OR plastic guide tube to keep long magnet vertical .... etc. <u>identify</u> uncertainty in timing as control variable ✓ <u>method:</u> increase sampling rate to reduce uncertainty in time **or** increase sensitivity in scale for p.d. **or** use automatic trigger on d-logger **or** identify using longer bar magnet increases transit time and thus reduces percentage uncertainty ✓	**3**	ignore clamps stands / unlabelled parts max 1 marks for diagram credit up to 2 sensible points - max 2 marks for method

Question			Answer	Marks	Guidance
	(c)		1 Peaks separate in time **or** a period of no emf between ✓ because only change in flux linking coil when magnetic poles enter or leave coil ✓ OR Second peak much greater amplitude and shorter duration ✓ due to higher velocity (under acceleration of gravity) as pole leaves coil and flux linkage changes at much greater rate ✓ 2 Very small **or** zero induced emf ✓ because flux of magnet loops close to magnet and does not reach to link with the much larger diameter coil ✓	**4**	
	(d)		Total flux linking coil = area under graph $N\Phi = \Sigma \varepsilon \Delta t$ **or** counting squares **or** area Δ ✓ ($\Phi = A / N = ½ \times 0.08 \times 5.8 \times 10^{-3} / 1100$) $= 0.21 \times 10^{-6}$ (Wb)✓	**2**	
			Total	**15**	