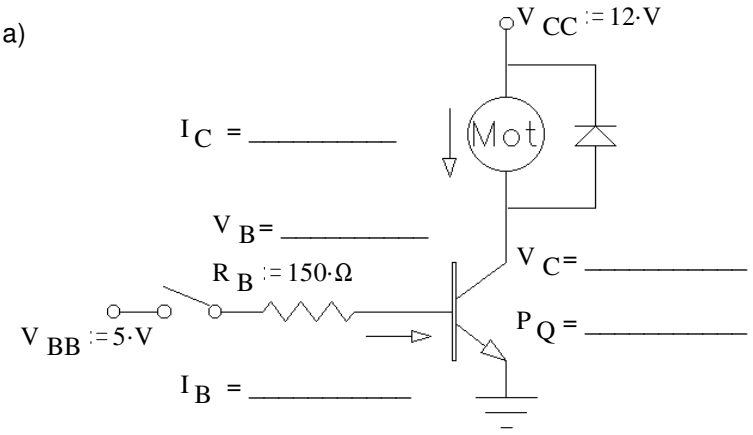
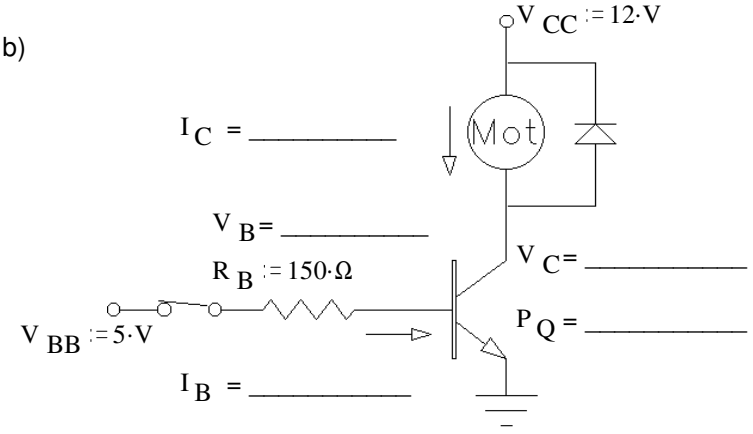
1. Fill in the blanks in the circuits below and on the next page. Assume that the motor can be modeled with a 25 Ω resistor and that transistor β's are 20 (a very conservative estimate).

$R_{mot} := 25 \cdot \Omega$ $\beta := 20$

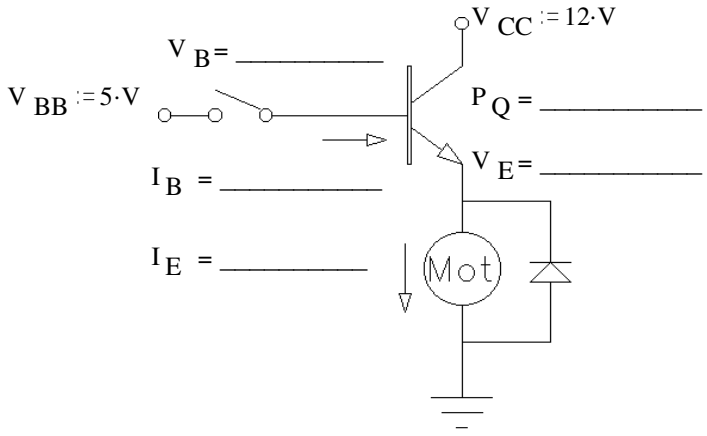
a)



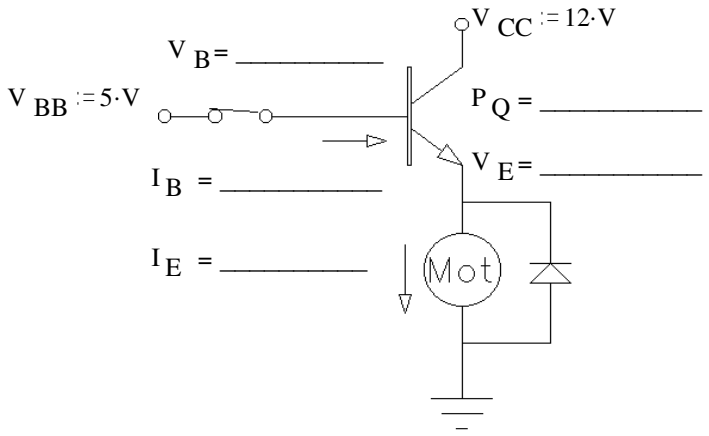
b)



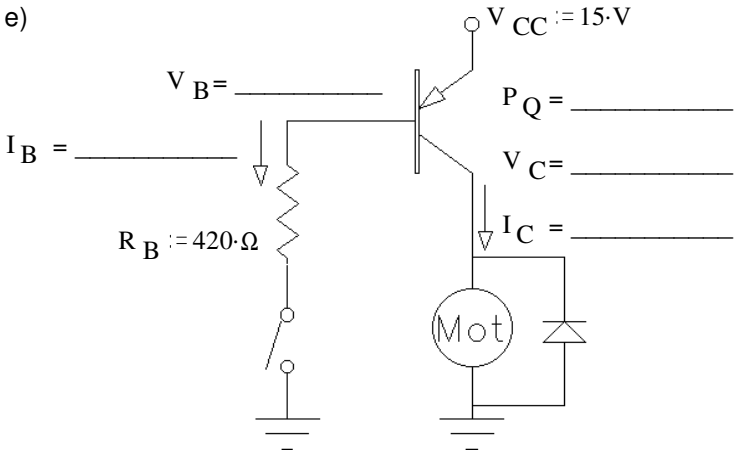
c)



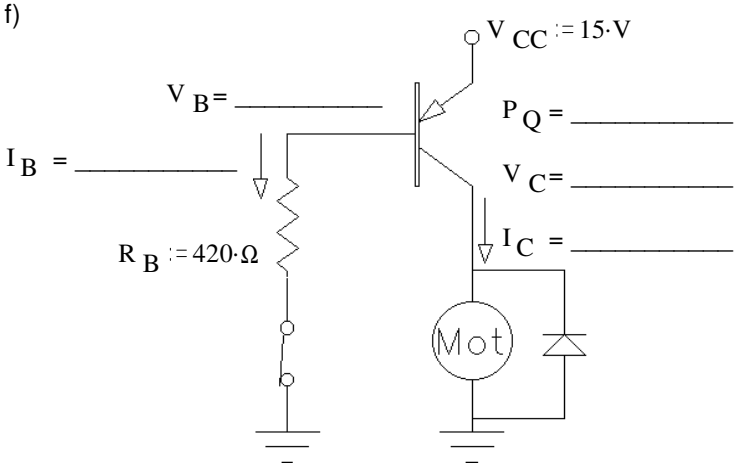
d)


V CC := 12·V
V B =
V BB := 5·V
P Q =
V E =
I B =
I E =
Mot

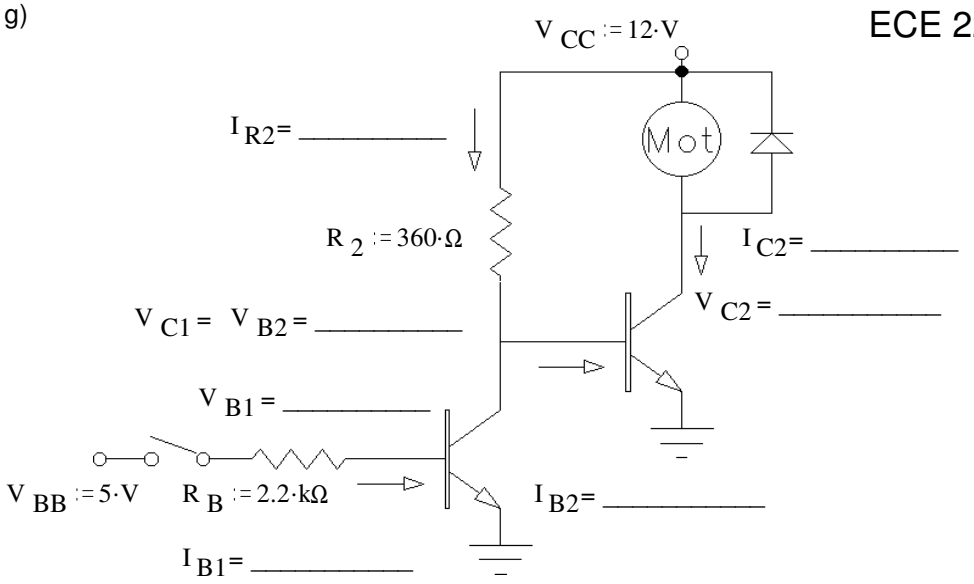
e)


V CC := 15·V
V B =
P Q =
I B =
V C =
I C =
R B := 420·Ω
Mot

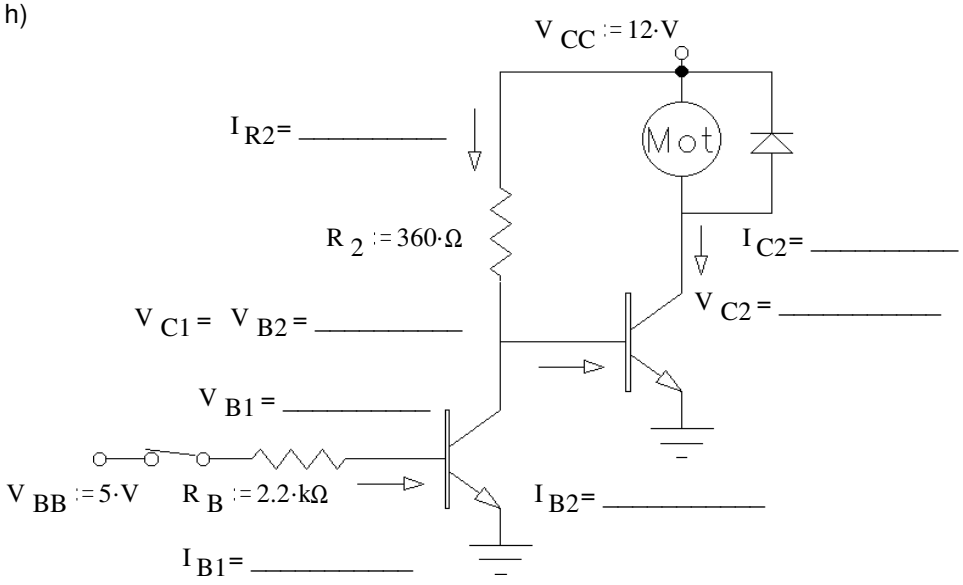
f)


V CC := 15·V
V B =
P Q =
I B =
V C =
I C =
R B := 420·Ω
Mot

g)



h)

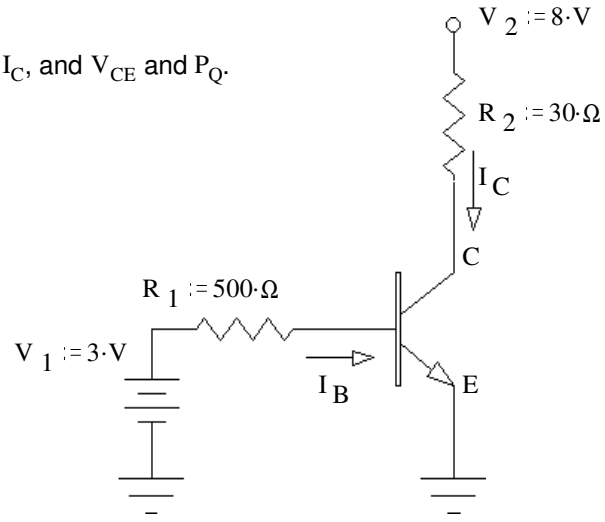


2. In problem 1b, What is the largest value that R_B could be and still keep the transistor in saturation?

3. In problem 1f, What is the largest value that R_B could be and still keep the transistor in saturation?

4. a) $\beta := 40$ Assume the transistor is in the active region, find I_C, and V_{CE} and P_Q.

I_C = ? V_{CE} = ? P_Q = ?



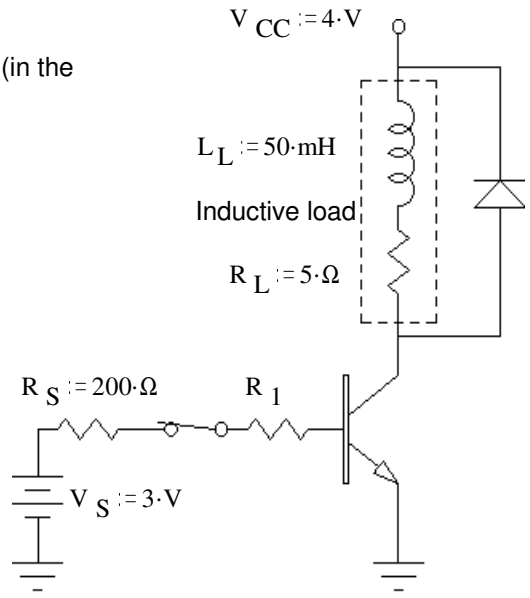
b) Was the transistor actually operating in the active region? yes no circle one

How do you know? (Specifically show a value which is or is not within a correct range.)

c) $\beta := 40$ find the maximum value of R_1, so that the transistor will be in saturation.

d) $R_1 = 500 \cdot \Omega$ and can't be changed, find the minimum value of β, so that the transistor will be in saturation.

5. A transistor is used to control the current flow through an inductive load (in the dotted box, it could be a relay coil or a DC motor).



a) Assume the transistor is in saturation (fully on) and that switch has been closed for a long time. What is the load current?

I_C = ?

b) $\beta := 80$ find the maximum value of R_1, so that the transistor will be in saturation.

Use this R_1 for the rest of the problem.

c) You got a bad transistor. $\beta := 40$ Find the new I_C, and V_{CE} and P_Q.

I_C = ? V_{CE} = ? P_Q = ?

The power dissipation was too high for the transistor and it burned out. You replace the transistor with a new one that has $\beta \geq 80$

d) The diode in this circuit conducts a significant current: (circle one)

A) never.
B) when the switch opens.
C) whenever the switch is open.
D) when the switch closes.
E) whenever the switch is closed.
F) always.

e) The switch is opened and closed a few times. What is the maximum diode current you expect. (Answer 0 if it never conducts.)

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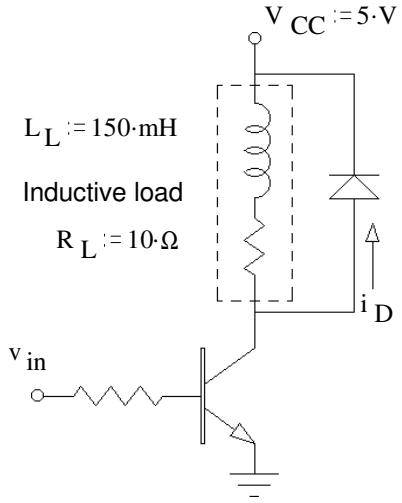
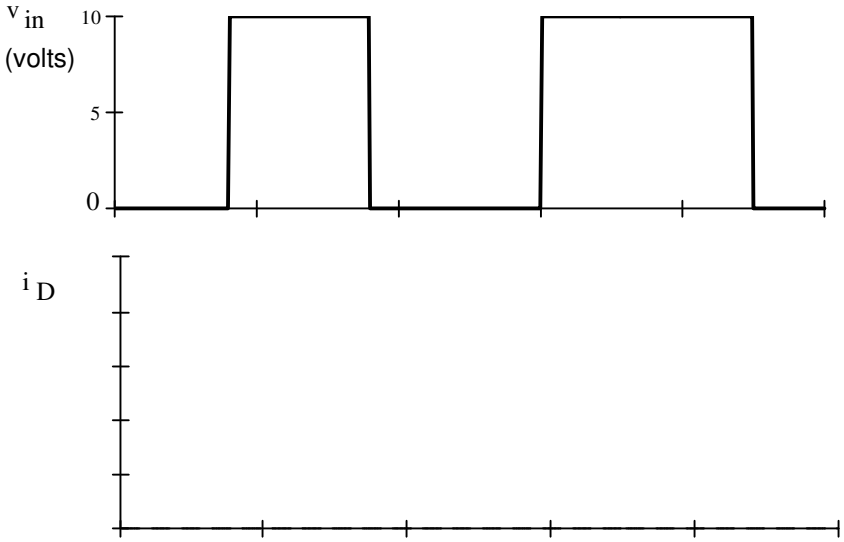
6. A power transistor is used to control the current flow through an inductive load (in the dotted box, it could be a relay coil or a DC motor). The input to the base of the transistor is shown below (v_{in}). The time constant of the RL load is much shorter than the on or off times of v_{in}. When the transistor conducts, consider $V_{CE} = 0.2V$.



a) what is the maximum load current you expect.

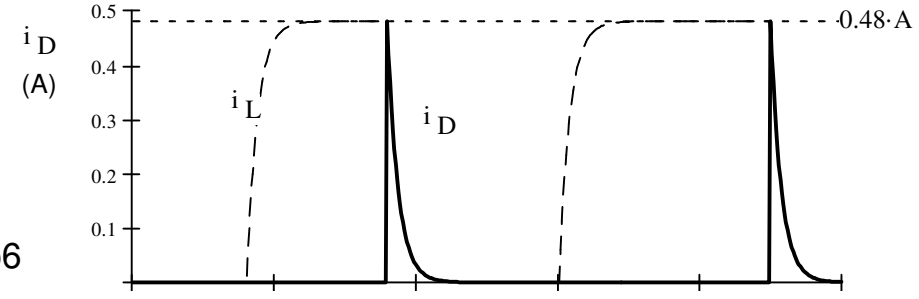
b) If the diode ever conducts, what is the maximum diode current you expect.

c) If the diode ever conducts, sketch the approximate diode waveform below.



Answers

1. a) $V_B = 0$ V, $I_B = 0$ mA, $V_C = 12$ V, $I_C = 0$ mA, $P_Q = 0$ mW
   b) $V_B = 0.7$ V, $I_B = 28.7$ mA, $V_C = 0.2$ V, $I_C = 472$ mA, $P_Q = 94.4$ mW
   c) $V_B = 0$ V, $I_B = 0$ mA, $V_E = 0$ V, $I_E = 0$ mA, $P_Q = 0$ mW d) $V_B = 5$ V, $V_E = 4.3$ V, $I_E = 172$ mAmore below
   d, con't) $I_B = 8.2$ mA, $P_Q = 1.26$ W, OR: $I_B = 8.6$ mA, $P_Q = 1.32$ W if you neglect I_B contribution to I_E:
   e) $V_B = 15$ V (due to slight leakage through emitter-base junction), $I_B = 0$ mA, $V_C = 0$ V, $I_C = 0$ mA, $P_Q = 0$ mW
   f) $V_B = 14.3$ V, $I_B = 34$ mA, $V_C = 14.8$ V, $I_C = 592$ mA, $P_Q = 118$ mW
   g) $V_{B1} = 0$ V, $I_{B1} = 0$ mA, $V_{C1} = V_{B2} = 0.7$ V, $I_{B2} = I_{R2} = 31.4$ mA, $V_{C2} = 0.2$ V, $I_{C2} = 472$ mA
   h) $V_{B1} = 0.7$ V, $I_{B1} = 1.95$ mA, $V_{C1} = V_{B2} = 0.2$ V, $I_{R2} = I_{C1} = 32.8$ mA, $I_{B2} = 0$ mA, $I_{C2} = 0$ mA, $V_{C2} = 12$ V
2. 182 Ω 3. 483 Ω
4. a) 184·mA 2.48·V 0.456·W b) yes $V_{CE} = 2.5 \cdot V > 0.2 \cdot V$ c) 354·Ω d) 56.5
5. a) 0.76·A b) 42.1·Ω
   c) 380·mA 2.1·V 0.798·W
   d) B e) 0.76·A
6. a) 0.48·A b) 0.48·A c) at right



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