29:128   Homework Problems
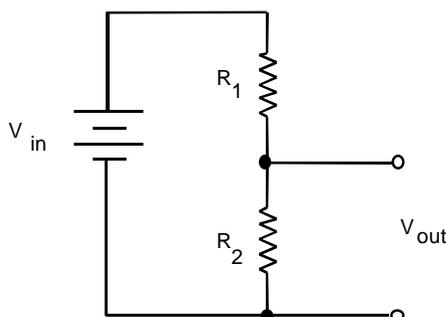
29:128   Homework 1   (15 points)

references:
    Sections 1.6-1.7 & 4.8, Meyer
    Chapter 1 of Horowitz and Hill, 2nd Edition

(1)   In the circuit shown below, V_{in} = 9 V, R_1 = 1.5 kΩ, R_2 = 5.6 kΩ,
    (a) Calculate V_{out}
    (b) Calculate the power dissipated in R_1 and R_2 .
    (c) Is a ¼ Watt resistor sufficient, or should you buy a resistor rated for a higher
        level of heat dissipation?

(2)   Repeat (1), but with R_1= 1.5 Ω, R_2 = 5.6 Ω.

(3)   Suppose you have two ac signals, which we'll call signals *A* and *B*, which are sine
    waves that have *peak-to-peak* amplitudes of 30 mV and 600 mV, respectively.

    (a) What is the dB for signal *A*, as compared to signal *B*?
    (b) Your answer to (a) was either positive or negative. What is the significance of
        this sign?
    (c) What are the *peak* voltages for signals A and B?
    (d) What are the *rms* voltages for signals A and B?

29:128   Homework 2   (10 points)

references:

 Sections 1.6-1.7 & 4.8, Meyer

 Chapter 1 of Horowitz and Hill, 2nd Edition

notes:

- MultiSym is required for this homework set. Complete your work in 201 VAN, which closes at 5 PM. See Michael Ciha in 218 VAN for technical assistance with printers or PCs.
- If you have difficulty printing an image using Multisym, use the following Windows screen-shot trick:
    - Select the window you wish to print, type ALT-SHIFT-PRINT SCREEN to copy a bit-map image of that window
    - Paste into the Windows Accessory application called Paint, and then select and copy the rectangular portion of the image you want.
    - Open a blank Word document and perform a paste. You will now have a printable word document with a screenshot of what you saw on the monitor. You should hand in pages of hand-written solutions, pages printed from MultiSym.

(1)

(a) Easy voltage divider problem. Use Multi-sym to make a voltage divider circuit as shown in the screen shot to the right. For the resistors, use a "virtual" resistor, and add a multimeter as shown. Attach printouts of (i) the circuit and (ii) the multimeter display (it's called an "instrument map" in Multisym's print menu).
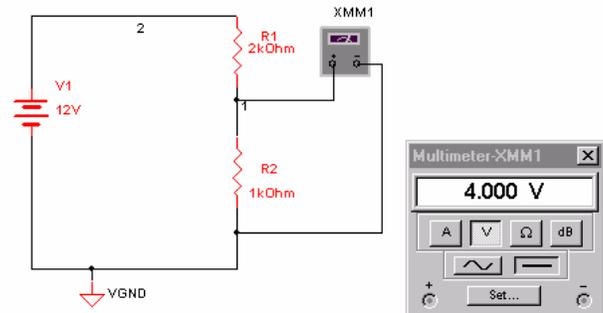
(b) Now change the component values to the following: V1 = 9 V, R1 = 1.4 kΩ and choose a value for R2 that will result in an output voltage of 5.0 V. Attach printouts of the circuit and multimeter display, and show a calculation of R2.

29:128   Homework 3   (30 points)

notes:
- Pages from Horowitz and Hill are needed to complete this assignment.
- MultiSym is required for this homework set.
- If you have difficulties making your circuit operate, try deleting nodes and then rewiring the circuit.
- You should hand in pages of hand-written solutions, pages printed from MultiSym, and the page of this question sheet that has the table for problem 2.

(1)   Horowitz & Hill Exercise 1.27
            Notes:
- This problem is related to a diode experiment in Laboratory 3, and you will find the problem easiest to do after you have done the lab.
- Be careful not to confuse *peak* and *rms* amplitudes. Review these two concepts for ac signals, if you're not sure.
- The electrical power in North America is 60 Hz.
- Pay attention to diode drops – and to how many are experienced by the current as it makes a round trip from one side of the transformer secondary to the other

(a) Solve the problem on paper. What you are supposed to do is choose the values of :
    (i) the *rms* voltage output of the transformer and
    (ii) the value of the capacitor
(b) What type of capacitor (ceramic, mylar, etc.) would you use (hint – see p. 22 Horowitz and Hill 2nd Edition)?
(c) What is the value of the load resistance R$_{load}$, if the output current is $I_{out} \leq 10$ mA. (Specify your result as either $R_{load} \leq X$ Ω or $R_{load} \geq X$ Ω, whichever is appropriate.)
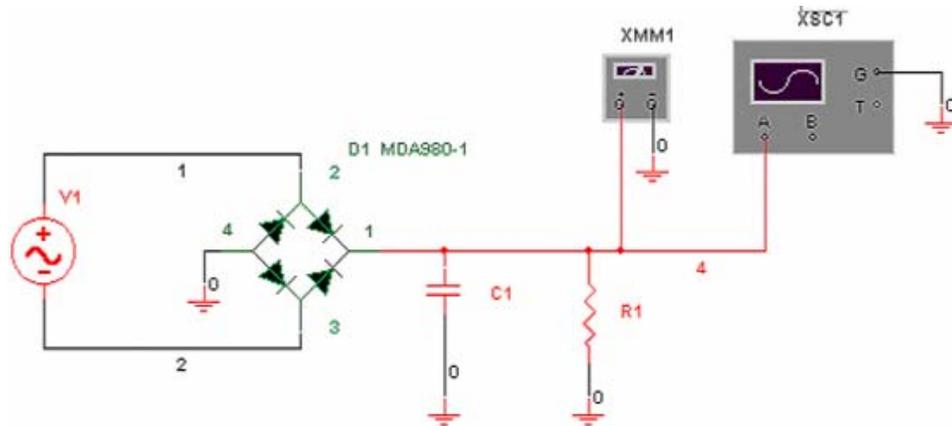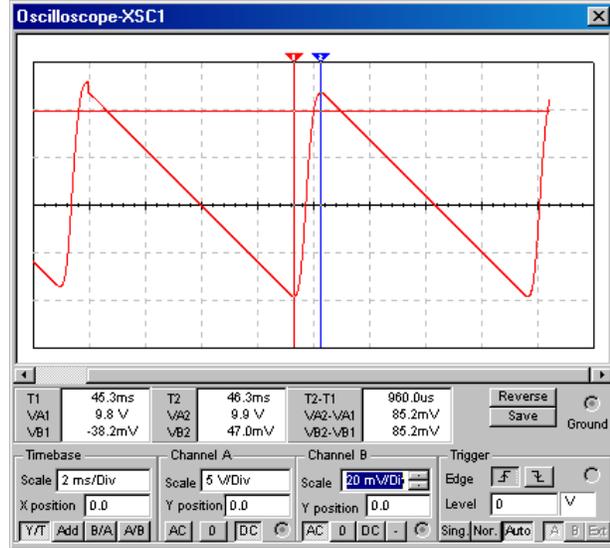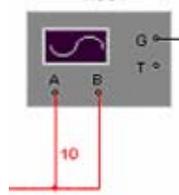
(d) Set this circuit up as a simulation, using Multisym, as shown in the screenshot. The component values are hidden; you should use the values you found in part (a). Instead of using Multisym's transformer, use its ac voltage source, and specify the *peak* voltage corresponding to your result for 2 (a) (i).

(i) Choose the load resistor that you calculated for $I_{out} = 10$ mA. Your circuit should begin with an ac voltage source that produces the ac voltage that you calculated in (a) as the desired output of the transformer. Be careful not to confuse rms with peak values of voltage. Use the MDA980-1 bridge rectifier. Attach a printout showing the circuit.

ac voltage source

(ii) Set up an "oscilloscope" display. You will need to observe the waveform too ways, dc coupled to show the dc output level, and ac coupled to better show the ripple. You can connect the circuit's output to both the A and B channels to show both the dc and ac coupled signals at the same time, as shown in the screenshots.

Oscilloscope-XSC1

T1	45.3ms	T2	46.3ms	T2-T1	960.0us	Reverse	
VA1	9.8 V	VA2	9.9 V	VA2-VA1	85.2mV	Save	Ground
VB1	-38.2mV	VB2	47.0mV	VB2-VB1	85.2mV		

Timebase
Scale 2 ms/Div
X position 0.0
Y/T Add B/A A/B

Channel A
Scale 5 V/Div
Y position 0.0
AC 0 DC

Channel B
Scale 20 mV/Div
Y position 0.0
AC 0 DC -

Trigger
Edge
Level 0 V
Sing. Nor. Auto A B Ext

10

Be sure to choose vertical and horizontal scales that are suitable so that the signal with its peaks is easily seen and measured. Your results should look something like the screenshot presented here.

Use the two cursors to measure the voltage at the maximum and the minimum of the ripple; see the screenshot for an example.

Attach printouts of the oscilloscope display (it's called an "instrument map" in Multisym's print menu), showing both dc coupling, and ac coupling.[1]

---

[1] For ac coupling, allow the oscilloscope trace to refresh itself twice before stopping and printing, otherwise you will only see an uninteresting transient at the beginning.

(2) Suppose that you now decide that what you really want is a 5 V power supply. Here you will test two ways of adding components to your circuit above to achieve a 5 V output. The screenshot presented here shows both ways, with some component values hidden. When you are asked for a DC voltage, you must decide which "instrument" to use to make the best measurement.
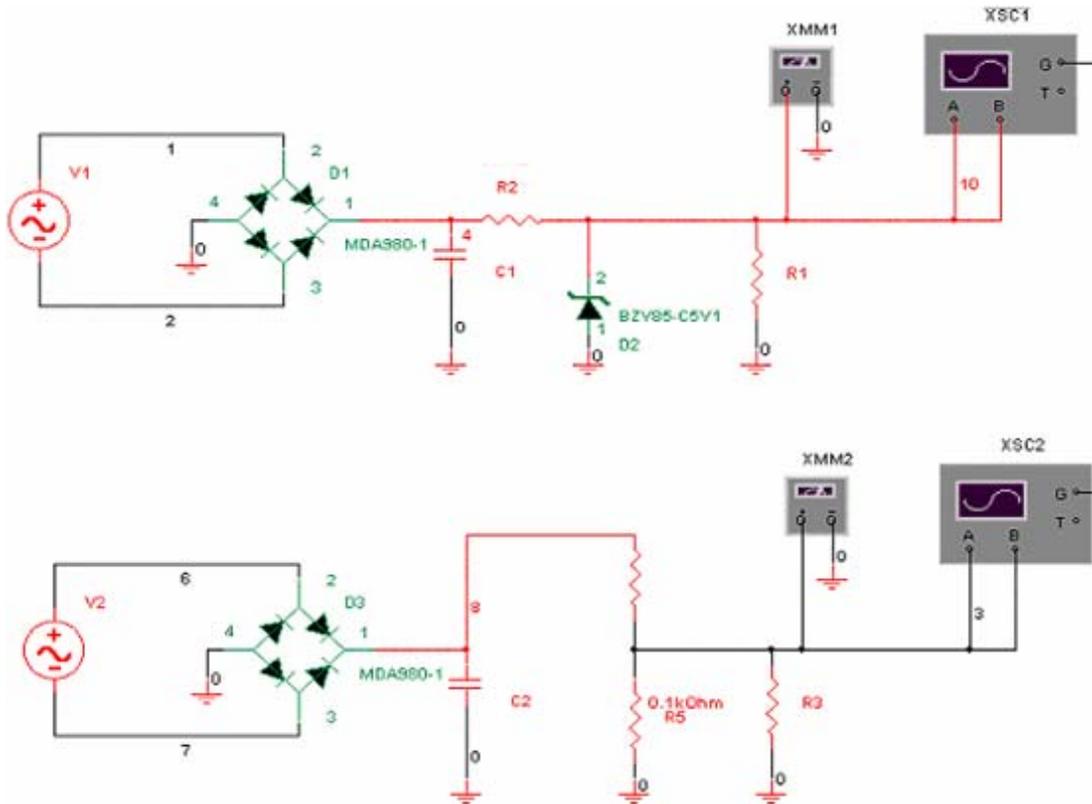
(a) After the filter capacitor, include a 5.1 V zener diode (for example, Philips BZV85-C5V1) with a series resistor. (i) Choose a value for the series resistor by testing two values, 100 Ω and then 1000 Ω, to see which gives you a smaller ripple. Report the corresponding peak-to-peak ripple values, as measured after the zener diode, and identify the value for the series resistor that gives the smaller ripple (Thereafter, always use that value for the series resistance.) (ii) Choose a value for the load resistor, which is located after the zener regulator; choose a value to achieve a load current of 10 mA (at 5 Volts). Attach a printout of your circuit.

(iii) Set up an "oscilloscope" display first with dc coupling showing the peak dc output and then with ac coupling showing the peak-to-peak ripple. (Be sure to choose vertical and horizontal scales that are suitable so that the signal with its peaks is easily seen and measured.) Using the cursor measurements, measure the peak-to-peak ripple. Also measure the DC voltage (note that at the end, you will need to calculate a difference of this DC voltage and another

nearly equal DC voltage, so it is necessary to measure the DC voltage with sufficient digits.) Attach printouts of instrument maps.

(iv) Repeat (iii) with the load resistance increased to 1 GΩ (so that there is essentially zero output current through the load).

(b) Repeat parts ii-iv above, but instead of the zener diode and its series resistor, use a pair of resistors in series, to form a voltage divider. Use the same load resistor that you used above in part (a)(i). For the resistor in parallel with your load, use 100 Ohms. Calculate the value of the other resistor yourself, to achieve the desired output voltage (as measured with the load resistor, not as measured with a 1 GΩ load).

(c) Fill out this table, and <u>hand it in</u> with your solutions (you may make a handwritten version of the table if you wish, so that you can keep the original copy of this page):

Method of reducing output voltage to 5 V.	*dc output voltage (V)*	*ripple voltage peak-to-peak (mV)*
Zener regulator, with 10 mA output current through load		
Zener regulator, with 0 mA output current through load		
Difference in DC voltage		XXXXXXXXX XXXXXXXXX

Voltage divider, with 10 mA output current		
Voltage divider, with 0 mA output current through load		XXXXXXXXX XXXXXXXXX
Difference in DC voltage		XXXXXXXXX XXXXXXXXX

(d) State which method of reducing the output voltage to 5 V is more desirable (voltage divider or zener)? Write down *two* reasons for your answer.

29:128   Homework 4   (20 points)

note: this homework assignment requires the use of MultiSym to simulate a circuit.

(1)   Common-emitter amplifier. Use Multisym to connect the circuit shown in the screen shot below.

    (a) The value of R2 is not shown. (i) Choose a standard value for 5% resistors, as tabulated in Appendix C, to achieve a base bias that results in the most symmetric output waveform possible. Show your calculation, including a result for the base bias that you intend to achieve. (ii) Run the simulation with a sine wave amplitude of approximately 600 mV and observe the clipping. (iii) Vary the value of R2 to test whether you chose the optimal value. After you are certain that you have chosen the optimum value of a standard 5% resistor,
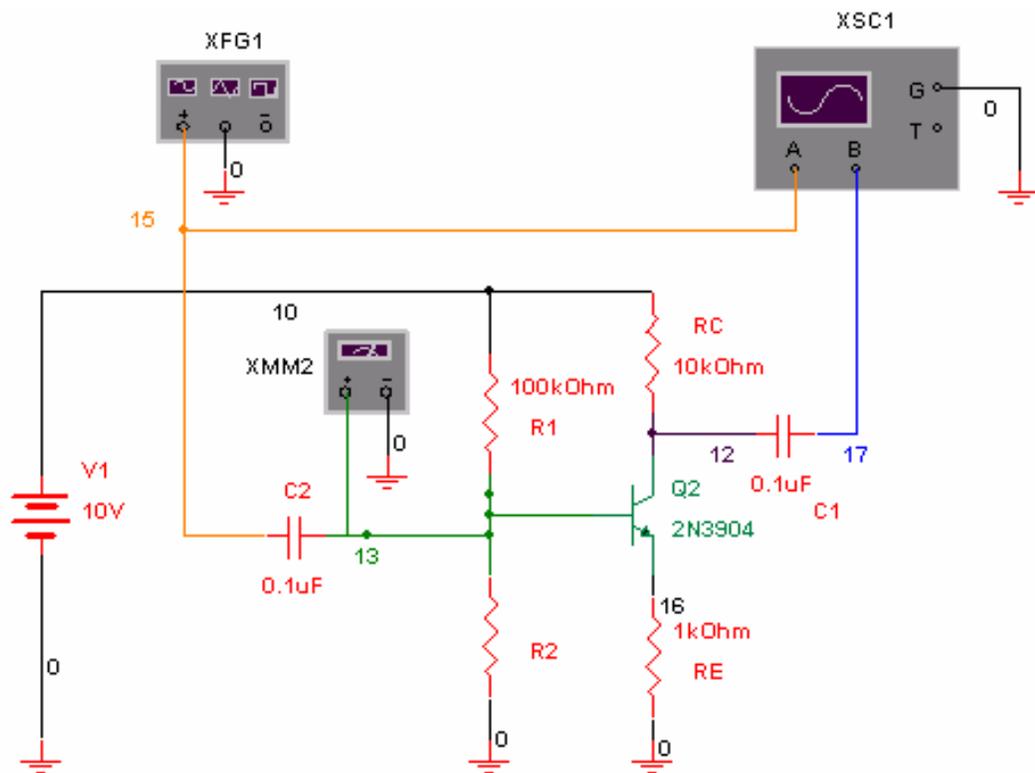
attach a printout[2] of the circuit schematic diagram as shown below (but showing the value of R2), and a printout of the oscilloscope display showing the clipping of the output waveform. (iv) Use the multimeter to measure the dc voltage on the base, and report this value.

(b) Reduce the input voltage amplitude to ~ 100 mV. Use the cursors to measure the input and output waveforms, at the maximum and minimum values. Reprot the peak-to-peak measurements. Calculate the ratio, including a minus sign if any, and report this as the gain. Repeat for R_C = 2 k and R_C = 5k. Compare to the theoretical values. Report your results in a table, similar to this:

	Measured peak-to-peak input	Measured peak-to-peak output	Measured gain	Theoretical gain
R_C = 2 k				
R_C = 5 k				
R_C = 10 k				

29:128   Homework 5   (20 points)

note:
- Pages from Horowitz and Hill are needed to complete this assignment.
- This homework assignment DOES NOT require the use of MultiSym

(1) Exercise 4.2 in Horowitz and Hil. (10 points)
- Show that $I_{load} = -V_{in} / R_2$.
- Provide a consolidated list of the principles and/or rules that you invoke in your solution
- Note: Be sure to recall that an opamp output can source or sink current

(2) Exercise 4.3 in Horowitz and Hil. (5 points)
   (a) For circuit A, show that gain = +1 with the switch in the follower position, and that gain = -1 with the switch in inverter position.
   (b) Repeat, for circuit B.

(3) Exercise 4.5 in Horowitz and Hil. (5 points)

29:128   Homework 6   (15 points)

note:
- Pages from Horowitz and Hill are needed to complete this assignment.
- This homework assignment DOES NOT require the use of MultiSym

Digital Electronics: Do the following exercises in Horowitz and Hill 2nd Edition

   (1)   exercise 8.7
   (2)   exercise 8.9
   (3)   exercise 8.12

29:128   Homework 7   (10 points)

note:

- This homework assignment DOES NOT require the use of MultiSym

(1) Consider the 555 timer circuit shown here. Show that the period is

$$T = 0.693 \ (R_A + 2 \ R_B) \ C.$$

Hint – review capacitor charging in the time domain (Meyer Sec. 2.7.1 or Horowitz & Hill pp. 23-24).