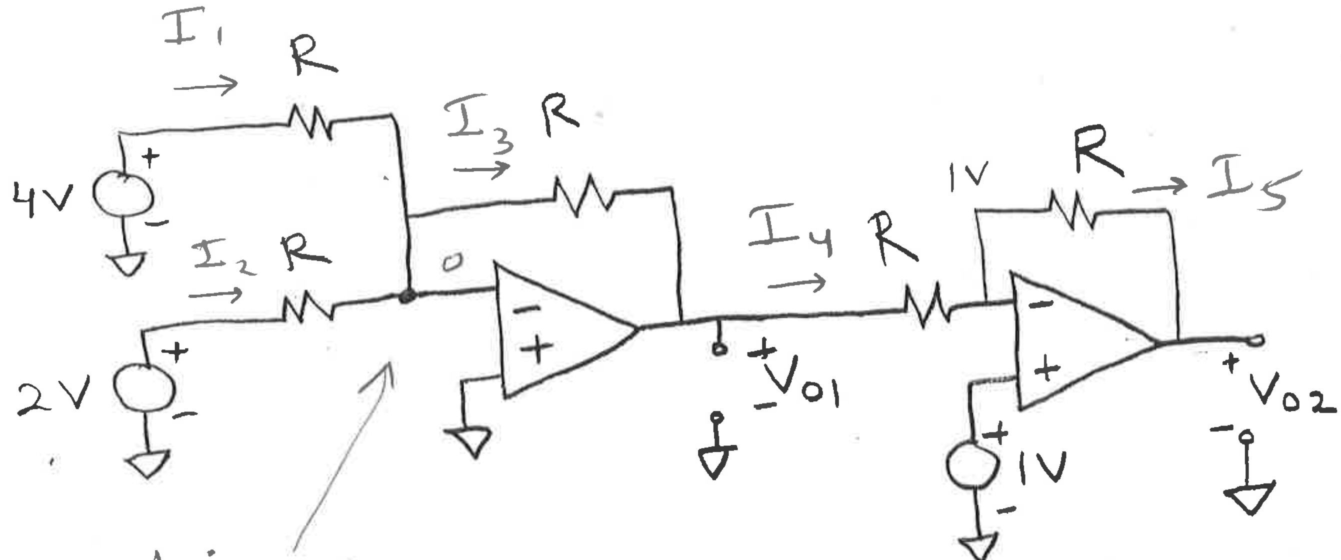
E100 MT 2 Sol'n F 2015

1. For the circuit below, what are the opamp output voltages, V_{O1} and V_{O2}? (note: the voltage sources are generating DC voltages.) Assume the op amp is ideal.

V_{O1} = ____________________ V_{O2} = ____________________



op amp 1:

$$I_1 + I_2 = I_3$$

$$\frac{4-0}{R} + \frac{2-0}{R} = \frac{0 - V_{o1}}{R}$$

$$\Rightarrow 4 + 2 = -V_{o1} \Rightarrow \underline{V_{o1} = -6\,V}$$

op amp 2:

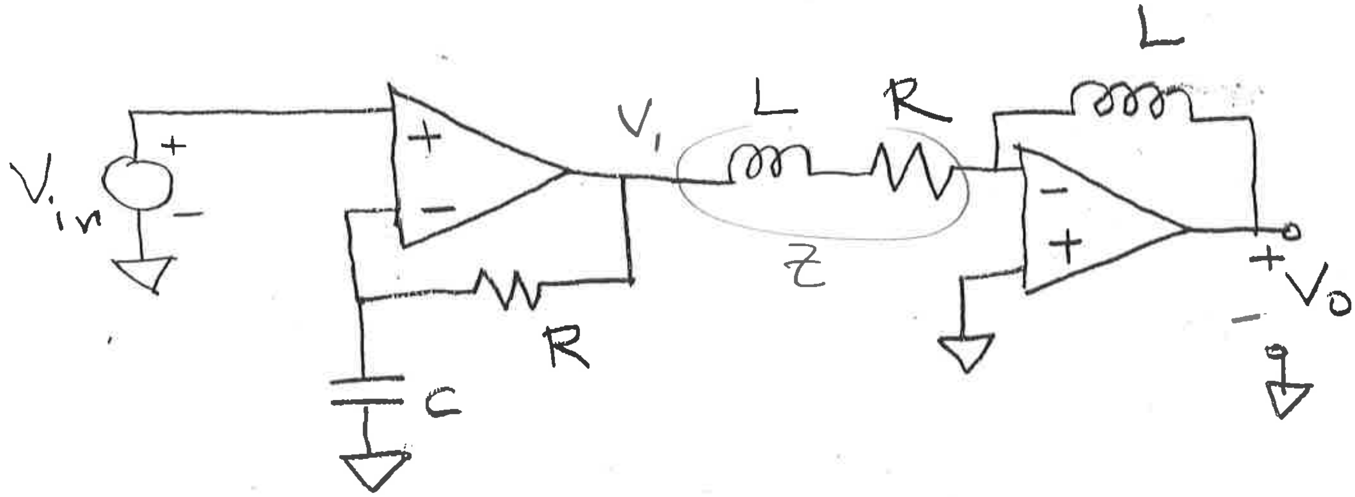
$$\frac{V_{o1} - 1}{R} = I_4 = I_5 = \frac{1 - V_{o2}}{R}$$

$$\Rightarrow -6 - 1 = 1 - V_{o2}$$

$$\underline{V_{o2} = 8\,V}$$

2. What is the s-domain transfer function $H(s) = V_O/V_{in}$ for the circuit below? Assume the op amps are ideal. (Your answer should be in the form N(s)/D(s), where N(s) and D(s) are polynomials in s.)

H(s) = ____________________



$$\frac{V_1}{V_{in}} = 1 + \frac{R}{\frac{1}{sC}} = 1 + sRC$$

$$\frac{V_o}{V_1} = -\frac{sL}{Z} = -\frac{sL}{R+sL}$$

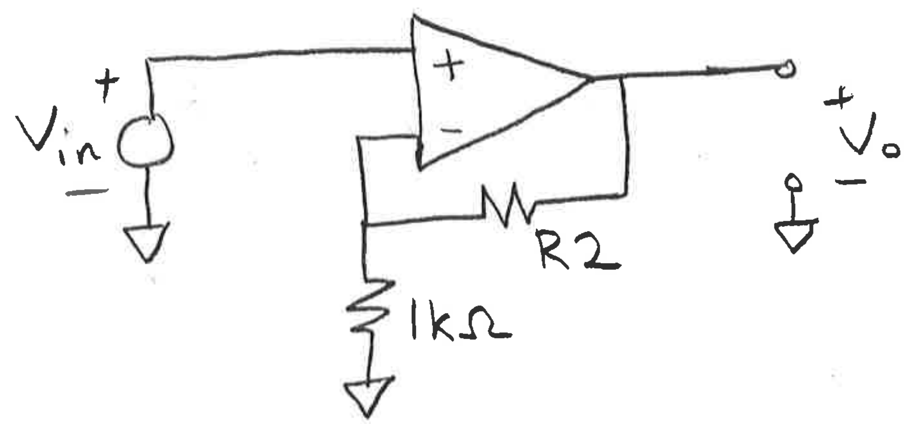
$$\frac{V_o}{V_{in}} = \frac{V_o}{V_1} \cdot \frac{V_1}{V_{in}} = -\frac{sL}{R+sL}(1+sRC)$$

$$= -\frac{sL + s^2LRC}{R+sL}$$

3. The circuit below uses an opamp that is NOT ideal. Assume that the op amp has a finite gain-bandwidth product (or unity-gain frequency) but is otherwise ideal. The opamp has a gain-bandwidth product of 100 MHz.

   In the feedback circuit shown below, what value of R2 will give a circuit with a bandwidth of 1 MHz?

R2 = ____________________



gain × bw = 100 MHz

⇒ gain × 1 MHz = 100 MHz

so want gain = 100

$$\text{gain} = 1 + \frac{R2}{1k\Omega} = 100$$

R2 = 99 kΩ

4. a) Convert the decimal number 29 (or 29_{10}) to a 6-bit 2's complement binary number.

Binary number = ______________________________

base 10	÷2	Quot.	Remainder
29	29/2	14	1
14	14/2	7	0
7	7/2	3	1
3	3/2	1	1
1	1/2	0	1

unsigned = 11101

2's comp = <u>011101</u>

b) Convert the 2's complement binary number 01110.01 to a base 10 number.

Base 10 number = ______________________________

01110.01

$\Rightarrow \quad 2^3 + 2^2 + 2^1 + 2^{-2}$

$8 + 4 + 2 + \frac{1}{4}$

<u>14.25</u>

c) Convert the decimal number –37 (or -37_{10}) to a 2's complement binary number with 7 bits.

Binary number = ______________________

base 10	÷ 2	Quot	Remaind.
37	37/2	18	1
18	18/2	9	0
9	9/2	4	1
4	4/2	2	0
2	2/2	1	0
1	1/2	0	1

37 ⇒ unsigned = 100101

2's comp = 0100101

–37 is 2's comp of 0100101

1's comp = 1011010

+1

⇒ 1011011 = -37_{10}

5. a) What is the sum of the 2's complement binary numbers i=01001 and k=11101? Give the sum in binary form (base 2).

i+k (in 2's-complement binary) = 000110

sign extend →

```
    001001
  + 111101
  --------
 X  000110
```

↗ ignore

b) Compute the difference (n – m) of the 2's-complement binary numbers n = 00111 and m= 01001

n – m (in 2's-complement binary) = ______

−m = 2's comp. of m: m = 01001

1's comp = 10110
+ 1
−m = 10111

sign extend ↓

```
n:      000111
−m  +   110111
        ------
        111110   = n − m
```

6. What is the standard Sum of Products (that is, a sum of minterms) expression for the logic function described by the truth table below?

F = ______________________________

A	B	F
0	0	1
0	1	0
1	0	1
1	1	1

minterm where row has F=1

$\overline{A}\,\overline{B}$

$A\,\overline{B}$

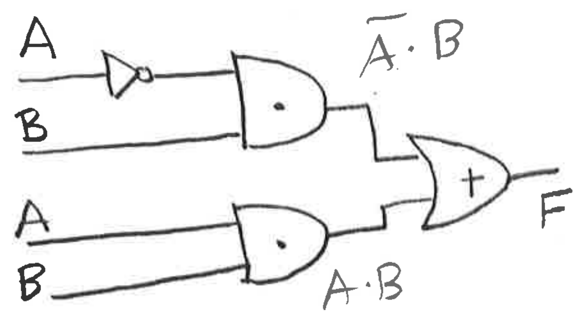
$A\,B$

$F = \overline{A}\cdot\overline{B} + A\cdot\overline{B} + A\cdot B$

7. For the logic circuits below, fill in the values for the output F in the truth table.

a)

A	B	F
0	0	0
0	1	1
1	0	0
1	1	1

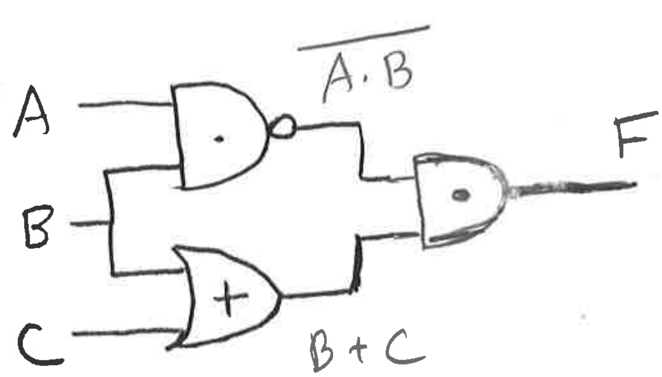


$F = \bar{A}\cdot B + A\cdot B$

b)

$\overline{A\cdot B}\cdot(B+C)$

A	B	C	F	$\overline{A\cdot B}$	B + C
0	0	0	0	1	0
0	0	1	1	1	1
0	1	0	1	1	1
0	1	1	1	1	1
1	0	0	0	1	0
1	0	1	1	1	1
1	1	0	0	0	1
1	1	1	0	0	1



8. Draw a circuit consisting of AND, OR and INVERT logic gates that implements the function below. The inputs to the circuit are A, B and C.

$$F = \overline{A}\,\overline{B} + AC$$