EECS 100/42/43 Spring 2006 Midterm # 2

PRINT NAME (Last, First): KEY

SIGN YOUR NAME: ____________________

STUDENT ID #: ____________________

CIRCLE ONE: EE 100 EE 42

# 1	# 2	# 3	# 4	SUBTOTAL
6	14	10	12	42

# 5	# 6	# 7	SUBTOTAL	TOTAL
16	12	15	43	85

Instructions:

1 Print and sign your name and enter your student ID number above.

2 Read the questions carefully.

3 Write your solution clearly.

4 You must show your work to get full credit.

5 This exam has 7 questions worth 85 points, so you should proceed at approximately 1 point per minute.

Problem # 1 $(2+2+2=6$ points)
Let R, L, C denote resistance, inductance, and capacitance respectively.
What are the units of the following quantities in MKS units?
Express your answer in terms of meters, kilograms, seconds, and coulombs.

(a) L/R RL ckt time constant
$\rightarrow$ L/R in seconds

Units of L/R are:
seconds

(b) RC RC ckt time constant
$\rightarrow$ seconds

Units of RC are:
seconds

(c) LC $= \frac{L}{R} \cdot RC \rightarrow \text{seconds}^2$

Units of LC are:
seconds^2

Problem # 2 (2 + 2 + 2 + 8 = 14 points)

(a) If you dope pure silicon with a Group V element from the periodic table which kind of semiconductor do you get (circle the correct answer)?

[✓ n-type] p-type intrinsic

(b) Shown below is the cross-section of a pn-diode.
In the dashed box, draw the circuit symbol of this diode.

(c) Write a brief definition of a *hole* in a semiconductor and say why holes are significant.

A hole is a mobile positive charge carrier in a semiconductor — a missing electron, It permits us to make pn junctions, etc.

(d) List 4 different solid-state diodes that are in common use and say briefly what each one does.

Rectifier ordinary pn-diode conducts current in only one direction

Light-emitting diode — emits light when sufficiently forward biassed

Laser diode — emits single-wavelength cohered light when sufficiently forward biassed

Zener diode — has reverse-current conduction at a designable voltage

Solar cell — produces electric power in an electric load when illuminated

Varactor diode — acts as voltage-variable capacitance

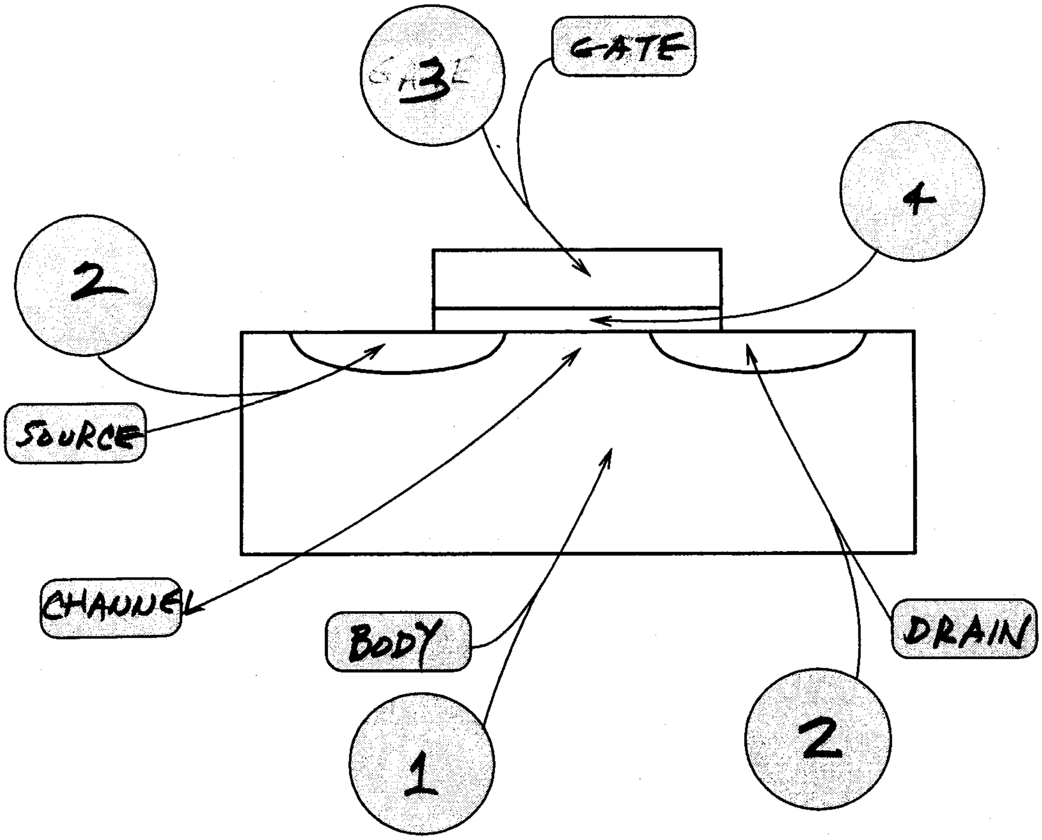
Problem # 3 (5 + 5 = 10 points)

Shown below is a cross-sectional view of a silicon n-channel transistor.
There are various regions that you have to name (in the shaded boxes) and label (in the shaded circle).

(a) Write the name of each region in the shaded box provided.
The names of these regions are the *source, drain, gate, bulk,* and *channel.*

(b) In each shaded circle, enter the appropriate labels (1,2,3,4, III, V) that are defined below.
You may have to use several labels for some regions.

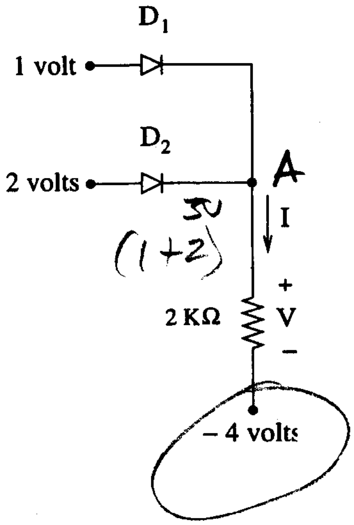
label	meaning
1	p-type region
2	n-type region
3	metal or heavily conducting region
4	insulator
III	regions containing dopants predominantly from Group III of the periodic table
V	regions containing dopants predominantly from Group V of the periodic table



Problem # 4 (4+4+2+2 = 12 points)

Consider the circuit shown below. The diodes are ideal.

For each diode, determine if it is conducting or not conducting.
Find I and V.



Assume D_2 conducting, D_1 off

$$\text{Then } I = \frac{2-(-4)\,V}{R} = \frac{6\,V}{2\,K\Omega} = 3\,mA$$

$$V_A = -4 + (3\,mA)(2\,K\Omega) = +2V$$

> 1 VOLT so D_1 is not conducting

$2\,V \rightarrow -4$

Diode # 1 is conducting [✓ not conducting] (circle your choice)

Diode # 2 is [✓ conducting] not conducting (circle your choice)

$I =$ 3mA

$V =$ +6V

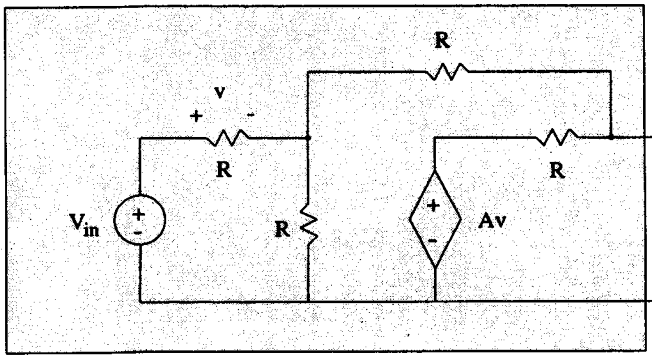
Problem # 5 (4 + 4 + 4 + 4 = 16 points)

Find the output resistance R_{out} for the circuit shown below.
We suggest the following steps:

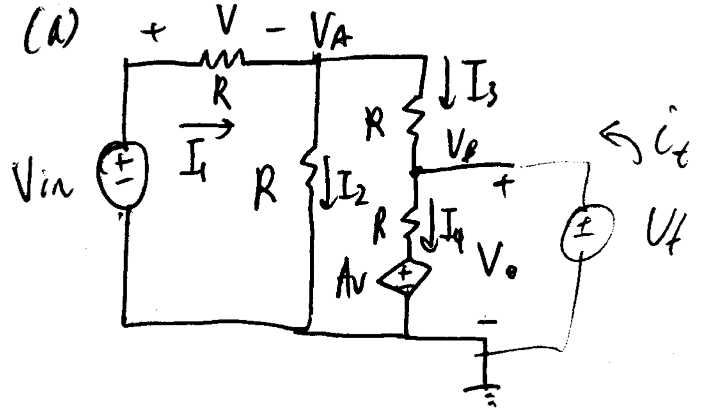
(a) Redraw the circuit you have to use to find the output resistance. (4 points)

(b) Analyze this circuit. (8 points)

(c) Show your algebra to find R_{out}. (4 points)



(a)



(b) $V_{in} \to 0$

Apply V_t, measure I_t
short V_{in}

$I_1 = I_2 + I_3$ @ V_A

@ V_B $I_T + I_3 = I_4$

$I_T = I_4 - I_3$

$I_4 = \frac{V_T - AV}{R}$ $\Big\}$ $V_A = 0 - V \Rightarrow V = -V_A$

$I_3 = \frac{V_A - V_T}{R}$

$I_1 = \frac{0 - V_A}{R}$

$I_2 = \frac{V_A}{R}$

$I_1 = I_2 + I_3$

$\frac{-V_A}{R} = \frac{V_A}{R} + \frac{V_A - V_T}{R}$

$\frac{V_T}{R} = \frac{3\,V_A}{R}$

$V_T = 3V_A \Rightarrow \boxed{V_A = \frac{V_T}{3}}$

$I_T = I_4 - I_3$

$= \frac{V_T - A(-\frac{V_T}{3})}{R} - \frac{V_T/3 - V_T}{R}$

$\Rightarrow I_T(R) = V_T\,(1 + \frac{A}{3} - \frac{1}{3} + 1)$

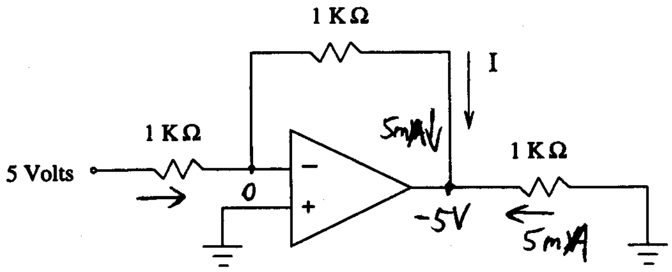
$= V_T(\frac{5}{3} + \frac{A}{3}) = V_T(\frac{5+A}{3})$

$I_T = V_T(\frac{5+A}{3R})$

$R_{\text{out}} = \frac{3R}{5+A}$

Problem # 6 (4 + 4 + 4 = 12 points)

An ideal 5 volt DC source is connected to an inverting amplifier. The output of the amplifier is connected to a $1K\Omega$ resistive load. The overall circuit is shown below. Assume that the op-amp behaves ideally.



(a) Find the current I.

$$\frac{5V-0}{1K} = 5mA$$

$I =$ 5mA

(b) How much power does the source deliver?

$I_s = 5mA$

$V_s = 5V$

$P_s = I_s V_s = 25mW$

power delivered by source = 25 mW

(c) How much power does the op-amp deliver?

$V_0 = -5V$

$I_{op\text{-}amp} = -10mA$

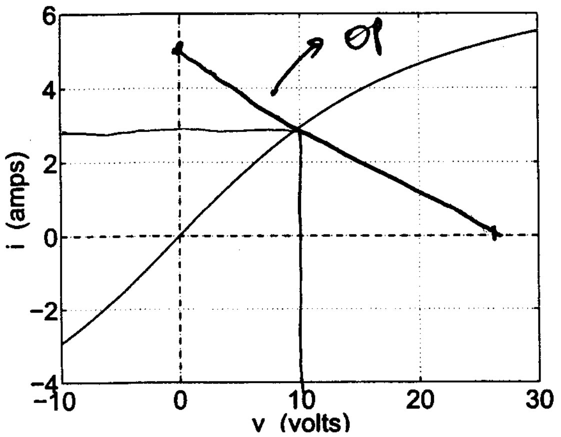
$P_{op\text{-}Amp} = -5V \cdot -10mA$

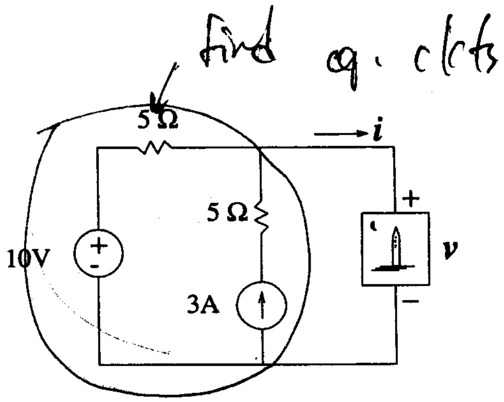
$= 50mW$

power delivered by op-amp = 50 mW

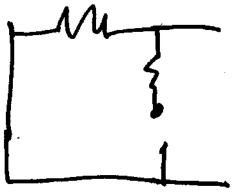
Problem # 7 $(4+4+1+2+2+2 = 15$ points)

The resistive network shown below is connecter to a berkelistor B. The berkelistor is a nonlinear device with $i-v$ characteristic shown below. Find the current i drawn by the berkelistor and the voltage v across the berkelistor.

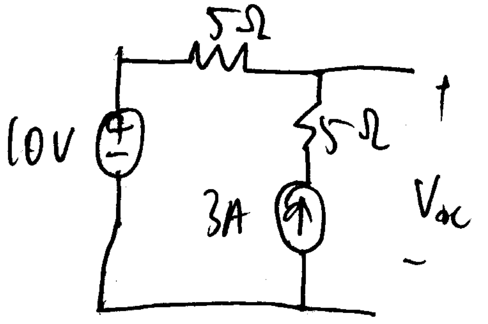




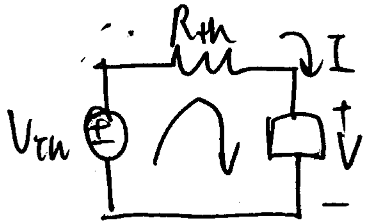
find $R_{th} \Rightarrow$ short all indep sources



$R_{eq} = R_{th} = 5\,\Omega$



$3A = \frac{V_{oc}-10}{5} \Rightarrow V_{oc} = 25V$



$-V_{th} + I R_{th} + V = 0$

$V_{th} = I R_{th} + V$

① $I = 0 \Rightarrow V = V_{th} = 25V$

② $V=0 \Rightarrow I = 5A$

$i =$ 3A

$v =$ 10 V