Homework 1
Date assigned: 09/15/2015
Date due: 09/22/2015 (MIDNIGHT)

Problem 1

Consider a wafer of radius w_r as shown in Figure 1. Assume square dies on the wafer with side dimension d_e.

a. Calculate the number of useful dies ("physically intact") on the wafer in terms of w_r and d_e.

b. What is the minimum ratio w_r/d_e for which at least one useful die is obtained.

c. Plot the number of useful dies as a function of the ratio w_r/d_e. Make sure that the limits of w_r/d_e are correct as obtained in answer (b) above.

d. Assume that the wafer has a defect density of D_d per unit area. Calculate the wafer yield, Y.
Note that the wafer yield is defined as Y = (no. of physically intact dies on the wafer) × (die yield). To compute Y, you have to use the results from part (a) above.

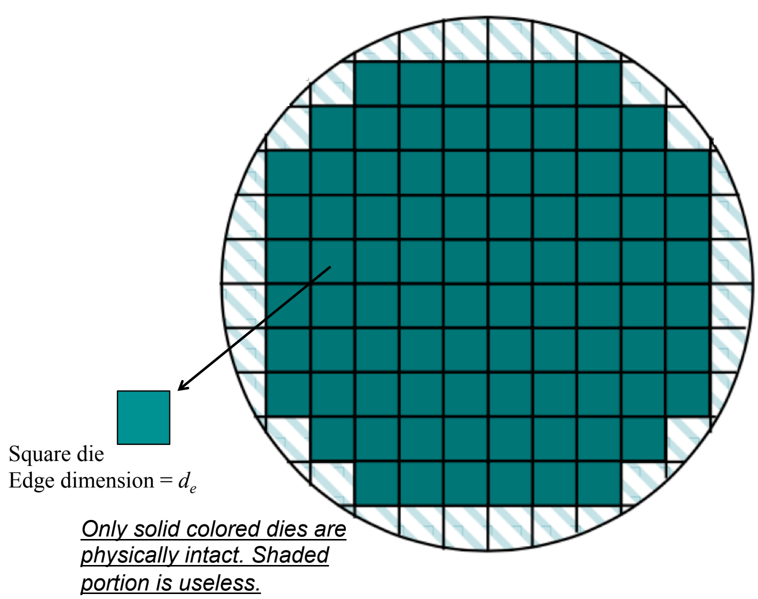

Figure 1: The wafer radius is w_r. Shaded dies are useful. To find answer to part (a), calculate how much area is wasted in the shaded portion.

Problem 2

Consider the I_D-V_d characteristics of the transistor for $V_{gs} > V_T$. That is, the transistor is in ON condition.

a. Compute the resistance of the transistor as $(\partial I_D/\partial V_d)^{-1}$ for <u>linear</u> and <u>saturation</u> regimes of transport.
b. Qualitatively plot the resistance as a function of V_{ds} and V_{gs} on two separate plots.

Your answer must be presented in a tabular format as below.

Linear operation	**Saturation operation**
Transistor resistance = <Your answer>	Transistor resistance = <Your answer>
Qualitative plot of transistor resistance versus V_{ds}.	Qualitative plot of transistor resistance versus V_{ds}.
Qualitative plot of transistor resistance versus V_{gs}.	Qualitative plot of transistor resistance versus V_{gs}.

Problem 3

Consider the I_D-V_g characteristics of the transistor.

a. Derive the transistor trans-conductance $g_m = \partial I_D/\partial V_g$ for $V_{gs} < V_T$. Recall: for $V_{gs} < V_T$, transistor current varies exponentially with V_{gs}-V_T. Note that the dependence of I_D on V_d is very weak for $V_{gs} < V_T$.

b. Derive the transistor trans-conductance for $V_{gs} > V_T$. Recall: for $V_{gs} > V_T$, transistor is ON. But the current I_D depends on whether the device is in linear or saturation modes of transport. For this part, you need to derive the results for both linear and saturation regimes.

Your answer must be presented in a tabular format as below.

$V_{gs} < V_T$ (OFF conditions) and assume $V_{ds} >> k_BT/q$
Trans-conductance = <Your answer>
Qualitative plot of trans-conductance versus V_{gs}.

$V_{gs} > V_T$ (ON conditions)	
Linear operation	**Saturation operation**
Trans-conductance = <Your answer>	Trans-conductance = <Your answer>
Qualitative plot of transistor resistance versus V_{ds}.	Qualitative plot of transistor resistance versus V_{ds}.
Qualitative plot of transistor resistance versus V_{gs}.	Qualitative plot of transistor resistance versus V_{gs}.