Physics 3/3 Assignment 7

1. a) From characteristic curves, for $I_B = 0.3 \text{ mA}$, $I_C = 10 \text{ mA}$
   $\beta = h_{FE} = 10 \text{ mA} / 0.3 \text{ mA} = 33$

   b) power dissipated is greatest in upper right, where both
      $I_C = V_{CE}$ are largest
      highest point shown has $I_C = 12 \text{ mA}$, $V_{CE} = 22 \text{ V}$
      $P = I_C V_{CE} = (0.012 \text{ A}) (22 \text{ V}) = 0.269 \text{ W} > 0.4 \text{ W}$ (just barely)

2. a) Example 1, given $V_{CC} = +15 \text{ V}$, $V_B = 3.6 \text{ V}$, $R_1 = 10k$, $R_2 = 3k$

   $V_E = V_B - 0.6 = 3.0 \text{ V}$
   $I_E = \frac{V_E - V_{EE}}{R_2} = \frac{3 \text{ V}}{3k} = 1.0 \text{ mA}$

   $I_B = \frac{I_E}{h_{FE}} = 0.01 \text{ mA}$  \hspace{1cm} (h_{FE} \approx 1 = h_{FE} \text{ to within } 1\% \approx 5\%)
   $I_C \approx I_E = 1.0 \text{ mA}$

   $V_C = V_{CC} - I_C R_1 = 15 \text{ V} - (1.0 \text{ mA})(10 \text{ k}) = 5.0 \text{ V}$

   b) $V_E \leq V_{EE}$; $V_C \leq V_{CC}$; $V_{CE} = 5.0 \text{ V} - 3.0 \text{ V} = 2.0 \text{ V} > 0.2 \text{ V}$
   so transistor on → assumption OK

   c) if $h_{FE} = 80$, $I_B = \frac{1.0 \text{ mA}}{80} = 0.0125 \text{ mA}$
   everything else is the same to within 5%.

   d) with $R_1 = 15 \text{ k}$, $V_C = 15 \text{ V} - (1.0 \text{ mA})(15 \text{ k}) = 0 < V_E$
   so transistor could not be on with the given parameters.
   Very little current would flow, and $V_C = V_{CC} + V_E > V_{EE}$

3. Emitter Follower
   a) no voltage gain ($V_O = V_{in}$)

   b) current gain of $h_{FE}$ ($I_C / I_B = h_{FE}$). so it depends on transistor's $h_{FE}$

   c) $R_{in} = h_{FE} R_{load} = 100 \text{ Ohms} \rightarrow$ typically big ($R_{load}$ typically large, so 100X)

   d) $R_{out} = R_{source} / h_{FE} \approx R_{source} / 100 \rightarrow$ small
      \hspace{1cm} (this is very large)

   e) for $V_{CE} = +12 \text{ V}$, to keep $V_C \leq V_{CC}$, $V_E = V_{in} - 0.6 + V_{CE} \geq 0.2$
      so $V_C \geq V_E + 0.2 = V_{in} - 0.4 \implies V_{in} = V_C + 0.4 \leq 12.4 \text{ V}$
      for $V_{EE} = -10 \text{ V}$, to keep $V_E \geq V_{EE}$, $V_E = V_{in} - 0.6$
      so $V_E = V_{in} - 0.6 \geq V_{EE} \implies V_{in} \geq V_{EE} + 0.6 = -9.4 \text{ V}$

   OK for $-9.4 \text{ V} \leq V_{in} \leq 12.4 \text{ V}$