UNIVERSITY COLLEGE LONDON

University of London

EXAMINATION FOR INTERNAL STUDENTS

For The Following Qualification:-

B.Sc.

Physics 3C75: Principles and Practice of Electronics

COURSE CODE	:	**PHYS3C75**
UNIT VALUE	:	**0.50**
DATE	:	**25-MAY-04**
TIME	:	**10.00**
TIME ALLOWED	:	**2 Hours 30 Minutes**

04-C1099-3-30

Answer ALL SIX questions in Section A and TWO of the questions from Section B

The numbers in square brackets in the right-hand margin indicate the provisional allocation of maximum marks per sub-section of a question.

Section A

1. Draw the circuit of a resistive potential divider connected to a power supply using the conventional symbols and layout. Label the earth (ground) line with the appropriate symbol. Label the resistor that connects to the power supply as "R_1" and the resistor that connects to earth as "R_2" and label the output terminal as "A". [2]

   If the power supply delivers 5 V, R_1 has a value of 300 Ω and R_2 has a value of 100 Ω, find the output voltage at "A" when no load is connected. [2]

   If a short-circuit link is connected between earth and "A", find the current that would flow in the link. [2]

   Draw the equivalent Thévenin circuit, stating the values of all components. [2]

2. Draw the circuit symbols for the following logic gates, label all of the terminals, and write down the truth table for each:
   (a) 2-input AND,
   (b) 3-input NOR,
   (c) XOR. [6]

3. State de Morgan's Theorems for three Boolean variables. [2]
   Use de Morgan's Theorems to show that

$$(\overline{A}+B+C)(A+\overline{B}+C)(A+B+\overline{C}) = \overline{A B \overline{C} + \overline{A} B \overline{C} + \overline{A} B C}$$

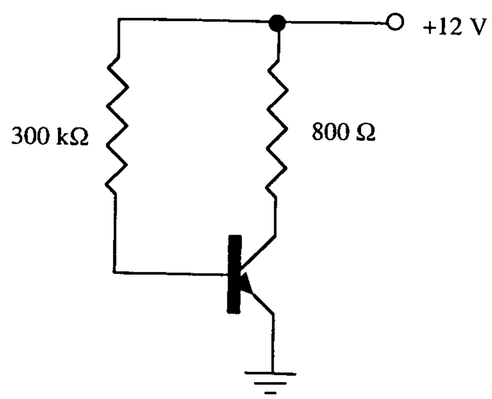
[4]

4. Draw the circuit symbols and briefly describe the characteristics and functions of the *diode*, the *Zener diode* and the *npn bipolar transistor*. Use schematic graphs where appropriate to clarify your descriptions. [8]

5. Draw the circuit diagram of an inverting amplifier that uses a single operational amplifier as its active element, has a voltage gain of 20, and has an input impedance of 500 Ω. Indicate on your diagram the location of the *virtual earth*. [6]

PLEASE TURN OVER

6. For the circuit below calculate the base current, the collector current and the collector voltage when the transistor has a common emitter current gain of $\beta = 150$. Take the base-emitter voltage to be 0.6V. [6]



Section B

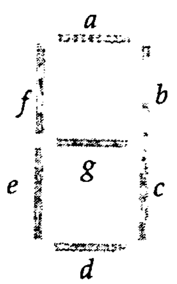
7. Describe in words the purpose of the *half adder* logic circuit. If the inputs to a half adder are labelled *A* and *B*, draw the truth tables for the *Sum* output and for the *Carry* output. Identify the Sum logic and the Carry logic each with a single type of logic gate: AND, NAND, OR, NOR, XOR or NXOR. Hence draw the logic circuit for a half adder that uses two standard logic gates. [7]

Describe in words the difference between a *full adder* and a half adder. Draw the truth tables for the *Sum* output and for the *Carry* output of a full adder. Show how the *Sum* output of a full adder can be obtained by using just two half adders. Demonstrate the correctness of this circuit using a complete truth table which has columns for all inputs and all outputs of both half adders. [6]

Use your truth tables to deduce the additional logic required in order to produce the full adder *Carry* output. Draw the circuit of the complete full adder in terms of half adders and the other logic gates necessary. [5]

Draw the schematic diagram of a circuit that can add together two 2-bit binary numbers employing half adders and/or full adders. [4]

Using the diagram below as a template, draw the states of a seven segment display for each decimal number in the range 0 to 3. Construct the truth table for each segment. Draw the Karnaugh map for each element and find the minimised logic (you do not need to draw the circuits). [8]



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8. Draw the circuits of the *R-S latch* and the *R-S flip flop* in terms of 2-input NAND gates and inverters and write out their truth tables. Briefly state any restrictions on the correct operation of these circuits. [6]

Write down the truth table for the *J-K master-slave flip flop*. Define "change function" and show using a truth table that the change function for the J-K flip flop can be written as

$$J\overline{Q} + KQ \qquad [6]$$

A digital twelve hour time-keeping clock requires a synchronous scale-of-12 counter to register the hours. Design a suitable binary counter using J-K flip flops and any necessary logic gates. The counter should be designed such that if it starts up in an illegal state (0 or > 12) it will enter a legal state at the first clock input pulse. Demonstrate the functioning of your design using a truth table and draw the final circuit. [18]

9. Describe the concept of voltage-derived series-applied negative feedback as applied to amplifier circuits. Include an explanation of the term *series-applied feedback* and derive the expression for the closed-loop voltage gain. [8]

Draw the circuit of a single transistor common emitter amplifier with emitter feedback (you do not need to include components whose purpose is purely to establish the bias conditions). Explain how this circuit makes use of negative feedback and obtain approximate expressions for its voltage gain and input impedance. [8]

A common emitter amplifier with emitter feedback consists of a transistor with current gain $\beta = 100$, emitter resistance $R_e = 100\ \Omega$ and collector resistance $R_c = 6\ k\Omega$. Find the approximate voltage gain, input impedance and output impedance of this circuit. [7]

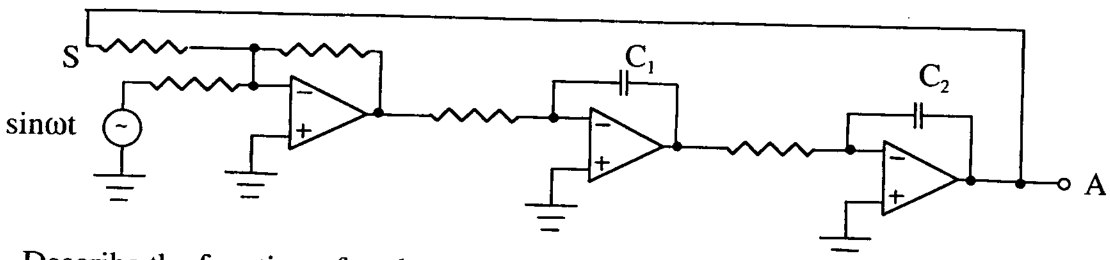
If two such circuits are connected directly together to form a two-stage amplifier, find the voltage gain of this amplifier. [7]

PLEASE TURN OVER

10. The equation describing the displacement of the forced motion of a mass M connected to a damped spring is

$$M\frac{d^2x}{dt^2} = \sin\omega t - kx - \lambda\frac{dx}{dt}$$

where $\sin\omega t$ is the driving force, k is the spring constant and λ is the damping factor. This equation is to be modelled using an analogue computer circuit. Below is the circuit, omitting the components representing the damping term, where all resistors have the same value R except the one marked S. One volt is to be equivalent to one newton of force. Draw the complete circuit including the damping term components. [7]



Describe the function of each operational amplifier section of the complete circuit and give their operational equations. [8]

Find the differential equation for the circuit and by comparing it with the equation for the mechanical system obtain equations relating each mechanical parameter to the electrical component values. Write down the mechanical equivalent of the voltage at "A". [9]

The "integrator switches" have so far been omitted from the circuit. Add them to your circuit and explain their purpose. [6]

END OF PAPER