National Exams May 2016

07-Elec-A5, Electronics

3 hours duration

Notes:

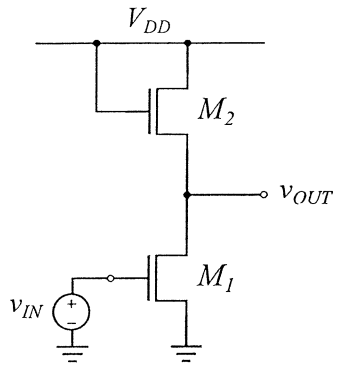
1. If any doubt exists as to the interpretation of any question, the candidate is urged to submit, within their answer, a clear statement of any assumptions made.
2. This is a **CLOSED BOOK EXAM**.
   Any non-communicating calculator is permitted.
3. Answer all **FIVE** (5) questions.
4. All questions are worth 20 marks each.
5. Please start each question on a new page and clearly identify the question number and part number, e.g. Q4(a).
6. In schematics, ground and chassis may be assumed to be common, unless specifically stated otherwise.
7. Unless otherwise specified, assume that Op-Amps are ideal and that supply voltages are ±15V.
8. If questions require an answer in essay format, clarity and organization of the answer are important. Provide block diagrams and circuit schematics whenever necessary.

QUESTION (1)

The following is a single stage amplifier circuit with an enhancement load.
Assume that both transistors has the same W/L ratio and the threshold voltage $V_{Tn} = 0.2 \times V_{DD}$.

a) Provide an accurate sketch of the transfer function, v_{OUT} versus v_{IN}. (12 points)

b) Provide an expression for the small signal mid-band gain of this amplifier. (8 points)



Useful formulae: for n-channel MOSFET

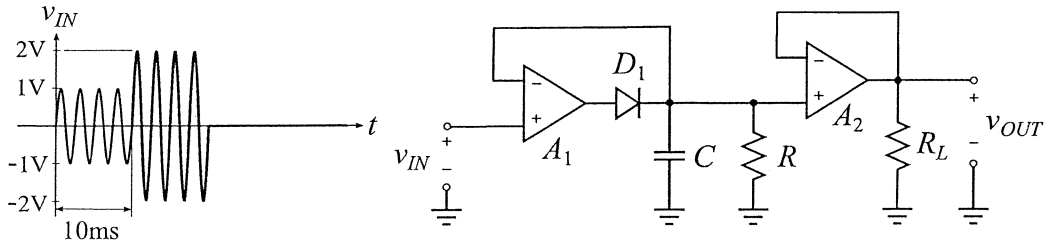
$$i_{DS} = K\left[(v_{GS} - V_{TH})v_{DS} - \frac{1}{2}v_{DS}^2\right] \quad \text{triode region}$$

$$i_{DS} = \frac{1}{2}K(v_{GS} - V_{TH})^2(1 + \lambda v_{DS}) \quad \text{saturation region}$$

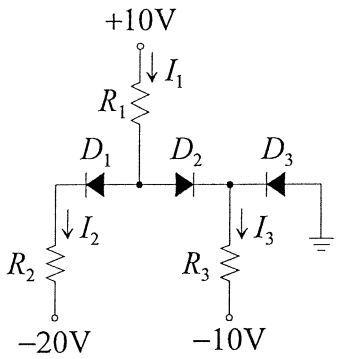
QUESTION (2)

a) For the op amp circuit below, sketch accurately the output voltage waveform (as a function of time). Given: $R = R_L = 1\ \text{k}\Omega$, $C = 10\mu\text{F}$ (16 points)

b) What is a possible function of this circuit? (4 points)



QUESTION (3) Solve for the currents I_1, I_2, and I_3 in the following diode circuit. (20 points)



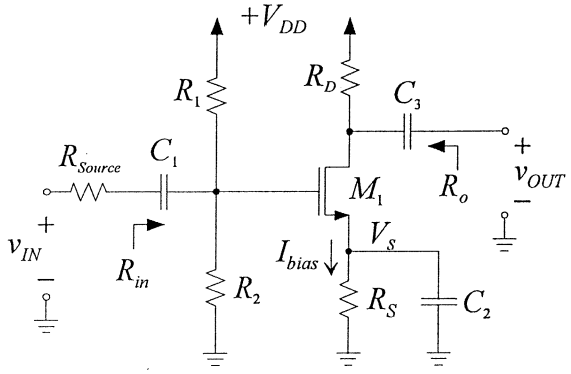
Given:

All diodes are ideal with 0.6V forward drop

$R_1 = R_2 = R_3 = 10\ \text{k}\Omega$

QUESTION (4)

Consider the common source amplifier circuit on the right. Determine the voltages at all nodes and the current through all branches. (20 points)



Given:

$R_1 = 100\ \text{k}\Omega$	$R_2 = 100\ \text{k}\Omega$
$R_D = 6\ \text{k}\Omega$	$R_S = 6\ \text{k}\Omega$
$V_{TH} = 1\text{V}$	$\lambda = 0\ \text{V}^{-1}$
$V_{DD} = 10\text{V}$	
$K_n'(W/L) = 1\text{mA/V}^2$	

Useful formulae: for *n*-channel MOSFET

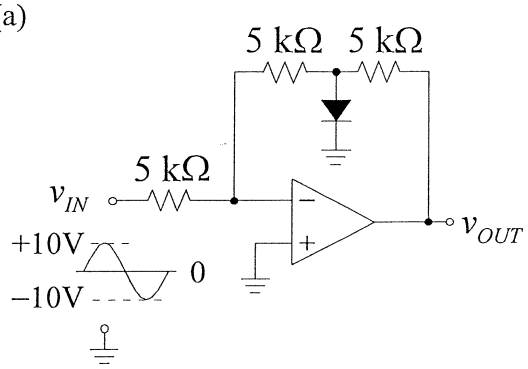
$$i_{DS} = \mu_n C_{ox} \frac{W}{L}\left[(v_{GS} - V_{TH})v_{DS} - \frac{1}{2}v_{DS}^2\right] \qquad \text{triode region}$$

$$i_{DS} = \frac{1}{2}\mu_n C_{ox} \frac{W}{L}(v_{GS} - V_{TH})^2(1 + \lambda v_{DS}) \qquad \text{saturation region}$$

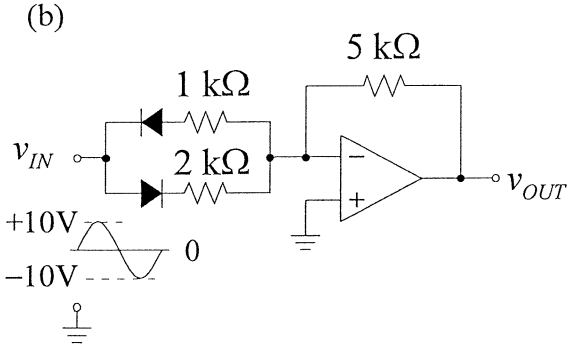
QUESTION (5)

In the following circuits, assume that the diode is ideal and has a forward voltage of 0.7V, and all op amps are ideal and with supply voltages of ±15 V. Sketch the output waveform for one complete sine wave input. (20 points)

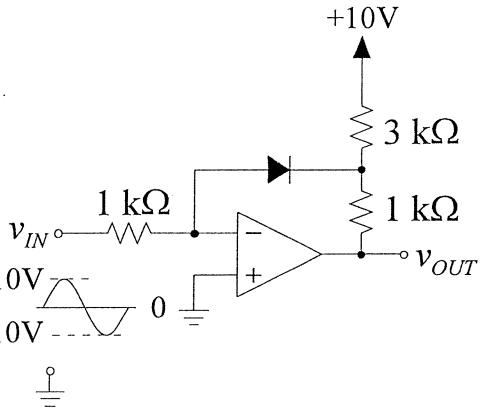
(a)



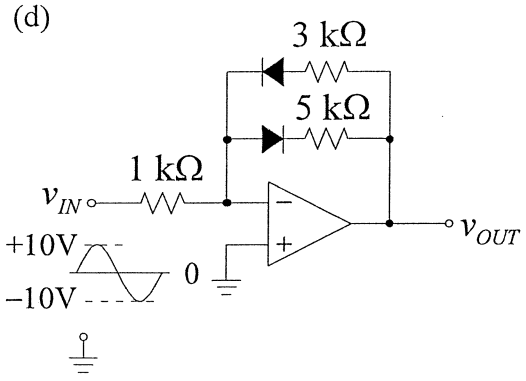
(b)



(c)



(d)



(e)