National Exams

07-Elec-A5, Electronics

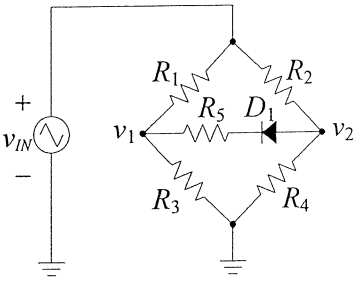
3 hours duration

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.

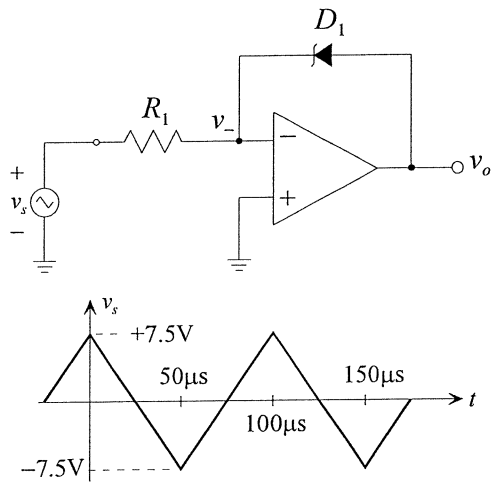
QUESTION (1)

In the following circuit, the input voltage v_{IN} is a 1 kHz, ±10 V triangular source. Provide an accurate sketch of the voltage waveforms v_1 and v_2 as a function of time. The diode D_1 is ideal with a 0.7V forward drop. (20 points)



Given:
R_1 = 1 kΩ
R_2 = 3 kΩ
R_3 = 3 kΩ
R_4 = 1 kΩ
R_5 = 10 kΩ

QUESTION (2)



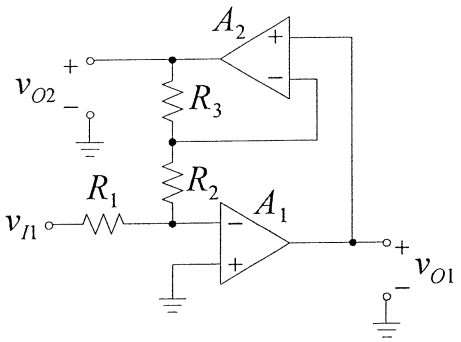
The op amp in this circuit is ideal except for a slew rate limit of 0.5V/μs. It is powered by ±15V supplies. Given that

R_1 = 10kΩ
For D_1, V_Z = 5V, forward voltage drop = 0.7V

Sketch **accurately** in your answer book the voltage waveform for v_O. You must indicate the breakpoints, including accurate timing and voltage levels. (20 points)

QUESTION (3) a) Derive an expression for the output v_{O1} and v_{O2} as a function of R_1, R_2, R_3, and v_{I1} in the following op amp circuit. (14 points)

b) Provide a possible set of values for R_1, R_2, R_3, such that $|v_{O2}/v_{I1}|$ has a gain of 20 V/V. (6 points)



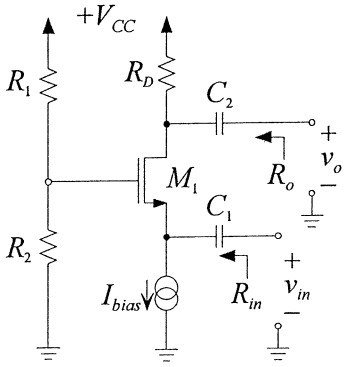
QUESTION (4)

Transistor M_1 in this common gate 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} = 1 mA,
$C_1 = C_2 = \infty$,
R_1 = 10 kΩ, R_2 = 5 kΩ, R_D = 5 kΩ



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

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

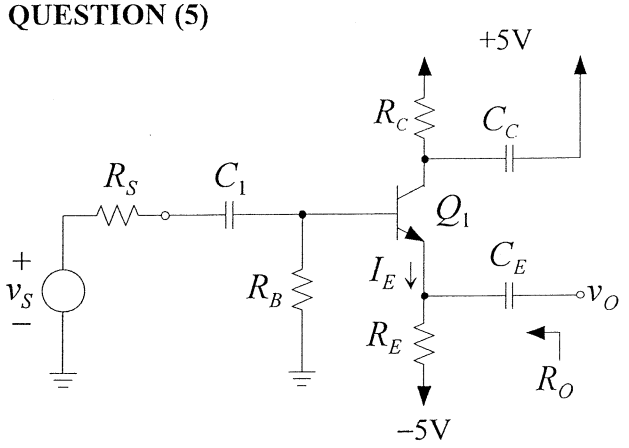
c) Determine the output resistance, R_o. (4 points)

Useful formulae: for n-channel MOSFET

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

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

QUESTION (5)



Assume that the BJT has the following characteristics:

β = 100
$V_{EB(on)}$ = 0.7V
$V_{EC(sat)}$ = 0.3V
V_A = ∞
R_S = 100Ω
R_B = 100Ω
C_1, C_E, and C_C are large capacitors

a) Design this common collector amplifier circuit to have DC bias current, I_E = 2mA. Provide values for R_E and R_C. (5 points)

b) What is the equivalent output resistance, R_O? (10 points)

c) What is the maximum undistorted peak to peak output voltage swing at the output? (5 points)