AdvTec/sample solutions

PHYSICS 1003/1902
Mid-Semester Test SAMPLE: SOLUTIONS

Surname				**First name**			
SID				**Team no. (e.g. 6TEC12)**			
Q1 /4	**Q2 /4**	**Q3 /4**	**Q4 /4**	**Q5 /4**	**Q6 /10**	**Q7 /10**	**Total mark /40**

Duration **60** minutes + 5 minutes reading time. CLOSED BOOK test.
Questions 1–5 are worth 4 marks each; questions 6 and 7 are worth 10 marks each.
There should be sufficient space for working, but only the final answer is checked.
All numerical answers must have appropriate units and significant figures

DATA

Permittivity of free space	$\varepsilon_0 = 8.854 \times 10^{-12}\ \mathrm{F.m^{-1}}$
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{T.m.A^{-1}}$
Elementary charge	$e = 1.602 \times 10^{-19}\ \mathrm{C}$
Local gravitational acceleration	$g = 9.80\ \mathrm{m.s^{-2}}$

FORMULAS

$$F = ma$$

$$V = IR$$

$$V_{\mathrm{ab}} = E\,d$$

$$\varepsilon = vBL$$

$$R_{\mathrm{total}} = R_1 + R_2$$

$$v_{\mathrm{out}} = \frac{v_{\mathrm{in}} R_2}{R_1 + R_2}$$

$$v = V_0 e^{j\omega t} = V_0 \cos(\omega t) + jV_0 \sin(\omega t)$$

$$\omega_0 = \frac{1}{RC}$$

$$Q = \frac{f_0}{f_2 - f_1} = R\sqrt{\frac{C}{L}}$$

$$v_{\mathrm{out}} = \frac{v_{\mathrm{in}} Z_2}{Z_1 + Z_2}$$

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

$$E = \frac{\sigma}{\varepsilon_0} = \frac{Q}{\varepsilon_0 A}$$

$$\overrightarrow{F} = i\,\overrightarrow{l} \times \overrightarrow{B}$$

$$C = \frac{Q}{V_{ab}} = \varepsilon_0 \frac{A}{d} \quad \text{(parallel plates)}$$

$$F_B = ILB$$

$$\frac{1}{R_{\mathrm{total}}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$Z = R + jX$$

$$X_C = -\frac{1}{\omega C}$$

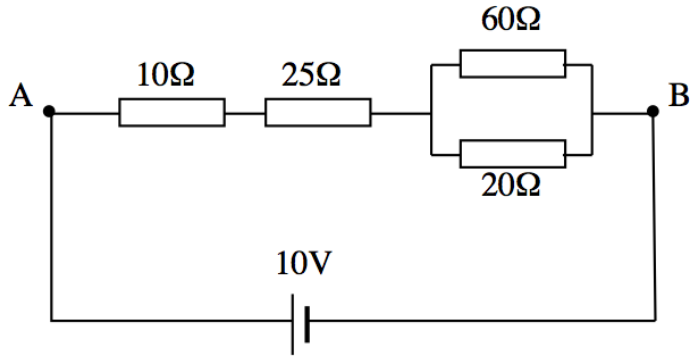
$$X_L = \omega L$$

$$Z_{\mathrm{total}} = Z_1 + Z_2$$

$$\frac{1}{Z_{\mathrm{total}}} = \frac{1}{Z_1} + \frac{1}{Z_2}$$

$$\omega = 2\pi f$$

Question 1 **[Total: 4 marks]**



(a) What is the resistance between the terminals A and B?

50 Ω

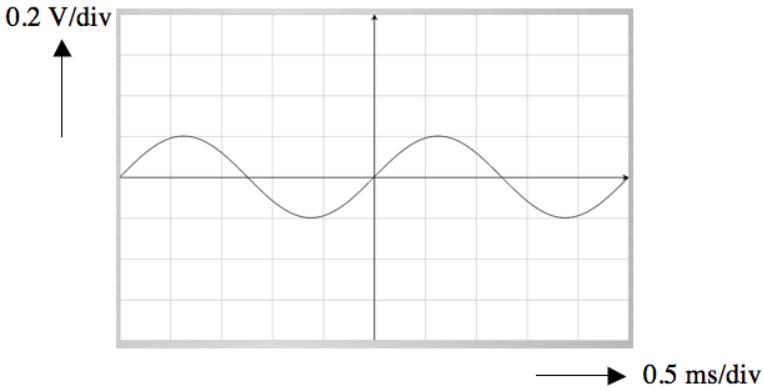
(2 marks)

(b) Calculate the current through the 60 Ω resistor.

0.05 A

(2 marks)

Question 2 **[Total: 4 marks]**



The above signal is observed on an oscilloscope with its controls set as indicated.

(a) What is the amplitude of the signal?

0.2 V

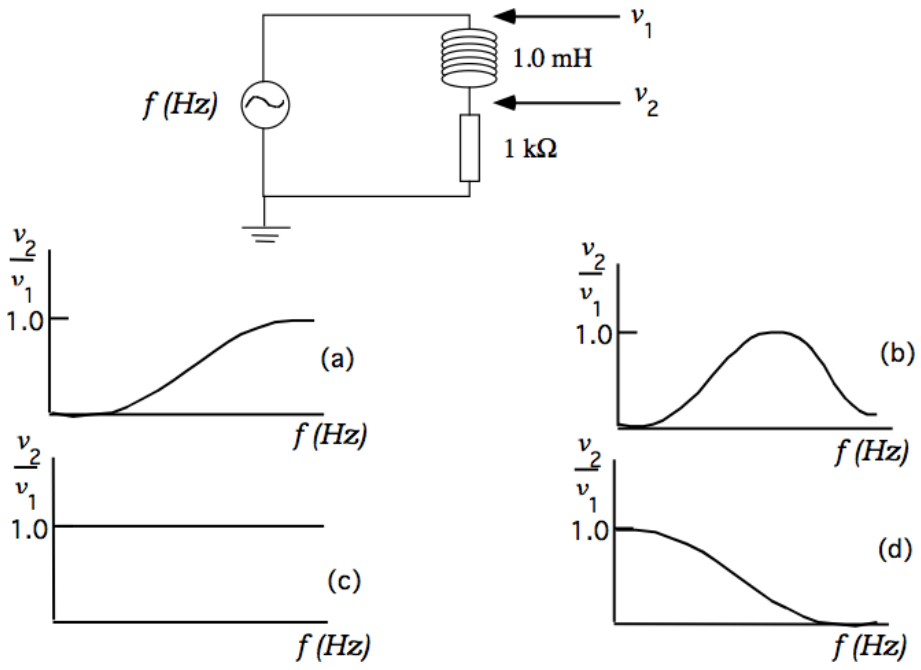
(2 marks)

(b) What is the frequency of the signal?

400 Hz

(2 marks)

Question 3 **[Total: 4 marks]**



(a) Which of the graphs (a) to (d) best represents the ratio v_2/v_1 vs f in this circuit?

(d)

(2 marks)

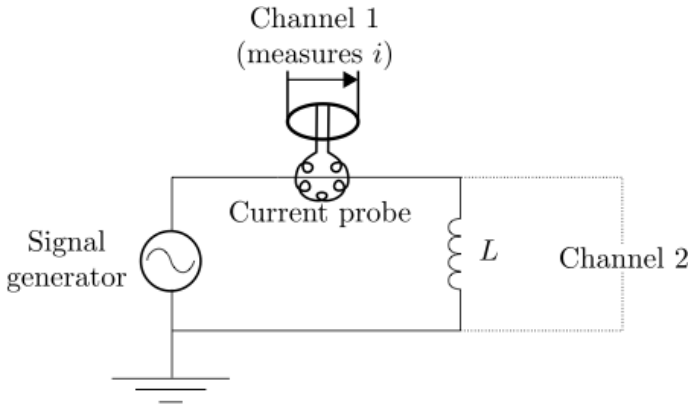
(b) What is this circuit used for?

Low-pass filter: low frequencies are passed unchanged, but high frequencies are attenuated.

(2 marks)

Question 4 **[Total: 4 marks]**

The signal generator in the circuit shown below has a sine wave output of amplitude 10 V (measured by channel 2 of an oscilloscope), at a frequency of 15 kHz. The inductor has $L = 10\ \mathrm{mH}$.



(a) Calculate the amplitude of the current measured by the current probe (Channel 1).

11 mA

(2 marks)

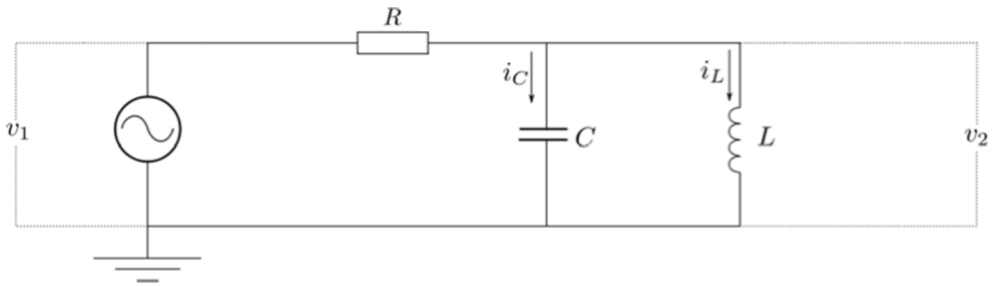
(b) Does the current lead or lag the voltage across the inductor?

Lags

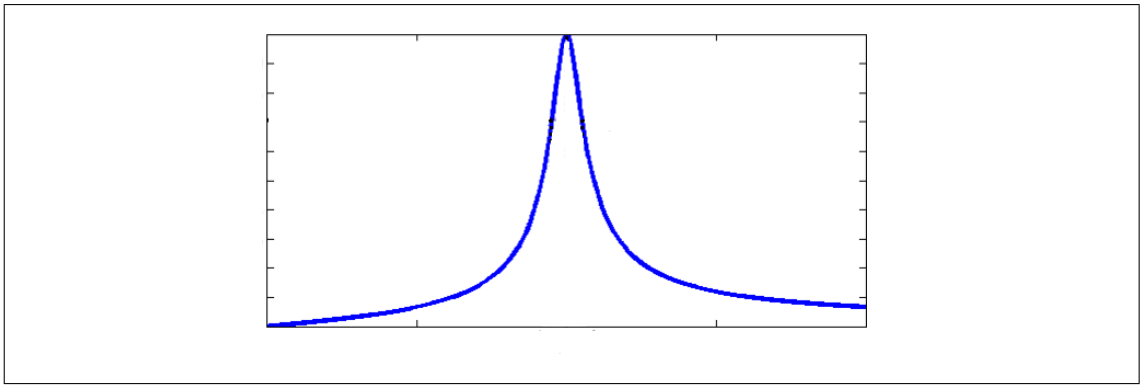
(2 marks)

Question 5 **[Total: 4 marks]**

In the RLC circuit below, $R = 10.0\ \text{k}\Omega$, $C = 10.0\ \text{nF}$, and $L = 10.0\ \text{mH}$,



(a) Sketch the frequency response of the above circuit.



(2 marks)

(b) Calculate the quality factor of the circuit.

10

(2 marks)

Question 6 **[Total: 10 marks]**

A horizontal parallel plate capacitor with plates of area $A = 1\ \mathrm{m}^2$ separated by distance $d = 0.02\ \mathrm{m}$ has a charge $Q = 4 \times 10^{-10}\ \mathrm{C}$ on the upper plate and $-Q$ on the lower one.

(a) Find the strength and direction of the electric field between the plates.

45 N/C, down

(2 marks)

(b) What is the capacitance of the capacitor?

$\mathbf{4.4 \times 10^{-10}\ F}$

(2 marks)

(c) What is the magnitude and direction of the electric force acting on an electron between the plates of the capacitor?

$\mathbf{7.2 \times 10^{-18}\ N}$**, up**

(2 marks)

(d) Compare the electric force with the gravitational force acting on the electron. Which way will the electron go?

$\mathbf{F_W = 9 \times 10^{-30}\ N \ll F_E}$**; up**

(2 marks)

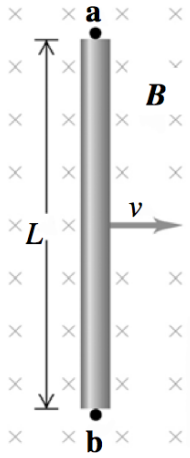
(e) If an electron is placed in the middle of the capacitor, how long would it take for it to hit one of the plates?

$\mathbf{t = 5 \times 10^{-8}\ s}$

(2 marks)

Question 7 **[Total: 10 marks]**

A conducting rod with length $L = 0.500$ m moves in a magnetic field B of magnitude 0.600 T directed into the plane of the figure below. The rod moves with velocity $v = 4.50$ m.s^{-1} in the direction shown.



(a) Calculate the motional emf induced in the rod.

1.35 V

(3 marks)

(b) What is the potential difference between the ends of the rod?

1.35 V

(2 marks)

(c) Which point, a or b, is at higher potential?

a

(2 marks)

(d) When the charges in the rod are in equilibrium, what is the magnitude and direction of the electric field within the rod?

2.7 V.m^{-1}, a $\rightarrow$ b

(3 marks)

THERE ARE NO MORE QUESTIONS.