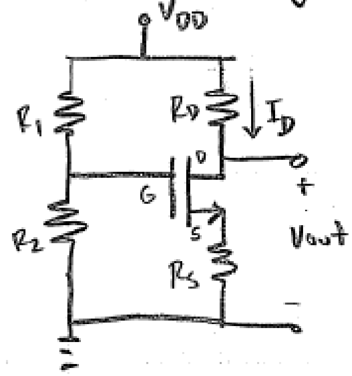
Stephen Maloney | Prelab 5

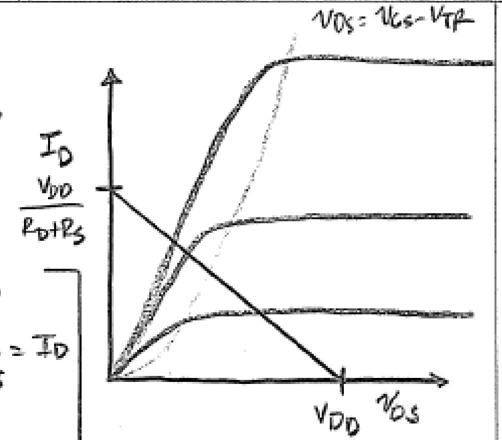
1.



$$V_{DD} = I_D R_D + V_{DS} + I_D R_S$$

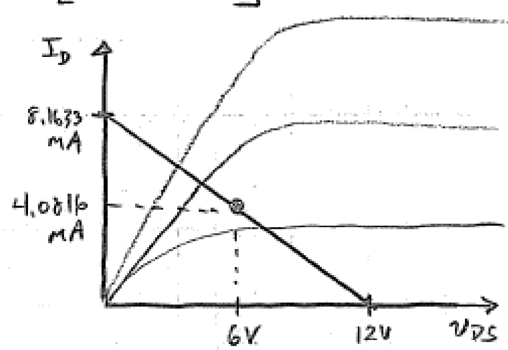
$$\left[\frac{V_{DD} - V_{DS}}{R_D + R_S} = I_D \right]$$

$$\left[\begin{array}{l} I_D = 0 \\ \therefore \quad \dfrac{V_{DD} - V_{DS}}{R_D + R_S} = 0 \\ V_{DD} = V_{DS} \end{array} \right] \left[\begin{array}{l} V_{DS} = 0 \\ \therefore \quad \dfrac{V_{DD}}{R_D + R_S} = I_D \end{array} \right]$$



2.

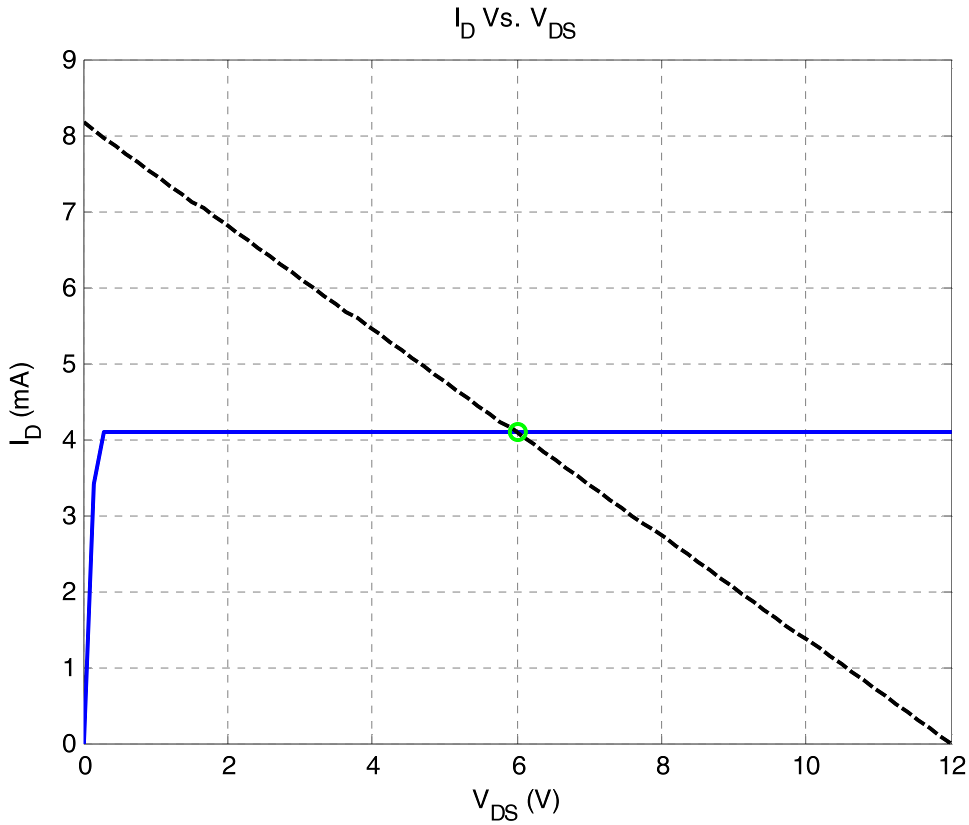
$V_{TR} = 1.8$
$R_D = 1\,K\Omega$
$R_S = 470\,\Omega$
$V_{DD} = 12V$
$K_P = .1233\ A/V^2$
$K = \frac{K_P}{2} = .0617\ A/V^2$



$V_{DSQ} = 6V$ $\quad$ $I_{DQ} = 4.0816\,mA$

$V_{RD} = I_{DQ} R_D = 4.0816\,V$ $\quad$ $V_{RS} = I_{DQ} R_S = 1.9184\,V$

3)



For quiescent point of:

I_{DQ} = 4.0816 mA, V_{DSQ} = 6 V

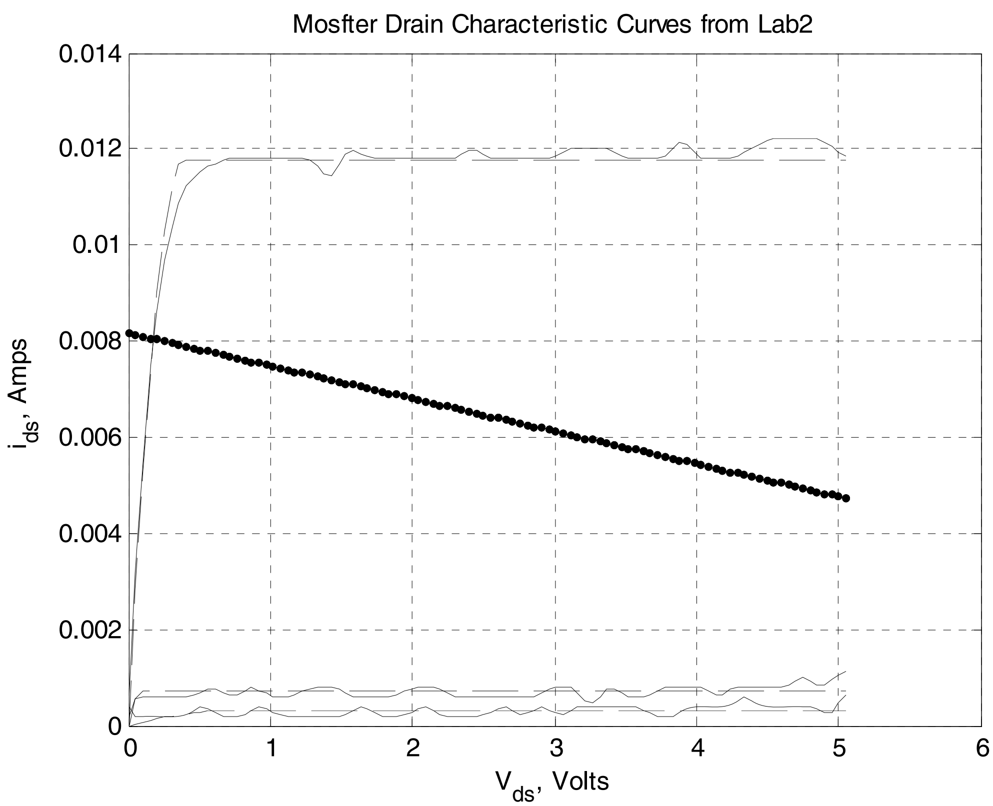
Final VGS = **V_{GS} = 2.0573 V**

```
% Prelab 5 - Problem 3
% Written by Stephen Maloney

clear all; clc; close all;

% Set up parameters
Vtr = 1.8;
Rd = 1e3;
Rs = 470;
Vdd = 12;
Kp = .1233;

% The desired quiescent point is midway down the load line to give room for
% maximum swing without going into non-linear regions

% Find desired quiescent point
Vdsq = Vdd/2;
Idmax = Vdd/(Rd+Rs);
Idq = Vdd/(2*(Rd+Rs));
```

```
% Parameters for repeating the q point matching
acc = 10;           % Granularity of function generation
finalError = 100;
tolerance = 1e-3;   % Lower for more accuracy
VgsRangeStart = Vtr;
VgsRangeEnd = Vtr + .3;

while (finalError(1) > tolerance)
    % Build the load line
    Vds = linspace(0, 12, acc);
    Ill = (Vdd - Vds)/(Rd+Rs);

    VgsRange = linspace(VgsRangeStart, VgsRangeEnd, acc);

    err = zeros(length(VgsRange));
    count = 1;

    for Vgs = VgsRange
        % Generate mosfet curve for a particular Vgs
        Id = nmos(Vds, Vgs, Kp, 1, 1, Vtr);

        % Find where it intersects with the load line to find a quiescent
point
        [errTemp, minIdx] = min(abs(Id-Ill));

        % Translate this into the current quisecent current and voltage
        Idcq = Id(minIdx(1));
        Vdscq = Vdd - Idcq*(Rd+Rs);

        % Find the error between the desired q point and the current q point
        err(count) = sqrt((Idcq-Idq)^2+(Vdscq-Vdsq)^2);

        % Display output to visually confirm sweep
        plot(Vds, Id*10^3, Vds, Ill*10^3, 'k--', Vdsq, Idq*10^3, 'go', Vdscq,
Idcq*10^3, 'ro', 'Linewidth', 2);
        grid on;
        title(['I_D Vs. V_D_S, Current error : ' num2str(err(count))]);
        xlabel('V_D_S (V)'); ylabel('I_D (mA)');

        pause(.0001);
        count = count + 1;
    end

    % Figure out how close the best fit q point was to the desired q point,
    % and if necessary, go through the loop again with a finer granularity.

    [finalError, minIdx] = min(err);
    if(finalError(1) > tolerance)
        %The loop is going to have to be repeated with a better range of
        %values
        VgsRangeStart = VgsRange(minIdx(1)-1);
        VgsRangeEnd = VgsRange(minIdx(1)+1);
        acc = acc*2;
```

```
    end
end

% Display final output
Id = nmos(Vds, VgsRange(minIdx(1)), Kp, 1, 1, Vtr);

close all;
plot(Vds, Id*10^3, 'b', Vds, Ill*10^3, 'k--', Vdsq, Idq*10^3, 'go',
'LineWidth', 2);
grid on;
title('I_D Vs. V_D_S');
xlabel('V_D_S (V)'); ylabel('I_D (mA)');

disp('For quiescent point of:');
Idq*10^3
Vdsq

disp('Final VGS:');
Vgs = VgsRange(minIdx(1))
```

4)



Any attempt at guessing the V_{GS} necessary to produce the quiescent point will be accepted here, as it is fairly difficult to have recorded enough of a sweep using the curve tracer previously that would allow you to accurately guess this number. The important thing here is to note where the load line crosses over a MOSFET transfer characteristic curve, and try to find one that approximately passes through the V_{DS} = 6V portion of the load line.

It will be much more accurate to use the MATLAB solution that to try and guess at it from the curve tracer output for the most part; some TC's may have enough spread to provide a fairly good guess for a particular MOSFET.

5. $I_D = \frac{k_p}{2}(V_{GS} - V_{TR})^2$ [6]

$$\sqrt{\frac{2I_D}{k_p}} = V_{GS} - V_{TR}$$

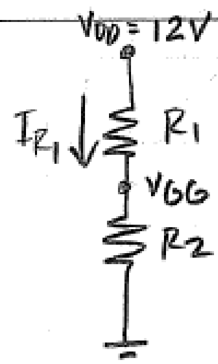
$$\therefore V_{GS} = \sqrt{\frac{2I_D}{k_p}} + V_{TR} = 2.05731\ V$$

→ Note: V_{GS} here is almost identical to that found by iteration! $V_{GS,IT} = 2.0573\ V$

$$I_D = \frac{V_{GG} - V_{TR}}{R_S} \quad [8]$$

$$\therefore V_{GG} = I_D R_S + V_{TR} = 3.71835\ V$$

6.



$V_{GG} = 3.71835\ V$ (from 5)

$$\frac{V_{DD} R_2}{R_1 + R_2} = V_{GG}$$

$$\left[\frac{R_2}{R_1 + R_2} = \frac{V_{GG}}{V_{DD}} = .309863\right]$$

$$I_{R_1} = \frac{V_{DD}}{R_1 + R_2} = \frac{I_{DQ}}{100} = 40.816\mu A$$

$$\therefore \frac{1}{R_1 + R_2} = \frac{40.816\mu A}{V_{DD}} = 3.4013 \times 10^{-6}$$

$$[294002 = R_1 + R_2]$$

$$R_1 = 203\ k\Omega$$

$$\frac{R_2}{294002} = .309863$$

$$R_2 = 91.1\ k\Omega$$

7)

Below are the variations due to K_P changes; K_P can fluctuate to one third of the original value and only cause a 3/10 of a milliamp swing in output current.

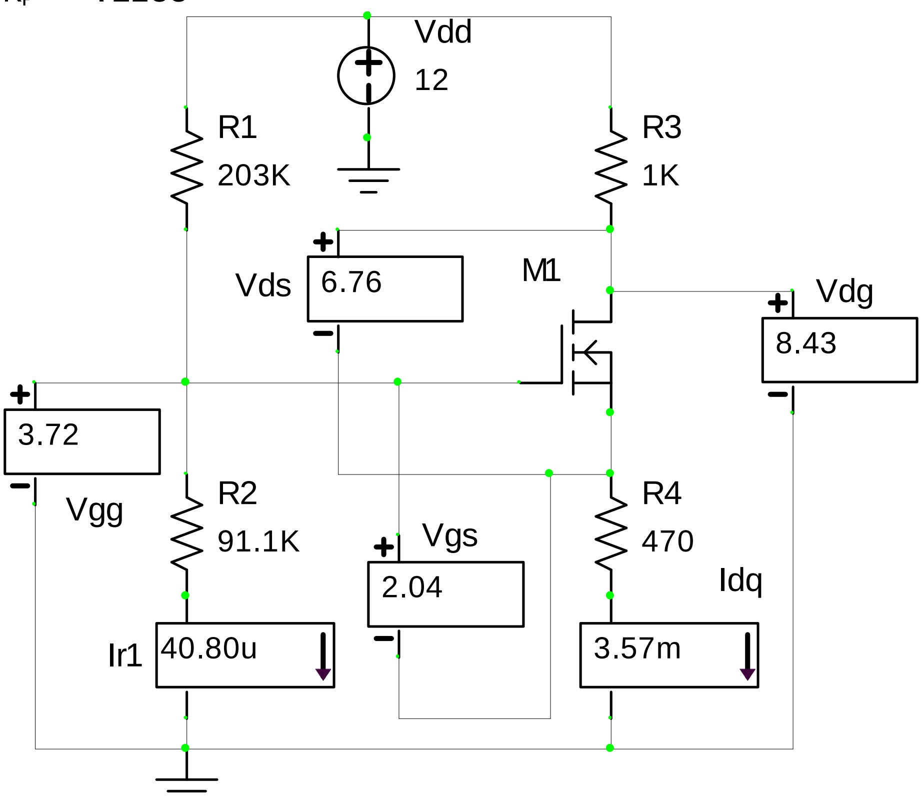
```
IdOriginal = 3.5696

VdOriginal = 6.7527



IdOneHalf = 3.3773

VdOneHalf = 7.0353



IdOneThird = 3.2371

VdOneThird = 7.2414
```

```
% EE462 - Prelab5 - P7
% Written by Stephen Maloney

clear all; clc;

Vgg = 3.71835;
Vtr = 1.8;
Rs = 470;
Rd = 1e3;
Kp = .1233;
Vdd = 12;

% Below is equation 9
Id = (((Vgg-Vtr)/Rs + 1/(Rs^2*Kp)) - ...
    sqrt(((Vgg-Vtr)/Rs + 1/(Rs^2*Kp))^2 - (Vgg-Vtr)^2/Rs^2))*10^3

Vd = Vdd - Id/10^3*(Rd+Rs)

Kp = .1233/2;

IdOneHalf = (((Vgg-Vtr)/Rs + 1/(Rs^2*Kp)) - ...
    sqrt(((Vgg-Vtr)/Rs + 1/(Rs^2*Kp))^2 - (Vgg-Vtr)^2/Rs^2)) *10^3

VdOneHalf = Vdd - IdOneHalf/10^3*(Rd+Rs)

Kp = .1233/3;

IdOneThird = (((Vgg-Vtr)/Rs + 1/(Rs^2*Kp)) - ...
    sqrt(((Vgg-Vtr)/Rs + 1/(Rs^2*Kp))^2 - (Vgg-Vtr)^2/Rs^2)) *10^3
```

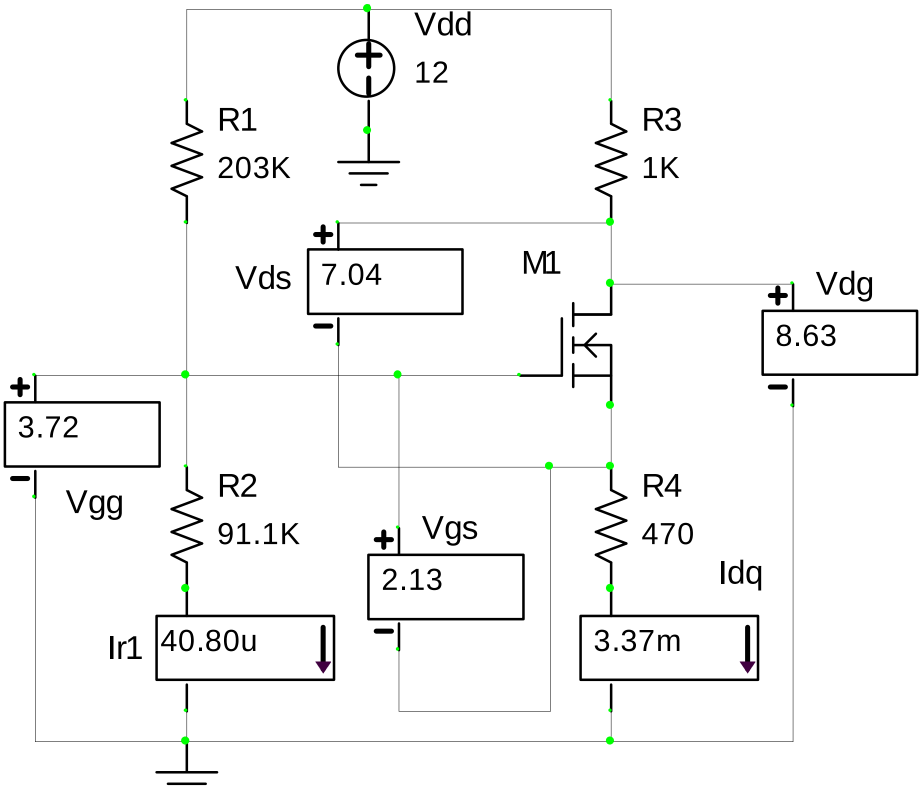
```
VdOneThird = Vdd - IdOneThird/10^3*(Rd+Rs)
```

8)

K_P = .1233



K_P = .06165



K_P = .0411