Electromagnetic forces – ① Motor effect

Magnetic fields + wires

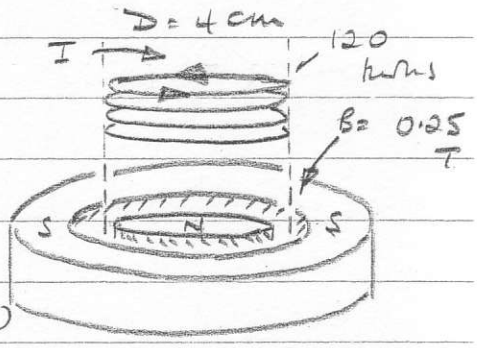
A Physics

Data:

Murphys £1.80 pint^{-1}

Loudspeaker

1. The coil of a speaker sits in a radial magnetic field as shown →



(a) Sketch a plan view of the coil and B-field and state which way it will move with the current as shown (2)

(b) Calculate the force on the coil for I = 1.8A. (3)

(c) The coil is made of wire with a mass of 5×10^{-3} g/m. Calculate the mass of the coil. (2)

(d) What is the maximum acceleration of the coil? (2)

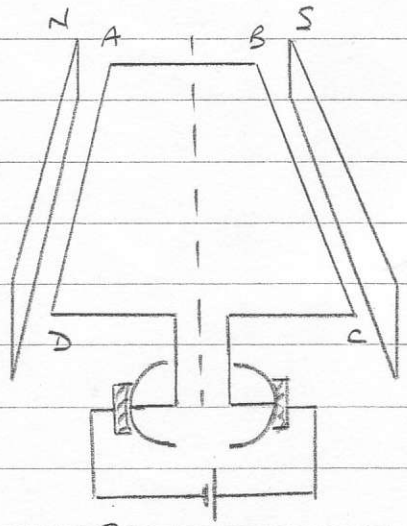
(e) The coil is fed with a fairly low frequency of 500 Hz, with a maximum current of 1.8 A (as in (b). State what kind of motion the coil follows, and calculate its amplitude of movement. (4)

(f) Sketch a graph to show the displacement of the coil over 2 cycles of the 500 Hz signal. (4)

(g) Mark on the graph the points where current in the coil is (i) greatest (ii) zero (2) [19]

Motoring....

2. The diagram shows the latest design of motor for a SONY minidisc player.*



(a) Which way will the coil rotate? (2)

(b) Sketch the coil ABCD and show the motor force on each of the sides. (2)

(c) Calculate the forces on... (i) side AB, (ii) side BC. (3)

(d) Calculate the turning effect (torque, in Nm) on the coil as shown in the diagram. (2)

(e) Imagine the coil in the diagram with 250 turns, and a moment of inertia = 1.1×10^{-4} kg m^2. Calculate.... (i) max. Torque (2) (ii) max angular acceleration (2)

B-field = 0.1 T

Size AB = CD = 4 cm

BC = AD = 6 cm

I = 1.5 A

[16]

(f) As this coil rotates, this torque varies between 0 and a max. Value. Can you draw a diagram to explain this? (3 : "No" gets 0.)

* £29.99 made of C from Willco.

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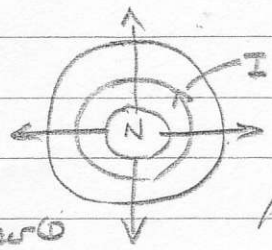
Electromagnetic forces – 1 – Answers — A Physics

wires in fields

1. (a)



B – ① field

coil moves down into paper ① /2

(b) $F = BIl$ ① wire at 90° to field

$l = 2\pi r N = \underline{15.1\ m}$ ①

$F = 0.25 \times 1.8 \times 15.1 = \underline{6.8\ N}$ ① /3

(c) coil mass = $l \times$ mass/m $= 15.1 \times 5 \times 10^{-3}$ ($\times 10^{-3}$ to kg)

$= \underline{75.4 \times 10^{-6}\ kg}$ /2

(d) $a = F_{max}/m$ ① $= 6.8/75 \times 10^{-6} = \underline{90.2 \times 10^{3}}$ ① m/s^2 /2

(e) coil "executes" (wobbles) with SHM ①

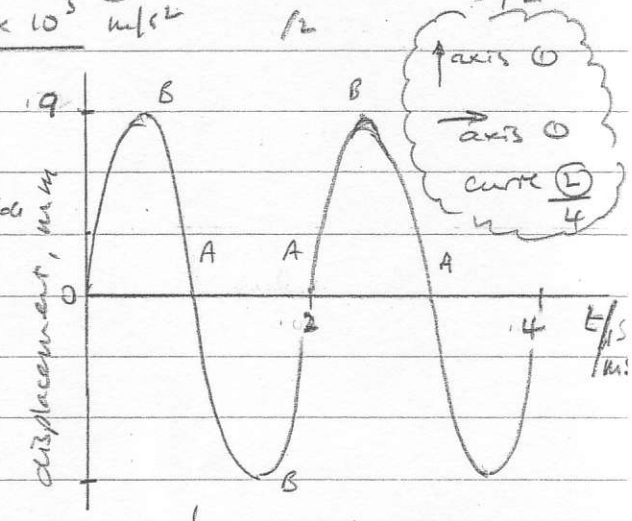
recall.... $a = -\omega^2 x$ ① $= -(2\pi f)^2 x$

and so $a_{max} = -(2\pi f)^2 A$ ✓ amplitude

$\omega = 2\pi f = 3141$ rad/s ①

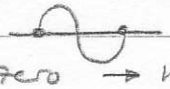
So Amplitude $A = 90.2 \times 10^3 / 3141^2$

somewhat large! $\rightarrow = \underline{9.1 \times 10^{-3}\ m}$ ① (9 mm)



/4

(f) $f = 500$ Hz $\rightarrow$ T.P. $= \underline{2 \times 10^{-3}\ s} = 2$ ms.

So for 1 wave  2 complete cycles /1

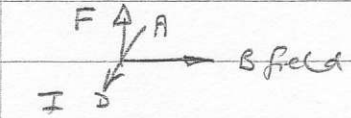
(g) when I coil = zero $\rightarrow$ no force on coil $\rightarrow$ no acceleration ∴

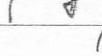
... so displacement / time graph is straight $\rightarrow$ positions A

I = max $\rightarrow$ max. force $\rightarrow$ max. change of slope $\rightarrow$ pos.tions B } /4

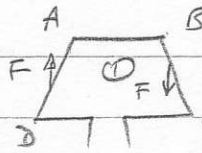
19

2. (a)



coil rotates  /2

(b)



F = 0 on AB & CD ① parallel to ① flux /2

(c) i (AB) $F_{BC} = BIl$ ① $= 0.1 \times 1.5 \times 6 \times 10^{-2}$

$= \underline{0.009}$ ① N (↑)

(ii) $F_{AD} = F_{BC} = \underline{0.009\ N}$ (↓) /3

(d) Torque $T = 2 \times F \times r = F \times d$ ① $= 0.009 \times 4 \times 10^{-2} = 0.00036 = \underline{360 \times 10^{-6}}$ ① Nm /2

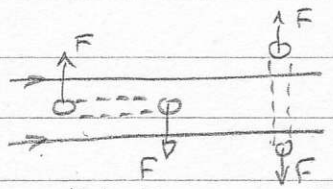
(e) (i) Torque for 250 turns $= 250 \times F \times d$ ① $= \underline{0.09}$ ① Nm

(ii) angular a max $= T/I$ ① $= 0.09/1.1 \times 10^{-4} = \underline{818\ rad/s^2}$

recall $T = I\alpha$

16

(f) B field constant



coil parallel to field, T = max

coil at 90° to field /3

T = 0

TLN 10.98 +2.03.

Total 1/19 2/16 = /35

Y12