National Exams December 2011

07-Elec-A5, Electronics

3 hours duration

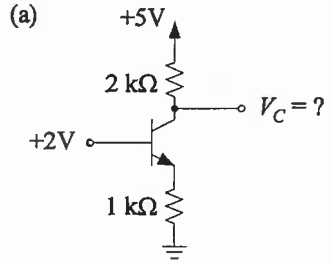
Notes:

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.
   A Casio or Sharp approved calculator is permitted.
3. FIVE (5) questions constitute a complete exam paper.
   The first five questions as they appear in the answer book will be marked.
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. Some questions require an answer in essay format. Clarity and organization of the answer are important. Provide block diagrams and circuit schematics whenever necessary.

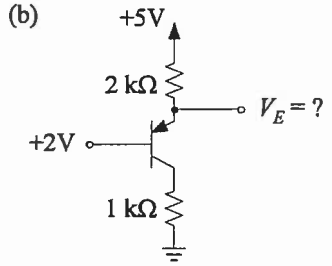
QUESTION (1)

In the following questions, all BJT transistors have $\beta = 50$, $V_{BE,on} = 0.6V$, $V_{CE,sat} = 0.3V$ and $V_A = \infty$. Solve for the required voltages. (20 points)

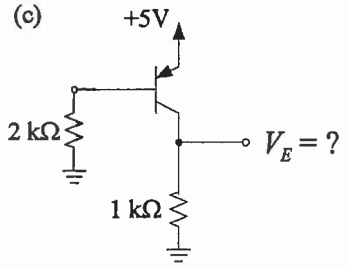
(a) (4 points)



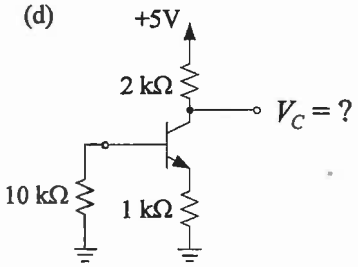
(b) (4 points)



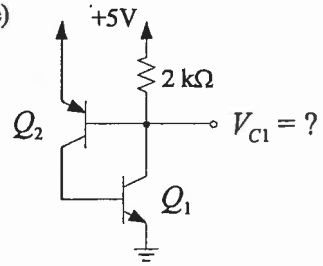
(c) (4 points)



(d) (4 points)

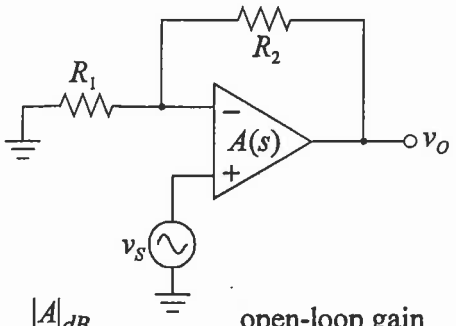


(e) (4 points)



QUESTION (2)

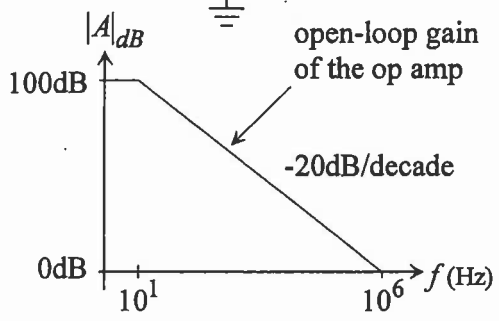
The op amp in the following non-inverting configuration is internal compensated with an open-loop gain as shown. It has a slew rate of 0.5V/μs. Given that R_1 = 1 kΩ, and R_2 = 100 kΩ.



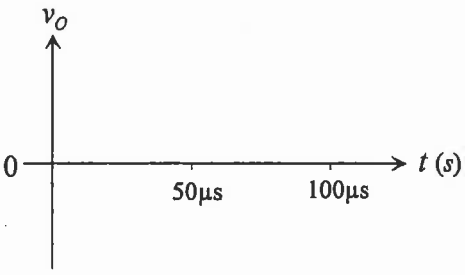
a) What is the f_{3dB} of this non-inverting amplifier? Sketch **accurately** the resulting frequency response. (6 points)

b) If the input is a sinusoidal wave at 10 kHz with an amplitude of 20mV peak to peak, sketch accurately the output waveform v_O. What is the resulting peak to peak output amplitude? (8 points)

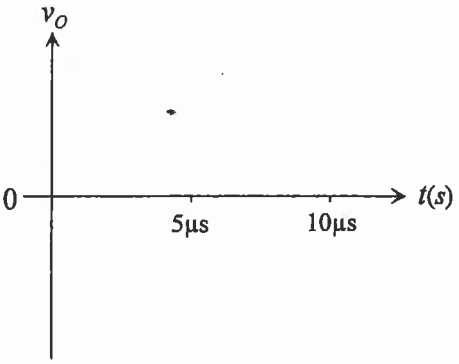
c) If the input is a sinusoidal wave at 100kHz with an amplitude of 5V peak to peak, sketch accurately the output waveform v_O. Provide an estimate for the resulting peak to peak output amplitude. (8 points)



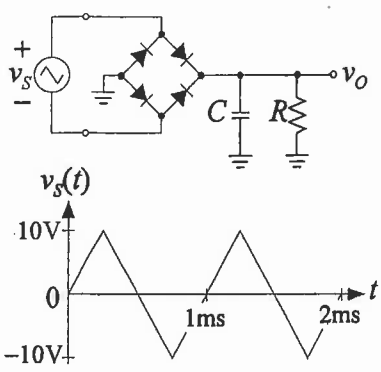
(b)



(c)



QUESTION (3)



For this full-wave rectifier circuit, assume that all the diodes are ideal with **zero forward voltage drop** and that the time constant RC = 500 ms. For a 1 kHz triangular input waveform with a peak amplitude of 10V, and using the assumption that $RC >> T$,

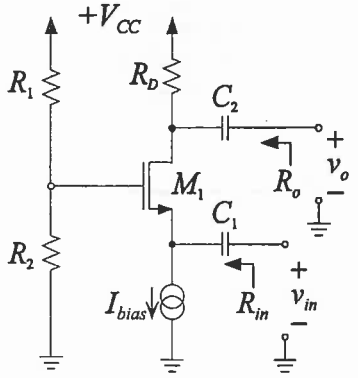
a) Sketch accurately in your answer book the output voltage waveform, v_O. (4 points)

b) What is the peak voltage, V_p and the ripple voltage V_r that would appear at the output? (8 points)

c) What is the average output voltage at v_o? (4 points)

d) Estimate the time interval, t_{on} during which the diodes conduct during each period. (4 points)

QUESTION (4)



Transistor M_1 in this common base amplifier circuit has the following characteristics:

V_{TH} = 1 V

K = 1 mA/V^2 λ = 0.1

Given: V_{DD} = 10 V, I_{bias} = 2 mA,
$C_1 = C_2 = \infty$,
R_1 = 10 kΩ, R_2 = 5 kΩ, R_D = 2 kΩ

a) Determine the small signal gain, v_o/v_{in}. (12 points)

b) Determine the input resistance, R_{in}. (4 points)

c) Determine the output resistance, R_o. (4 points)

Useful formulae: for n-channel MOSFET

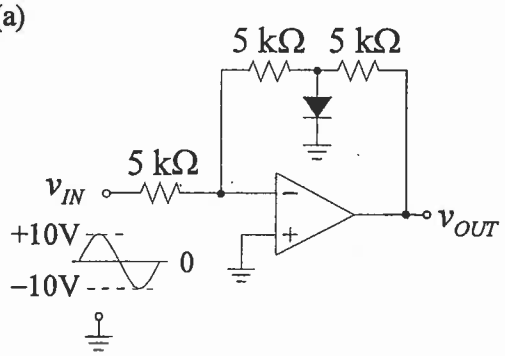
$$i_{DS} = K\left[(v_{GS} - V_{TH})v_{DS} - \frac{1}{2}v_{DS}^2\right] \quad \text{triode region}$$

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

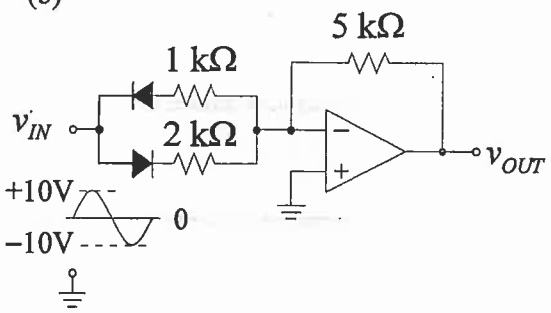
QUESTION (5)

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)

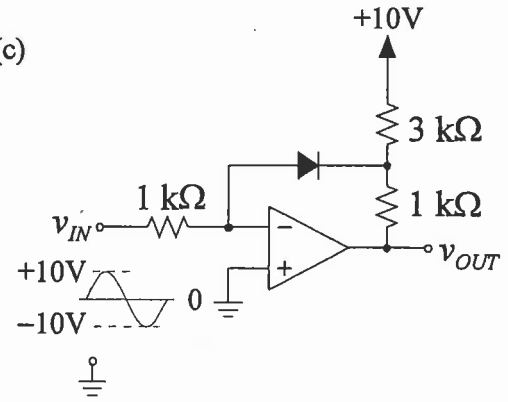
(a)



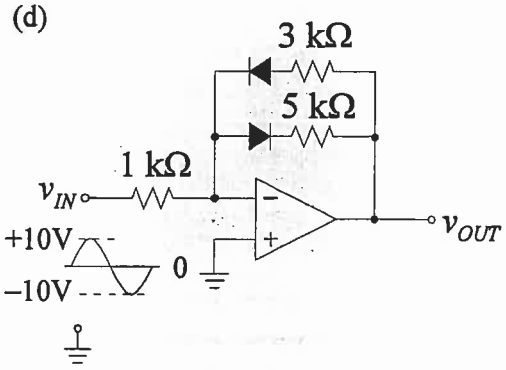
(b)



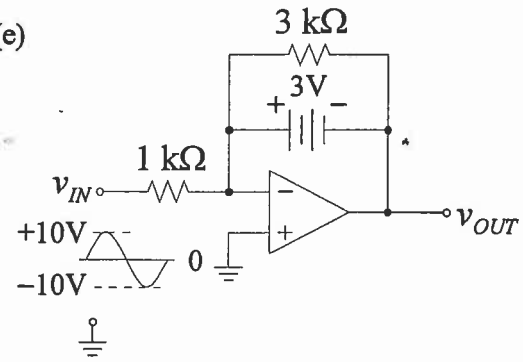
(c)



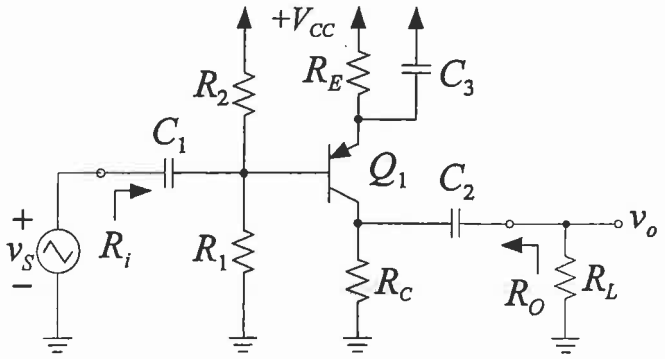
(d)



(e)



QUESTION (6)



Assume that the BJT has the following characteristics:

$\beta = 100$
$V_{EB(on)} = 0.7\text{V}$
$V_{EC(sat)} = 0.3\text{V}$
$V_A = \infty$

Given: $V_{CC} = 10\text{V}$, $R_L = 10\text{k}\Omega$, and $R_E = 1\text{k}\Omega$,

a) Design this common emitter amplifier circuit to have the following specification:

DC bias current, $I_E = 2\text{mA}$,
A mid-band voltage gain $v_{out}/v_S = 100$ V/V
Provide values for R_1, R_2, and R_C. (15 points)

b) What is the equivalent output resistance, R_O? (2 points)

c) What is the maximum undistorted peak to peak output voltage swing at the output? (3 points)