The synchronous generator described above is operating with constant mechanical torque, \( T_m \), equal to 0.8 per unit and delivering power to an infinite bus. The electrical power (torque) generated by the generator goes to zero for period of time, \( t_c \), (clearing time). The clearing angle, \( \delta_c \), is the angle of the rotor at \( t_c \). The critical clearing time, \( t_{cr} \), is the maximum clearing time for stable operation. The critical clearing angle, \( \delta_{cr} \), is the angle of the rotor at \( t_{cr} \).

Assume that:

\[
T_e = \begin{cases} 
T_{max}\cos(\delta) & t < 0 \\
0 & 0 \leq t < t_c \\
T_{max}\cos(\delta) & t_c \leq t
\end{cases}
\]

Part I
Using analytical methods (not simulation) calculate the:

1. critical clearing angle, \( \delta_{cr} \),
2. critical clearing time, \( t_{cr} \),
3. the maximum swing angle, \( \delta_{maxswing} \) (with \( t_c = 0.8t_{cr} \)), and
4. the minimum swing angle, \( \delta_{minswing} \) (with \( t_c = 0.8t_{cr} \)).

Part II
Modify the accompanying simulink file to verify by simulation the:

1. critical clearing time, \( t_{cr} \),
2. critical clearing angle, \( \delta_{cr} \),
3. maximum swing angle, \( \delta_{maxswing} \) (with \( t_c = 0.8t_{cr} \)), and
4. minimum swing angle, \( \delta_{minswing} \) (with \( t_c = 0.8t_{cr} \)).

For Part II submit the following:

1. a graph of two swings of \( \delta \) versus time with \( t_c = t_{cr} \)
2. a graph of \( \delta \) as a function of time for \( t_c = t_{cr} + \) a small amount; and
3. a graph of two swings of \( \delta \) versus time with \( t_c = 0.8t_{cr} \) label \( t_c \), \( \delta_c \), \( \delta_{maxswing} \), and \( \delta_{minswing} \) on the graph.