PURDUE UNIVERSITY NORTH CENTRAL

Electrical & Computer Engineering Technology Department

ECET 157 (Prof. Smith) **TEST #2** **Spring, 2009**

NAME: ANSWERS

Part I - - Sinusoidal Waveforms. *(15 points)*

1. For the signal below, determine the following. $V_{dc\ offset}$ = 0V V_{ampl} = 10V

$V_{AMPL} * 0.707$ → V_{rms} = 7.07V V_{pk} = 10V V_{p-p} = 20V V_{ave} = 0V

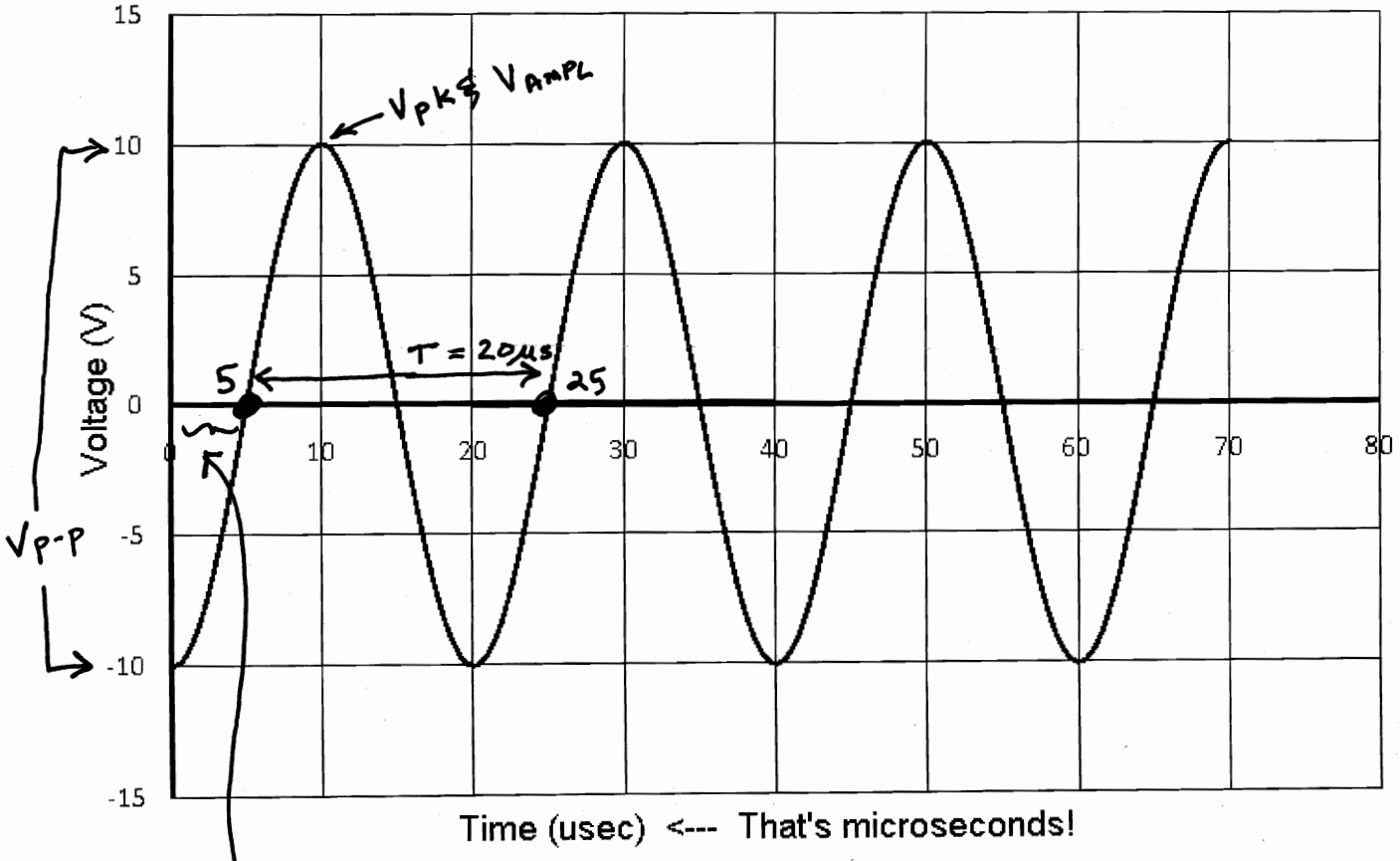
$\frac{1}{T}$ = f = 50K Hz period = 20µs phase shift = +90° ω = 314K rad/s ← $2\pi f$

$2 \times \pi \times 50K = 314K$

Write the time domain equation for the signal. v(t) = $10 \sin(314K t + 90°)$

Write the phasor notation for the signal. $\overline{V}$ = $7.07V \angle +90°$

V_{Rms} ↑ θ ↑



Time shift = +5µs

$$\theta = \frac{\text{Time shift}}{T} \times 360° = \frac{+5\mu s}{20\mu s} \times 360° = +90°$$

Part II - - True-False and Write-In Questions. *(30 points)*

2. (T) F The p-side of a diode is called the anode.

3. (T) F A BJT in saturation typically has 0.2 Volts or less across the collector-emitter ~~junction~~ connection.

4. (T) F As a semiconductor gets warmer, it conducts more current.

5. (T) F A Zener diode ~~useful~~ can be driven to the reverse breakdown point, then recover.

6. The three terminals of a bipolar junction transistor are called:

   a. Collector.

   b. Base.

   c. Emitter.

8. The Q-point indicates the (name the current) I_C current and the (name the voltage) V_{CE} voltage when the transistor's input is equal to (how many?) 0 Volts.

9. The three notable features that make op amps so useful are: (Also tell why each is important.)

   a. Hi Z_{in} → Draws almost zero current from previous ckt.

   b. Low Z_{out} → Sends most power to load.

   c. Large Gain → Useful amplifier.

10. Looking at a schematic, you notice that the input v_{in} to an op amp circuit goes to the (–) input terminal through a resistor. You also notice that there is a feedback resistor connected from the output to the same (–) terminal. What type of amplifier is this? (Check best answer.)

    ____ a. Non-Inverting Amplifier. X b. Inverting Amplifier. ____ c. Voltage Follower.

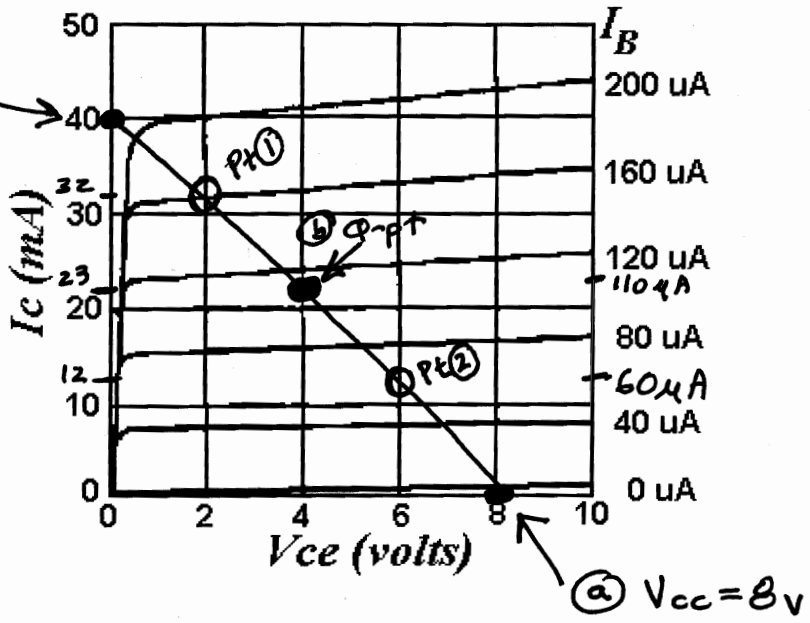
11. Briefly describe how an op amp's Input Offset Voltage (V_{IO}) and Input Bias Current (I_B) can affect the circuit. (Is this something to be concerned about? If so, why?)

    ADDS VOLTAGE TO OUTPUT, SO V_{OUT} WILL HAVE AN ERROR.
    ERROR MAY BE AMPLIFIED BY SUBSEQUENT AMPLIFIERS AND EVEN SEND OUTPUT TO EDGE.

Part III - - BJT Amplifier Circuit. *(25 points)*

12. Refer to the characteristic curve shown.

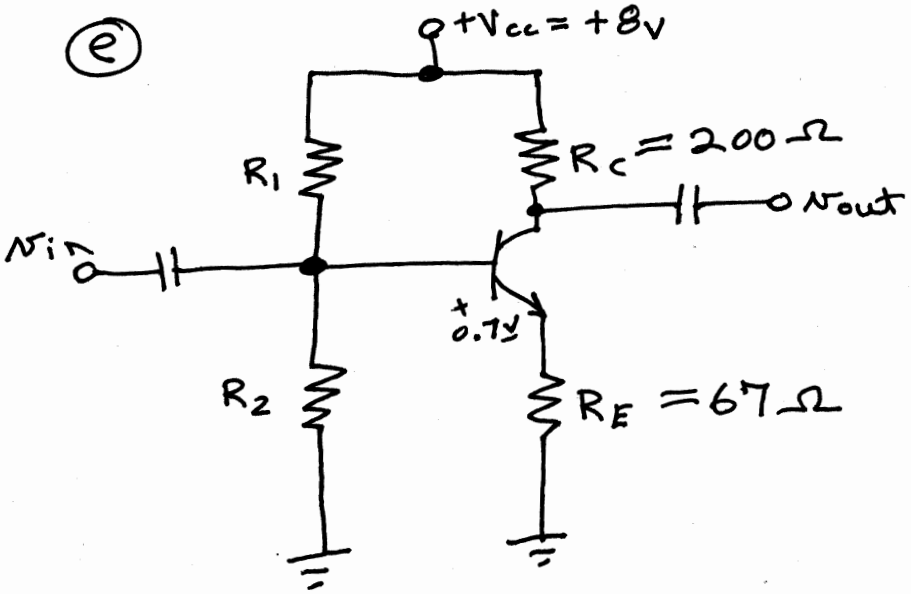
- ✓ (a) Use V_{CC} = 8V and $I_{C(max)}$ = 40 mA and label these on the plot.
- ✓ (b) Pick a Q-point & label it. (Clearly mark its I_C & V_{CE} !!!)
- ✓ (c) Calculate the β.
- ✓ (d) Calculate the α.
- ✓ (e) Draw the universal-bias circuit.
- (f) Calculate Ra, Rb, Rc and Re and label these values on your circuit. (Use the approximate method.)
- (g) Calculate I_B, I_C and I_E.
- (h) Calculate the AC gain.



(c) $\beta = \frac{I_C}{I_B} \approx \frac{23mA}{110\mu A} = \boxed{209}$

(d) $\alpha = \frac{\beta}{\beta+1} = \frac{209}{210} = \boxed{0.995}$

(e)



(f) $R_C \cong \frac{V_{CC}}{I_{C_{max}}} \approx \frac{8V}{40mA} = \boxed{200\Omega}$

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

CALCULATE I_C & I_E, THEN V_E & V_B (Part (g).)

From (g) $I_E \approx 23mA \Rightarrow V_E = R_E I_E = 67\Omega \times 23mA = 1.54V$

$\Rightarrow V_B = V_E + 0.7V = 1.54 + 0.7 = 2.24V$

choose $R_1 + R_2 = 80K\Omega \Rightarrow R_2 = \boxed{22.4K\Omega}$

(I.E. EACH 1V NEEDS 10KΩ.)

$R_1 = 80K - R_2$

$= 80K - 22.4K$

$= \boxed{57.6K\Omega}$

(g) READ FROM CHAR. CURVE:

At Q-point, $\boxed{I_C \approx 23mA}$ & $\boxed{I_B \cong 110\mu A}$

$\boxed{I_E} = I_C + I_B = \boxed{23.110mA}$

$\approx I_C \approx 23mA$

(h) AC Gain: Pick 2 points, one <u>above</u> and one <u>below</u> the Q-pt. (Labelled Pt ① and Pt ②.)

$\Delta I_C = I_{C_1} - I_{C_2} = 32mA - 12mA$

$= 20mA$

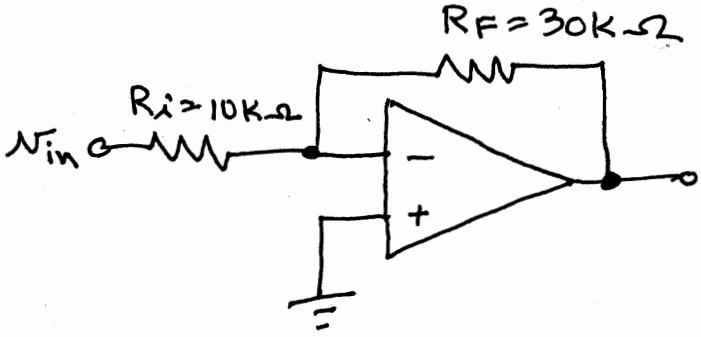
$\Delta I_B = I_{B_1} - I_{B_2} = 160\mu A - 60\mu A$

$= 100\mu A$

$\beta_{AC} = \frac{\Delta I_C}{\Delta I_B} = \frac{20mA}{100\mu A} = \boxed{200}$

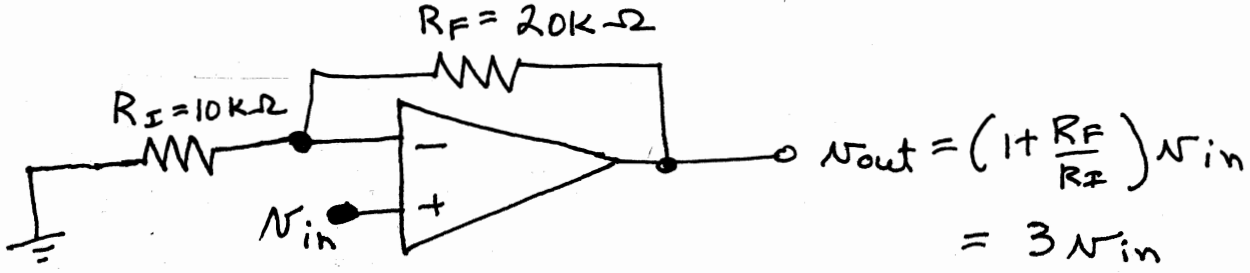
Part III - - BJT Amplifier Circuit. *(30 points)*

13. Draw an Inverting Amplifier Circuit with a gain of 3. $GAIN = -\frac{R_F}{R_I} \Rightarrow$ USE $R_I = 10K\Omega$, $R_F = 30K\Omega$



14. Draw a Non-Inverting Amplifier Circuit with a gain of 3.

$GAIN = 1 + \frac{R_F}{R_I} = 3 \Rightarrow \frac{R_F}{R_I} = 2 \Rightarrow$ USE $R_I = 10K\Omega$, $R_F = 20K\Omega$



15. Draw a Voltage Follower Circuit.