Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Autumn Semester 2007-2008 (2 hours)

Principles of Communication and Electrical Engineering 6

Answer **THREE** questions. **No marks will be awarded for solutions to a fourth question.** Solutions will be considered in the order that they are presented in the answer book. Trial answers will be ignored if they are clearly crossed out. **The numbers given after each section of a question indicate the relative weighting of that section.**

1.

a. Three point charges are placed at coordinates (2,0,0), (4,0,0), and (6,0,0) as shown in figure 1.1, where the unit of length is metres. Calculate the force exerted on charge B due to charges A and C. ($\varepsilon_0 = 8.854 \times 10^{-12}$ *F/m)*

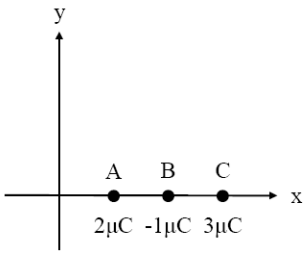

Figure 1.1 **(4)**

b. A parallel plate capacitor consists of two rectangular plates of area $a \times b$ separated by a distance d and contains three materials with different dielectric constants, ε_{r1}, ε_{r2}, ε_{r3}, as shown in figure 1.2.

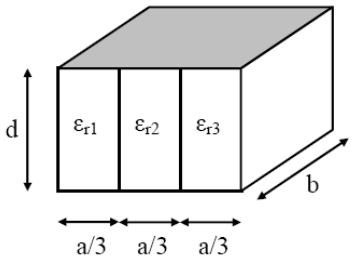

Figure 1.2

(i) Ignoring fringing fields, derive an expression for the total capacitance of this arrangement. **(4)**

(ii) If the capacitor is charged to 15V, calculate the energy stored in the capacitor when $a = 0.015$m, $b = 0.007$m, $d = 0.002$m, $\varepsilon_{r1} = 3$, $\varepsilon_{r2} = 6.5$, and $\varepsilon_{r3} = 4$. **(2)**

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c. The magnetic flux density at a point a perpendicular distance x from the centre of a thin straight conductor of length L, which is carrying a current I, is given by:

$$B = \frac{\mu_0 I}{2\pi x}\left[\frac{1}{1+(2x/L)^2}\right]^{\frac{1}{2}}$$

(i) Use this expression to deduce an expression for the B field at the centre of a square circuit where the length of each side is L. **(4)**

(ii) Figure 1.3 shows part of a circuit in the form of a regular polygon having n sides and carries a current I. The distance from the centre of the polygon to the vertices is b.

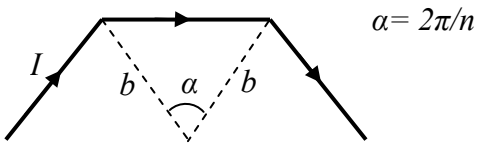


Figure 1.3

Show that the B field at the centre of the polygon is:

$$B_{POLY} = \frac{n\mu_0 I \tan(\pi/n)}{2\pi b}$$

You may require the expression: $1+\tan^2(\theta) = \frac{1}{\cos^2(\theta)}$ **(4)**

(iii) Use the equation given in part **c(ii)** for the field at the centre of a regular polygon to derive an expression for the B field at the centre of a circular loop of wire. **(2)**

2.

a. A 20kVA, 50Hz transformer which steps down from $1000V_{rms}$ to $100V_{rms}$ and has a primary winding resistance of 4Ω and a secondary winding resistance of 0.02Ω. The transformer draws a no-load current of $3A_{rms}$ at a 0.3 lagging power-factor when supplied at rated voltage. Calculate:

(i) the total resistance referred to the primary side **(1)**

(ii) the copper loss when operating on full load **(2)**

(iii) the cross-sectional area of the iron core if the maximum flux in the core must not exceed 1.5T and the primary winding has 2000 turns **(3)**

(iv) the losses in the core of the transformer **(1)**

b. A robot arm is actuated by a permanent magnet servo motor via a gearbox with a 5:1 transfer ratio. The parameters of the motor are as follows:

Torque constant = 0.3 Nm/A

Emf constant = 0.3 V/rads s

Armature resistance = 0.25Ω

It is a requirement that the robot arm moves through 150° in 3 seconds with the velocity-time profile shown in Figure 2.1. The total inertia of the system as seen by the motor is 0.5 kgm^2.

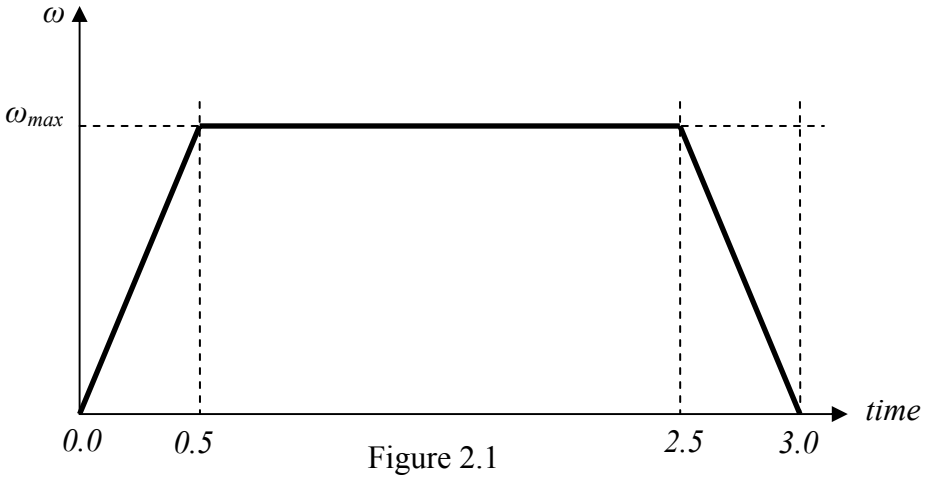


Figure 2.1

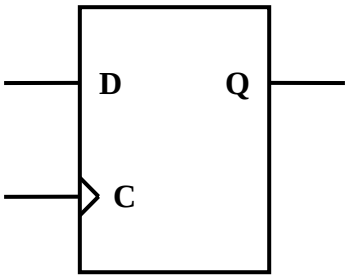
(i) Find the maximum speed of the servo motor. **(4)**

(ii) Find the peak torque required from the motor and hence sketch the current-time profile required from the servo amplifier. **(4)**

(iii) Utilising the equivalent motor circuit, sketch the applied voltage and back emf with respect to time. **(5)**

3.

a. Figure 3.1 shows the circuit symbol and truth table for a clocked D-Type flip-flop.



D	$Q_{(next)}$
0	0
1	1

Figure 3.1

(i) Show the circuit symbols and truth tables for clocked SR and JK type flip-flops. **(4)**

(ii) Using D-Type flip-flops similar to the one above and standard logic gates, draw the circuit of a 3-bit binary ripple counter which counts up. **(4)**

(iii) With the aid of a waveform diagram explain the disadvantage of ripple counters. **(2)**

b. A synchronous state machine is required to detect the sequence 0101 in an incoming bit stream. The system should output a '1' when the sequence is detected and a '0' at other times. Once the full sequence 0101 has been detected the system must be able to detect the full 4-bit sequence 0101 again, starting with the next input bit.

(i) Draw a state diagram for the system. **(4)**

(ii) Write down the state transition table. **(3)**

(iii) Derive Boolean expressions for the inputs to each of the flip-flops and for the output of the circuit. **(3)**

4.

a. **(i)** Describe, without stating the equation, what is meant by entropy and therefore explain why entropy for a binary system becomes very small when the probability of sending a 0, p(0) approaches 1 or 0. **(4)**

(ii) A set of messages, {A,B,C,D,E,F,G,H} are transmitted over a communications channel and analysis of their probabilities yields the following data.

Message	A	B	C	D	E	F	G	H
P(message)	0.01	0.33	0.14	0.07	0.13	0.1	0.18	0.04

Derive the Huffman code for this message set. Show how the derived codes for the messages improve the average information per bit when compared to fixed length encoding. **(8)**

b. What is meant by a multi access (MA) communication system? Name and give a brief description of 4 types of multi access. **(8)**

KM-JW / JW-KM