

PURDUE UNIVERSITY NORTH CENTRAL

Electrical & Computer Engineering Technology Department

ECET 157 (Prof. Smith)

PRE-TEST #2

Spring, 2009

NAME: ANSWERS

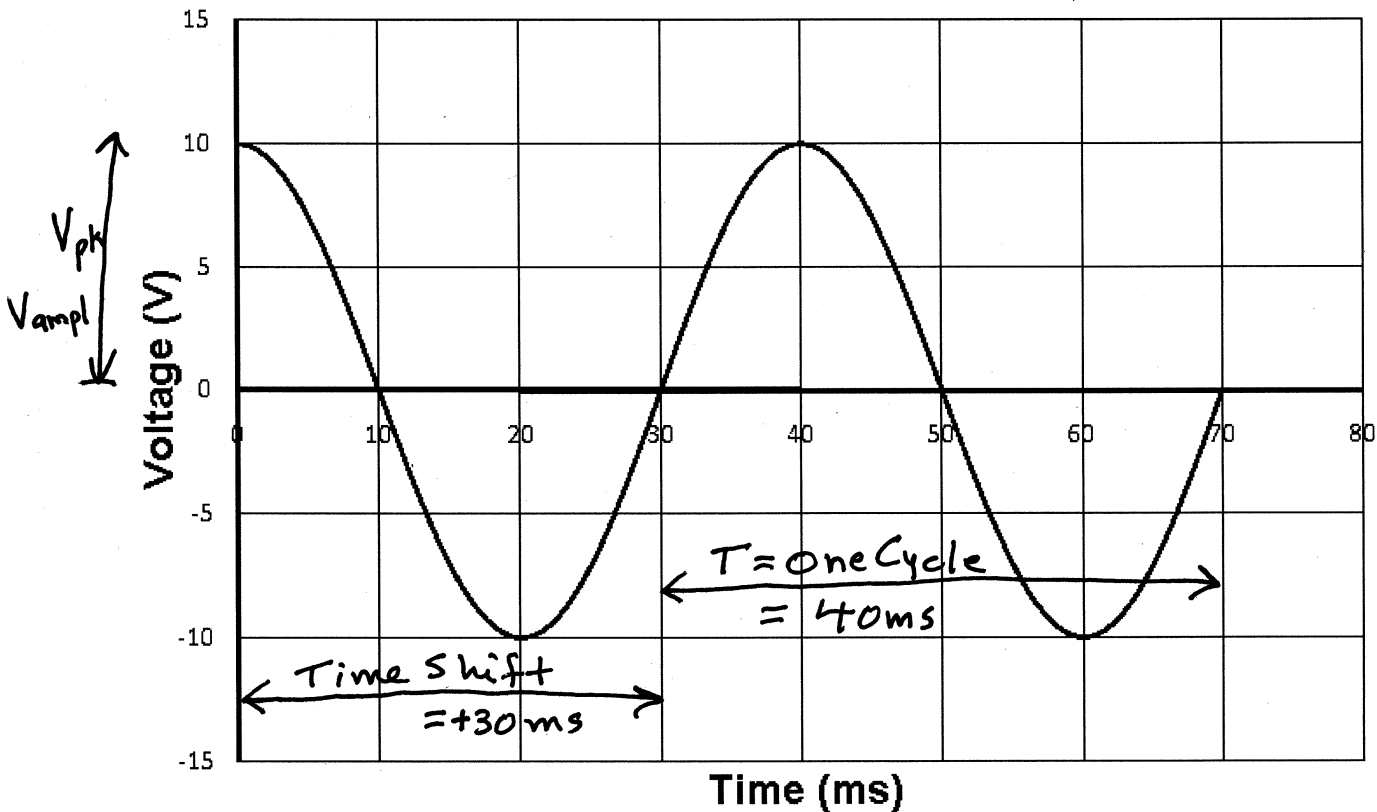
Part I -- Sinusoidal Waveforms.

1. For the signal below, determine the following. $V_{dc} = 0V$ $V_{ampl} = 10V$
 $V_{rms} = 7.07V$ $V_{pk} = 10V$ $V_{p-p} = 20V$ $V_{ave} = 0V$
 $f = 25k Hz$ $\text{period} = 40ms$ $\text{phase shift} = +270^\circ$ $\omega = 157K rad/s$

Write the time domain equation for the signal. $v(t) = 10 \sin(157Kt - 270^\circ)$

Write the phasor notation for the signal. $\bar{v} = 7.07V \angle \theta$

$\omega = 2\pi f = 2\pi * 25KHz = 157K$
 OR $+90^\circ$



$$\theta(\text{PHASE SHIFT}) = \frac{\text{Time Shift}}{T} * 360^\circ$$

$$= \frac{+30ms}{40ms} * 360^\circ = +270^\circ$$

$$= +270^\circ - 360^\circ = -90^\circ$$

$V_{ampl} \sin(\omega t - \theta)$

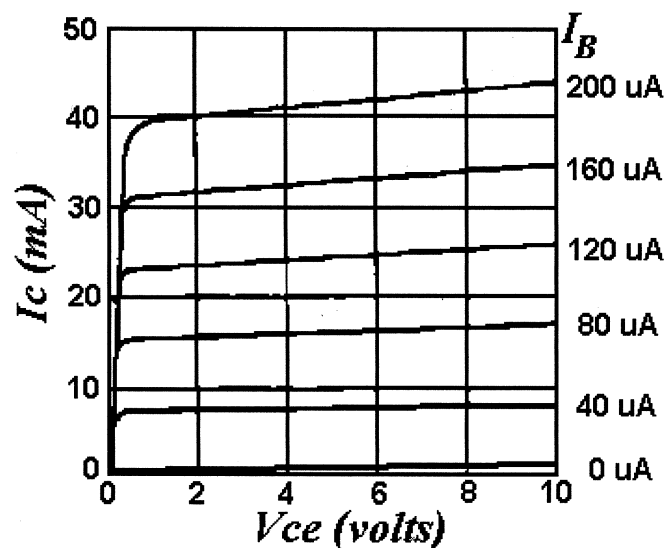
Part II - - True-False, Multiple-Choice and Short-Answer Questions.

NOTE: You should be familiar with all the True/False and Multiple-Choice questions from Pre-Test #1 and Test #1.

2. Name the three primary characteristics of op amps and tell why each is important.
3. Explain what Input Offset Voltage (V_{IO}) is and how it might affect an op amp circuit's operation.
4. Explain what Input Bias Current (I_B) is and how it might affect an op amp circuit's operation.
5. Explain what Input Offset Current (I_{OS}) is and how it might affect an op amp circuit's operation.
6. Explain the difference between Input Bias Current (I_B) and Input Offset Current (I_{OS}).
7. Explain what Slew Rate is and how it might affect an op amp circuit's operation.

Part III - - Circuits.

8. Refer to the characteristic curve shown.
 - (a) Pick a reasonable V_{CC} and $I_C(\max)$ and label these on the plot.
 - (b) Pick a Q-point & label it.
 - (c) Calculate the β .
 - (d) Calculate the α .
 - (e) Draw the universal-bias circuit.
 - (f) Calculate R_a , R_b , R_c and R_e and label these values on your circuit. (Use the approximate method.)
 - (g) Calculate I_B , I_C and I_E .
 - (h) Calculate the AC gain.



9. Draw an op amp Voltage Follower circuit. Assume that the op amp is ideal and attach a $5\text{-}V_{PK}$ sinewave source at the input. Sketch both this input and the output on the same graph, labelling which signal is which.
10. Draw an op amp Non-Inverting Amplifier circuit with a gain of ten. Assume that the op amp is ideal and attach a $5\text{-}V_{PK}$ sinewave source at the input. Sketch both this input and the output on the same graph, labelling which signal is which.
11. Draw an op amp Inverting Amplifier circuit with a gain of ten. Assume that the op amp is ideal and attach a $5\text{-}V_{PK}$ sinewave source at the input. Sketch both this input and the output on the same graph, labelling which signal is which.

- ②
- 1) Large gain.
 - 2) Large input impedance.
 - 3) Small output impedance.

③ V_{IO} adds a voltage to input(s).
 Multiplied by the gain, this may be enough to drive output to rail.
 At the least, it will cause an ^{output} error.

④/⑤ In similar fashion to V_{IO} , a current error may be amplified and cause an error in the output.

⑥ I_{OS} is the difference between the input current errors in the (+) input and the (-) input.

I_B is the average of the (+) and (-) input current errors.

⑦ Slew rate is a measure of how quickly the output of an op amp can change.

If the slew rate is too slow, ~~a fast~~ a quickly changing (i.e., high frequency) input might not even show up at the output.

Similar to propagation delay in digital ccts.

8 a I picked $I_{c(max)} = 50mA$ and $V_{cc} = 10V$.

NOTE: Your choices can be different. It's up to you.

b I picked the mid-point.

I.E., $V_Q = 5V$ & $I_Q = 25mA$.

NOTE: At my Q-point,

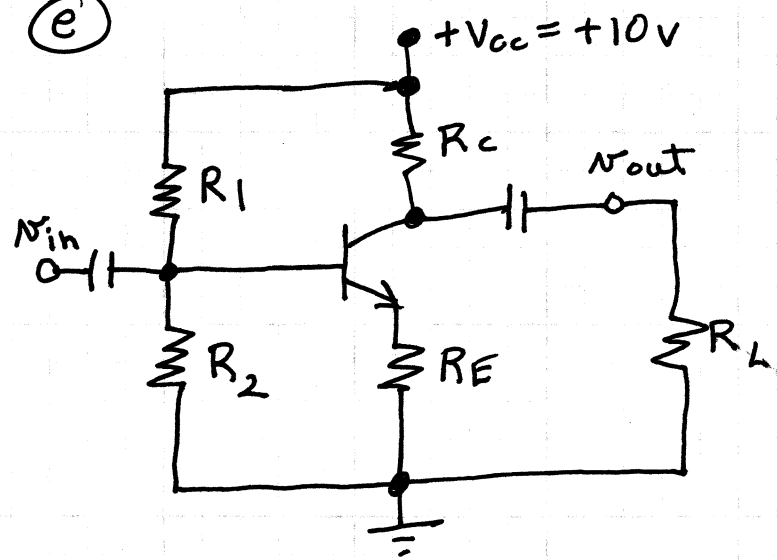
$I_B = 120\mu A$

c $\beta = \frac{I_c}{I_B}$ AT THE Q-POINT!!!

$= \frac{25mA}{120\mu A} = 208$

d $\alpha = \frac{\beta}{\beta + 1} = \frac{208}{208 + 1} = \frac{208}{209} = 0.995$

e



f $R_c = \frac{V_{cc}}{I_{c(max)}} = \frac{+10V}{50mA} = 200\Omega$

$R_E \approx \frac{1}{3} R_C = 67\Omega$

(Find R_1 & R_2 after 9.)

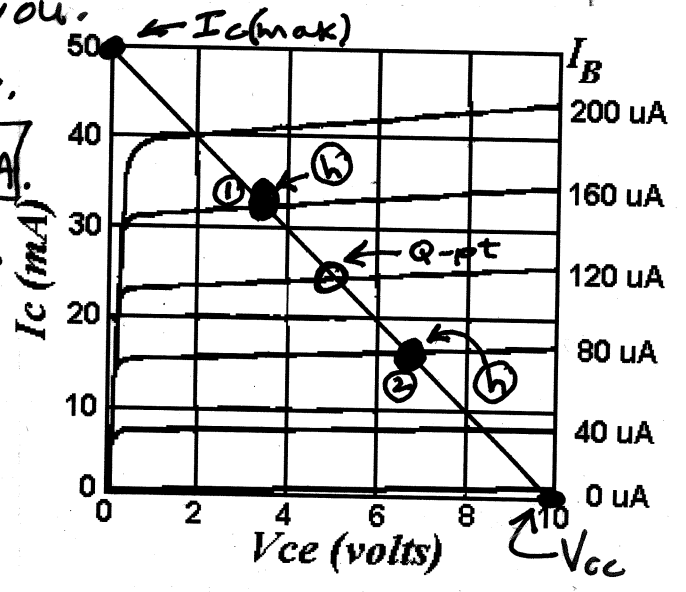
$V_E = I_E * R_E = 25.12mA * 67\Omega = 1.683V$

$V_{BE} \approx 0.7V$ (DIODE)

$V_B = V_E + V_{BE} = 1.683 + 0.7 \approx 2.38V$

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9 $I_c = 25mA$ } AT
 $I_B = 120\mu A$ } Q-pt!
 $I_E = I_c + I_B = 25.12mA$



(f) (cont.) Pick $R_1 \ll R_2$ to get $V_B = 2.38V$

$$V_{cc} = 10V \Rightarrow R_1 + R_2 = 10K\Omega$$

$$\Rightarrow R_2 = 2.38K\Omega$$

$$R_1 = 10K - 2.38K = 7.62K\Omega$$

(h) AC gain \Rightarrow Pick points on load line, one above and one below Q-pt. (Pick something to make the calculations easy!)

I drew the points that I picked on the char curve.

Point 1: $I_C \approx 32mA$ and $I_B \approx 160\mu A$.

Point 2: $I_C \approx 17mA$ and $I_B = 80\mu A$.

$$\begin{aligned}
 B_{AC} &= \frac{I_{C1} - I_{C2}}{I_{B1} - I_{B2}} = \frac{32mA - 17mA}{160\mu A - 80\mu A} = \frac{15mA}{80\mu A} \\
 &= 187.5 \\
 &\approx 188
 \end{aligned}$$