Please work the problems carefully. Show your work and note that partial credit is given only if work is shown neatly. Give appropriate units. The exam has 10 questions and a bonus question.

Q1: (10 pts.) Assuming ideal diode find I and V in the circuit shown below.

\[ I = 5 \text{mA} \]
\[ V = 5 \text{V} \]

D OFF \hspace{1cm} I = 5 \text{mA}, V = 5 \text{V}

Q2: (10 pts.) Consider the battery charging circuit shown below. \( V_m = 20 \text{ V} \), \( R = 20 \Omega \), \( V_B = 12 \text{ V} \). Find the peak value of \( i(t) \). Assume ideal diode.

\[ V_s(t) = V_m \sin(\omega t) \]
\[ \frac{20 - 12}{20} = \frac{8}{20} = 0.4 \text{A} \]
\[ i_{peak} = 0.4 \text{A} \]

Q3: (10 pts.) Sketch \( i(t) \) vs. \( \omega t \) for one cycle for the circuit shown in Q2.

\[ i(t) > 0 \text{ if } V_c(t) > V_B = 12 \text{V} \]
\[ V_m \sin(\omega t) > \frac{12}{\omega_0} \]
\[ \omega t > \sin^{-1}\left(\frac{12}{\omega_0}\right) \]
\[ > 36.9^\circ \]
\[ \text{Angle: } 37^\circ \text{ to } 143^\circ \]
Please work the problems carefully. Show your work and note that partial credit is given only if work is shown neatly. Give appropriate units. The exam has 10 questions and a bonus question.

Q1: (10 pts.) Assuming ideal diode find I and V in the circuit shown below.

\[ I = 5 \text{mA} \]
\[ V = 5 \text{V} \]

D OFF \hspace{1cm} I = 5 \text{mA}, V = 5 \text{V}

Q2: (10 pts.) Consider the battery charging circuit shown below. \( V_m = 20 \text{V}, R = 20 \Omega, \) \( V_B = 12 \text{V} \). Find the peak value of \( i(t) \). Assume ideal diode.

\[ u_s(t) = V_m \sin (\omega t) \]

\[ \frac{20 - 12}{20} = \frac{8}{20} = 0.4 \text{A} \]

\[ i_{\text{peak}} = 0.4 \text{A} \]

Q3: (10 pts.) Sketch \( i(t) \) vs. \( \omega t \) for one cycle for the circuit shown in Q2.

\[ i(t) > 0 \text{ if} \]
\[ u_s(t) > V_B = 12 \text{V} \]

\[ \frac{V_m \sin (\omega t)}{\omega t} > \frac{12}{20} \]

\[ 20 \omega t > 20 \sin^2 \left( \frac{180}{20} \right) > 26.90 \]

\[ 180 - 37 \approx 143^\circ \]
Q4: (10 pts.) Sketch an equivalent circuit of the circuit shown below for ac analysis. Replace the diode with its small signal model. Find $i_d(t)$, the ac diode current. $V_{DQ} = 0.6$ V, $n = 1$, $V_T = 26$ mV

Q5: (10 pts.) Consider the zener diode regulator circuit shown below. The diode Characteristics is also sketched below. Find the load voltage, $V_L$, if $V_{SS} = 20$ V, $R = 1.0$ kΩ, $R_L = 4$ kΩ.

Q6: (10 pts.) Find the value of $\beta$ for the transistor of the circuit shown below.
Q10: (10 pts.) Sketch the load-line (Rc = 1kΩ) on the output characteristics for the transistor shown below. Show the dc operating point (Q-point) on the load line. Find IBO, I CO, and VCEO.

\[ V_{CC} = +6\, V \]

\[ I_{BO} = 30\, \mu A \]  \hspace{1cm} \#2

\[ I_{CO} = 3\, mA \]  \hspace{1cm} \#4

\[ V_{CEO} = 3\, V \]  \hspace{1cm} \#4

BONUS QUESTION: (10 pts.) Using the characteristics shown above in Q 10, and the load-line you have drawn, find \( i_{C_{max}} \) and \( i_{C_{min}} \) if \( i_{C_{max}} \) and \( i_{C_{min}} \) are 60 mA and 0 mA, respectively. Comment on the choice of the dc operating point, e.g., Do you run into cutoff or saturation? Is it possible to change the slope of the load-line to keep the transistor in the active region?

\[ i_{C_{max}} = 5.8\, mA \]  \hspace{1cm} \#3

\[ i_{C_{min}} = 0\, mA \]  \hspace{1cm} \#3

slope dependent on \( R_c \) \[ \alpha = \frac{1}{R_c} \]

\[ R_c = 500\, k\Omega \], see the load line

To avoid cut-off keep \( i_{B_{min}} \) to at least \( 5\, mA \).