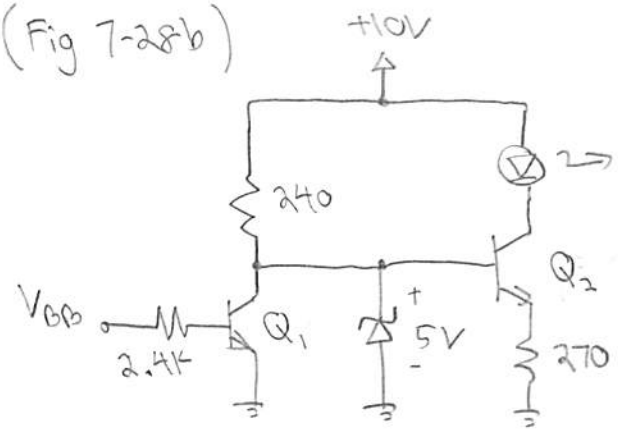
ECE248
HW #5 Solutions

Total = 100 pts

7.48 (+8)

(Fig 7-28b)



- If $V_{BB}=0$, then Q_1 is OFF
  - $\rightarrow I_{C1}=0$
  - $\Rightarrow$ Zener is ON
    ($I_Z \approx \frac{10-5}{240} = 20.8\,mA$)

$\Rightarrow I_{E2} = \frac{5-0.7}{270\Omega} = 15.9\,mA \Rightarrow I_{LED} = \frac{100}{101} \times 15.9\,mA = \boxed{15.7\,mA}$

- If $V_{BB} = 10V$, then Q_1 is ON
  - $\rightarrow I_{B1} = \frac{10-0.7}{2.4K} = 3.875\,mA$
  - $\Rightarrow$ What is I_{C1}? Let $I_{C1} = \beta I_{B1} = 100 \times 3.875\,mA = 387.5\,mA$

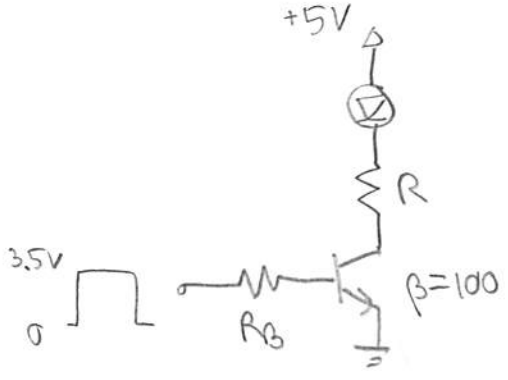
This not possible, because $V_{CE1} = 10-(.3875)(240)-0' = -83V$!

SO, Q_1 is saturated $\rightarrow V_{C1} = 0V \rightarrow V_{B2} = 0V$ ($V_{C1} = 0V$ because Zener is OFF) $\Rightarrow Q_2$ is OFF and therefore $\boxed{I_{LED}=0}$

7.X (+8)

STEP 1 Load properties

$V_F = 3.5V$ @ 25 mA



STEP 2 Saturated BJT

KVL: $5 - \boxed{V_F} - \boxed{I_C}R - \boxed{V_{CE}} = 0 \Rightarrow R = \frac{5-3.5}{.025A} = 60\Omega$

V_F: 3.5V, I_C: 25mA, V_{CE}: 0V

Choose $\boxed{56\Omega} = R$

STEP 3 Base current drive

- $I_B = \frac{1}{0.1\beta} I_C = \frac{25mA}{10} = 2.5mA \Rightarrow R_B = \frac{3.5-0.7}{2.5mA}$

$= 1.12K$

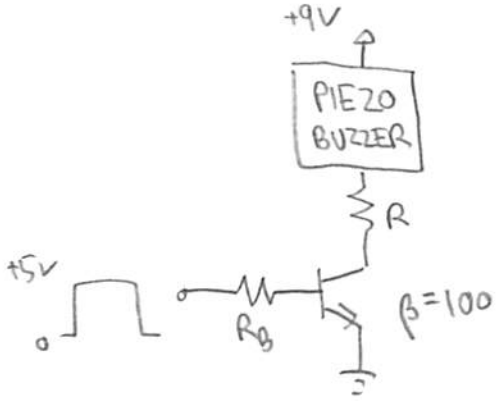
1.2K is also OK

Choose $\boxed{R_B = 1.1K}$

7.4 (+8)

STEP 1 Load properties

$V_L = 6V$ @ 120mA



STEP 2 Saturated BJT

KVL: $9 - \boxed{V_{LOAD}} - \boxed{I_C}R - \boxed{V_{CE}} = 0 \Rightarrow R = \frac{9-6}{0.12A} = 25\Omega$

V_{LOAD}: 6V, I_C: 120mA, V_{CE}: 0V

Choose $\boxed{R = 24\Omega}$

STEP 3 Base current drive

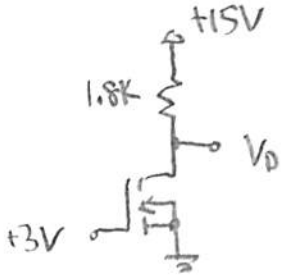
- $I_B = \frac{1}{0.1\beta} I_C = \frac{120mA}{10} = 12mA \Rightarrow R_B = \frac{5-0.7}{12mA} = 0.358K$

360Ω is also OK

Choose $\boxed{R_B = 330\Omega}$

14.11 According to Table 14-1, BS107 has (+8)

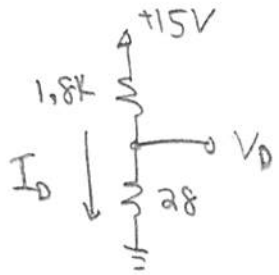
$V_{GS,ON} = 2.6V$, $R_{DS,ON} = 28\Omega$, $I_{D,ON} = 20mA$



- MOSFET is ON because $+3V > 2.6V$

Ohmic ? region.

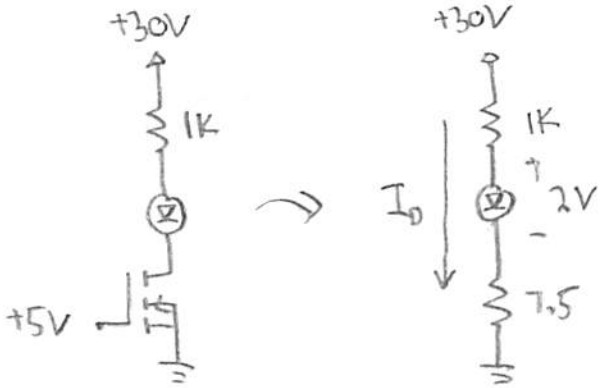
$$I_D = \frac{15V}{1.8K + .028K} = 8.2mA < 20mA \checkmark$$



$$\Rightarrow V_D = I_D \times 28 = (8.2mA)(.028K) = \boxed{0.23V}$$

14.14 (+8)

MOSFET is ON since $+5V = V_{GS,ON}$



Assume $V_F = 2V$

Compute I_D using KVL:

$$30 - I_D(1000) - 2 - I_D(7.5) = 0$$

$$I_D = \frac{30-2}{1000+7.5} = .0278A = \boxed{27.8mA} < 200mA$$ ohmic region ✓

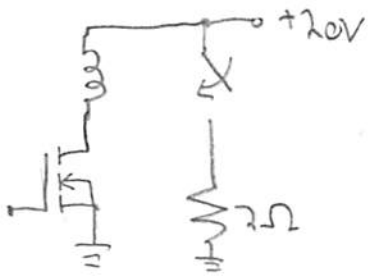
14.15 (+8)

When MOSFET is ON,

$R_{DS,ON} = 28\Omega$

$$I_D = \frac{20V}{1K + .028K} = \boxed{19.5mA} < \overbrace{20mA}^{I_{D,ON}}$$ HIGH

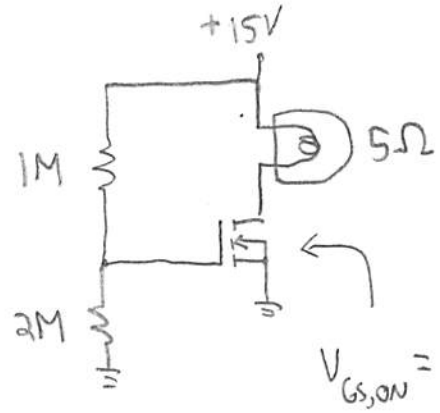
ohmic region ✓



Load current $= \frac{20V}{2\Omega} = \boxed{10A}$ ← Large!

14.27

(+8) DARK → Photodiode is OFF



$$V_{GATE} = 15\,\frac{2M}{2M+1M} = \underline{\underline{10V}} = V_{GS,ON}$$

$\Rightarrow$ MOSFET is ON

$V_{GS,ON} = 10V$

$I_{D,ON} = 5A$

$R_{DS,ON} = 1.07\Omega$

$$I_D = \frac{15}{5+1.07} = 2.47A < \overbrace{5A}^{I_{D,ON}}$$ ohmic region ✓

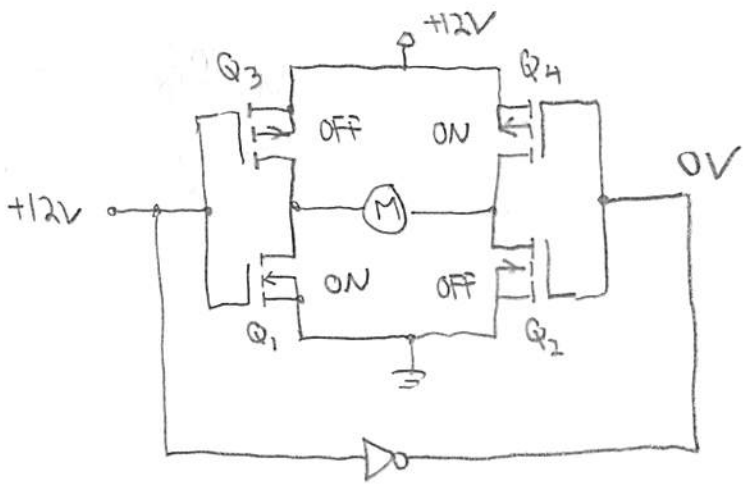
$$\text{Lamp power} = I^2R = (2.47A)^2(5\Omega) = \boxed{30.5W}$$

14.2

(+8)

When CONTROL = 12V

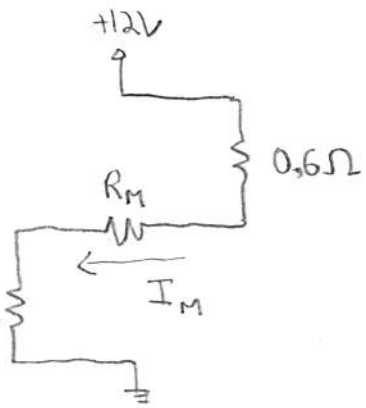
Q_3 = OFF	Q_4 = ON
Q_1 = ON	Q_2 = OFF



Motor equivalent resistance.

12V rating @ 500mA

$$\rightarrow R_M = \frac{12V}{.5A} = \underline{\underline{24\Omega}}$$



$I_{D,ON}$ ↓

$$I_M = \frac{12}{0.6+24+0.27} = \boxed{0.483\,A} < 5A$$

Ohmic region ✓

$$V_M = I_M R_M = (.483A)(24\Omega) = \boxed{11.6V}$$

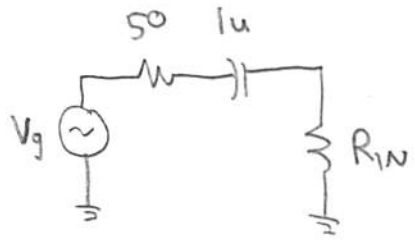
$$P_M = I_M V_M = (.483A)(11.6V) = \boxed{5.6W}$$

16.33 (+4)

$$f_1 = \frac{1}{2\pi(50+R_{IN})(10^{-6}F)}$$

$$R_{IN} = (10K \,//\, 2.2K) \,//\, 201 r_e'$$

- Stiff divider? $10K \,//\, 2.2K = 1.8K$, $\frac{201}{100} \times 1K = 2.01K$ ✓



$$V_{BB} = 10\,\frac{2.2K}{2.2K+10K} = 1.8V$$

$$I_{EQ} = \frac{1.8-0.7}{1K} = 1.1\,mA$$

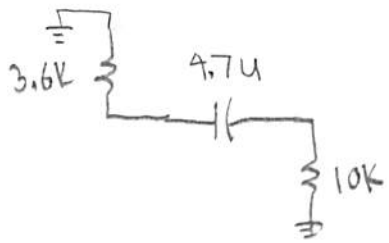
$$r_e' = \frac{.026}{.0011A} = \underline{\underline{23.6\Omega}}$$

$$\Rightarrow R_{IN} = 1800 \,//\, [201(23.6)] = \underline{\underline{1305\Omega}}$$

$$\Rightarrow f_1 = \frac{1}{2\pi(50+1305)(10^{-6})} = \boxed{117.5\,Hz}$$

16.34 (+4)

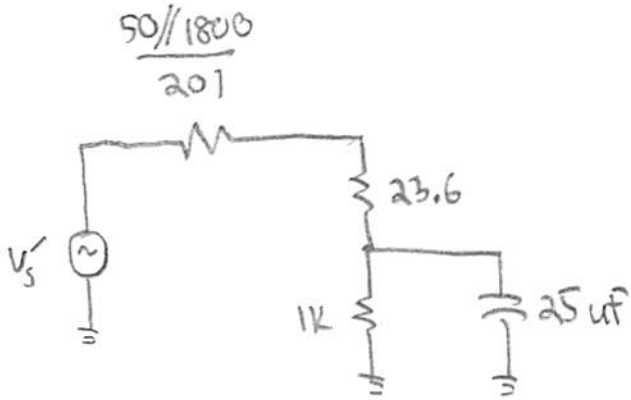
$$f_1 = \frac{1}{2\pi(3600+10000)(4.7\times10^{-6})} = \boxed{2.49\,Hz}$$



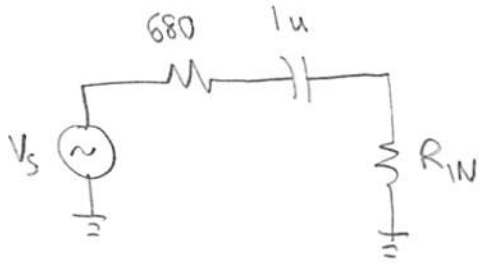
16.35 (+4)

$$f_1 = \frac{1}{2\pi\left[1000 \,//\, \left(23.6 + \frac{50\,//\,1800}{201}\right)\right](25\times10^{-6})}$$

$$= \boxed{273.4\,Hz}$$



16.x (+12)



- C_{IN}: $f_1 = \dfrac{1}{2\pi(R_S + R_{IN})C_{IN}}$ (680Ω, ?, 1u)

$R_{IN} = (6.8K \,//\, 4.7K) \,//\, 201(r_e' + 220)$ (?)

$V_{BB} = 12\dfrac{4.7K}{4.7K+6.8K} = 4.9V$

Stiff divides? $6.8K \,//\, 4.7K = 2.78K$; $\frac{201}{100}(1.2K + .22K) = 2.85K$ ✓

$I_{EQ} = \dfrac{4.9 - 0.7}{.22K + 1.2K} = 2.96\,mA$

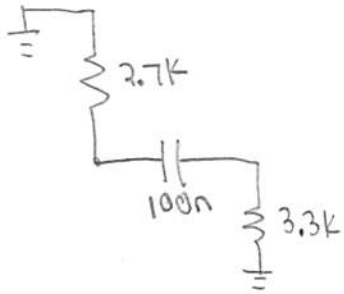
$r_e' = \dfrac{.026V}{2.96mA} = .0088K = 8.8\Omega$

$\Rightarrow R_{IN} = 2.78K \,//\, \underbrace{201(8.8+220)}_{46K} = \underline{2.62K}$

$\Rightarrow f_1 = \dfrac{1}{2\pi(680+2620)(10^{-6})} = \boxed{48.2Hz}$

- C_{OUT}: $f_1 = \dfrac{1}{2\pi(2700+3300)(100\times10^{-9})}$

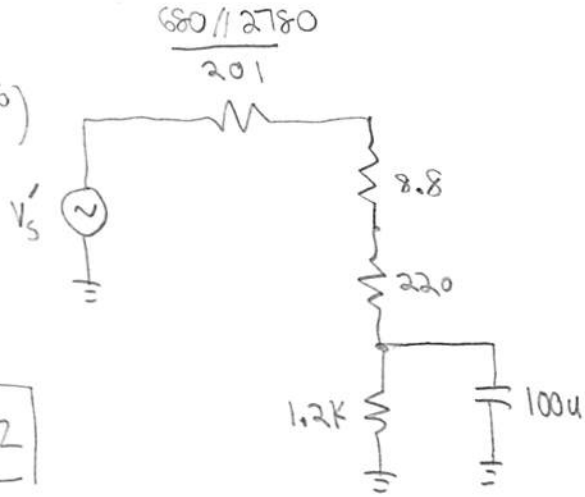
$= \boxed{265.3Hz}$



- C_E:

$f_1 = \dfrac{1}{2\pi\left[1200 \,//\, \left(220 + 8.8 + \frac{680 \,//\, 2780}{201}\right)\right](100\times10^{-6})}$

$= \boxed{8.2Hz}$

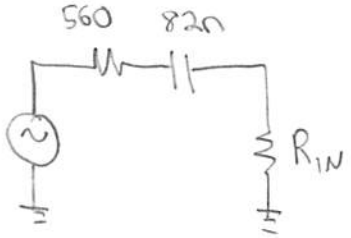


⇨ Dominant low cut-off freq = $\boxed{265.3Hz}$

↑ Due to C_{OUT}

16.4 (+12)

- C_{IN}: $f_1 = \dfrac{1}{2\pi(560+R_{IN})(82\times10^{-9})}$



$R_{IN} = (12K \,//\, 15K) \,//\, 2501(r_e' + 330 \,//\, 150)$

↑ 2

- Stiff divider? $12K \,//\, 15K = 6.67K$; $\frac{2501}{100}(.33K) = 8.25K$ ⎫ YES

$V_{BB} = 10\dfrac{15K}{15K+12K} = 5.56V$

$I_{EQ} = \dfrac{5.56-1.4}{330} = .0126A$

$r_e' = \dfrac{.026}{.0126A} = \underline{2.1\Omega}$

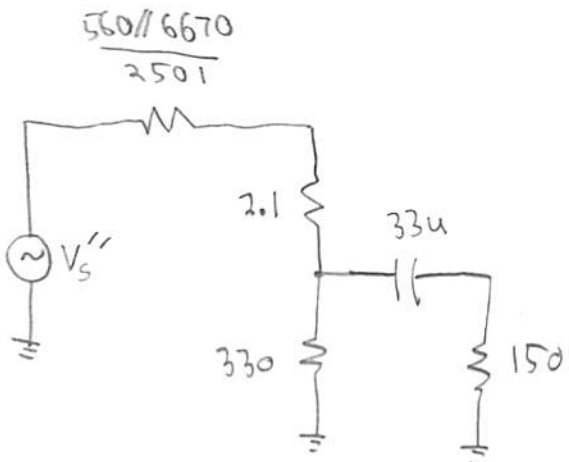
$\rightarrow R_{IN} = 6.67K \,//\, \underbrace{2501(2.1+103.1)}_{263K} = \underline{6.505K}$

$\Rightarrow f_1 = \dfrac{1}{2\pi(560+6505)(82\times10^{-9})} = \boxed{274.7\,Hz}$

- C_{OUT}:

$f_1 = \dfrac{1}{2\pi\left[150+330 \,//\, \underbrace{\left(2.1+\frac{560\,//\,6670}{2501}\right)}_{2.31}\right](33\times10^{-6})}$

$= \boxed{31.7\,Hz}$



⇒ Dominant low cut-off freq = $\boxed{274.7\,Hz}$ ← Due To C_{IN}