hrs	/ /20		Exams Office Use Only

University of the Witwatersrand, Johannesburg

Course or topic No(s)	ELEN224
Course or topic name(s) Paper Number & title	Electronics I
Examination/Test* to be held during month(s) of (*delete as applicable)	June 2000
Year of Study (Art & Sciences leave blank)	Second
Degrees/Diplomas for which this course is prescribed (BSc (Eng) should indicate which branch)	B.Sc (Eng) Elec.
Faculty/ies presenting candidates	Engineering
Internal examiners and telephone number(s)	Dr. A. R. Clark x7223
External examiner(s)	Dr. G. J. Gibbon
Special materials required (graph/music/drawing paper) maps, diagrams, tables, computer cards, etc)	None

Time allowance

Course Nos	ELEN224	Hours	Three

Instructions to candidates
(Examiners may wish to use this space to indicate, inter alia, the contribution made by this examination or test towards the year mark, if appropriate)

Answer *ALL* questions.
Type '2' Examination.

Internal Examiners or Heads of Department are requested to sign the declaration overleaf

1. As the Internal Examiner/Head of Department, I certify that this question paper is in final form, as approved by the External Examiner, and is ready for reproduction.

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Note: Show ALL workings, complete with the necessary comments!!—regardless of how fast your calculator can print the results in one step. I am not interested in how well you can read your formulae from your formula sheet. I am marking your reasoning, not only the answer!! Marks are awarded for the reasoning as well as the "answer". A correct numerical answer will not necessarily attract any marks!

Question 1

Op-Amp Question

An inverting amplifier with a gain of -100V/V and an input resistance of 100kΩ, uses an op-amp with a 1mV offset voltage, a bias current of 30nA, and an offset bias current of 3nA.

What output voltage offset results with
a) a basic uncompensated design
b) a bias-current compensated design (where a resistor is placed from the non-inverting terminal to ground).

Which offset source dominates in each case?

KC 2.50

This question will frighten most :-)

G=100, Rin = 100kΩ (=R1), hence R2=10MΩ

In the Uncompensated case, both the effects of the offset voltage and the bias currents cause a voltage at the inverting input. This voltage is then multiplied by the closed loop gain to form the output offset. The bias currents suck current from the efffective parallel combination of R1 and R2.

Hence the output voltage becomes

$$v_0 = (1 + R2/R1)(Vos + Vbias) \quad = 101(1mV + 30 \times 10^9 \times 100k||10M = 101(1mV + 3mV) \quad = 404mV$$

Note that the voltage from the bias currents dominates the output offset.

For the bias-current compensated design, $R_3 = R_1//R_2$, and the voltage at both terminals is raised due to the bias currents, and the output voltage offset is then cancelled. The only remaining cause of output offset is then the Vos and the Ios. In the worst case,

$$v_0 = 101(1mV + 3 \times 10^9 \times 100k) \qquad = 101(1mV + 0.3mV) = 131mV$$

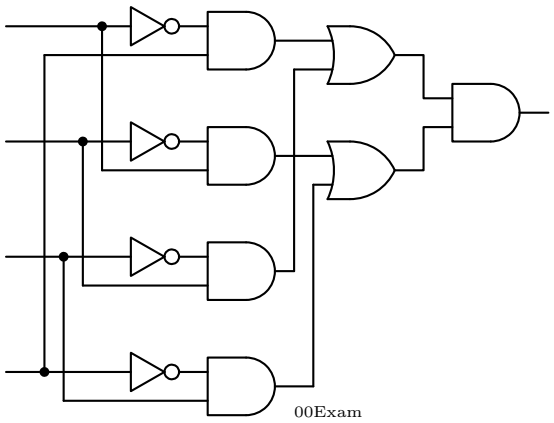
Note that the Vos dominates the output.

(20 marks)

Question 2

Digital Question – dead simple stuff.

(a) Simplify the following to a minimum number of gates:



(10 marks)

Trivial

(b) Design a state-machine which cycles between 5 possible states. (15 marks)
ie a counter with simple combinational logic to reset it. They have the choice of flip flops and polarity of edge triggering.

(Total 25 marks)

Question 3

Diode Question

Design a dual-ended power supply for an audio amplifier. It is required that the rails are at ±50V, and that each rail can deliver 4A. Justify all assumptions. *Hint: By "design", I mean specify the characteristics and ratings of all components used.* (20 marks)

Simple stuff, but will get a wide range of allowable ripple etc.. I am looking here for a bit of engineering judgement in sizing the caps. Can they actually relate the 4A to a discharge rate and hence a voltage drop.

If they do include a voltage regulator, the lowest ripple voltage must still be 2V above the output voltage etc.

Only twist is the dual-ended bit.

Clearly no "answer" in a numerical form.

Question 4

(a) Fully design and specify a circuit to turn on a security floodlight at night. Amongst other possible components, use an LDR (Light Dependant Resistor) and an NPN

I am looking for a simple but thorough design where the LDR is fed by a resistor. The question is really a check on whether they individually designed their project, where the LDR was used with op-amps to do the same.
As light decreases, the voltage at the LDR increases, and will turn on the NPN transistor. The subtlety comes in the fact that the base drive needs supplying from the potential divider too.
Hence sizing of the resistors is important. Most of the "feel" for the LDR etc will have come from the project. They must recognise that a relay will be needed for the mains. Bonus if they derive a non transformered power source!!!!
Bonus plus if they actually use a transistor based Schmidt Trigger
(The relay itself will provide sufficient hysteresis, but I don't expect anyone to actually mention this!)

(15 marks)

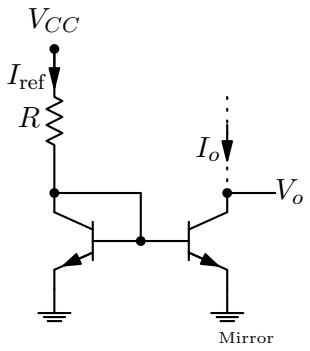
(b) With the aid of sketches, explain how an N-channel enhancement MOSFET first gains its channel. Further explain what happens when the transistor conducts an appreciable current. (10 marks)
A little bit of bookwork. Need to see gate-body rise to give depletion region, followed by n-channel forming after the threshold voltage. As current increases, channel skews and pinches off. Alleviated by incresing gate voltage.

(Total 25 marks)

Question 5

Transistor Question (SSEx6.7)

Consider the following circuit:



(a) For the current mirror shown above using two matched-gain transistors, find the value of R that results in $I_o = 1\text{mA}$ with V_{CC}=5V
i)Assume $\beta = \infty$
ii)Assume $\beta = 100$
iii)For case (ii), for what values of V_o will the current mirror work?

(b) In what application would the above circuit be used?. Transistor biasing, long tailed pairs etc

(20 marks)

Obviously, for infinite β, the current feeding into both bases is negected. Hence R=(5-0.7)/1mA=4.3k

For $\beta = 100$, however, a full analysis needs doing. Assuming that the base drives are the same (matched). We now get $2i_B$ through R as well. Hence $I_o = 1mA, i_B = 10\mu A, I_{ref} = 1.02mA, R = (5 - 0.7)/1.02mA = 4.22k$

(Total 20 marks)

(Exam Total 110 marks)

(100%=100 marks)