Solve the following questions for Week 10.

There are 10 questions, for a total of 20 marks.

1. (2 marks) Who formulated Moore's Law, and what does it predict?

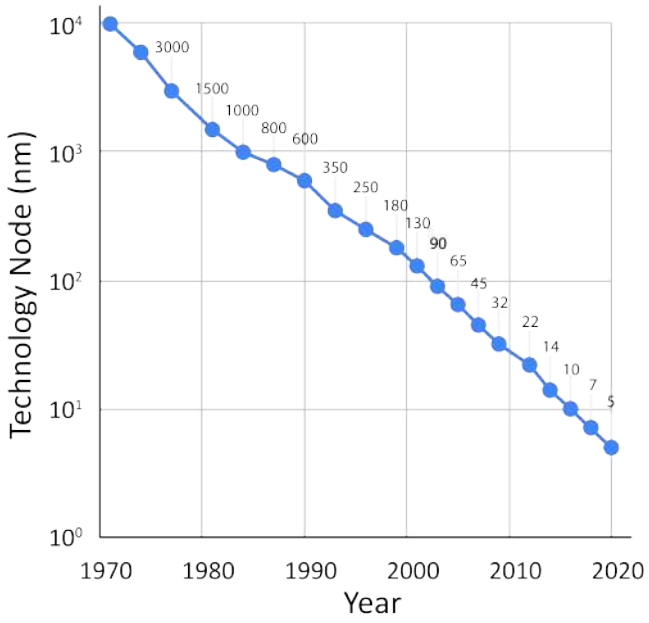
   A. Gordon Ramsay; It predicts that the number of mobile phones will double every two years.

   B. Gordon Freeman; It predicts that the speed of light in a vacuum will double every two years.

   C. Gordon Moore; It predicts that the number of transistors on a microchip will double approximately every two years, leading to exponential growth in computing power.

   D. Gordon Gecko; It predicts that the stock market will double in value every two years.

(For Q2-Q3) The evolution of various technology nodes over the years is given in the figure below.



2. (2 marks) Comment on the power dissipation in the technology nodes of $250\ nm$ and $90\ nm$. [*Hint*: Consider α as the scaling factor down each of the technology nodes]

   A. $P_{90} = \alpha P_{250}$

   B. $P_{90} = 2\alpha P_{250}$

   C. $P_{90} = \alpha^2 P_{250}$

   D. $P_{90} = \alpha^6 P_{250}$

   E. $P_{90} = 0.5\alpha P_{250}$

Technology node from 250 nm to 90 nm has scaled three times (250 → 180 → 130 → 90)
With each scaling by α times, power scales as α^2
So, $P_{90} = (\alpha^2)^3 P_{250}$
$P_{90} = \alpha^6 P_{250}$

F. $P_{90} = 4\alpha P_{250}$

3. (2 marks) Comment on the gate capacitance per unit area in the technology nodes of $250\ nm$ and $90\ nm$. [*Hint*: Consider α as the scaling factor down each of the technology nodes].

A. $C_{ox,90} = 3\alpha C_{ox,250}$

B. $C_{ox,90} = 2\alpha C_{ox,250}$

C. $C_{ox,90} = C_{ox,250}/\alpha$

D. $C_{ox,90} = \alpha^6 C_{ox,250}$

E. $C_{ox,90} = C_{ox,250}/3\alpha$

F. $C_{ox,90} = 4\alpha C_{ox,250}$

Gate capacitance $C_{ox} = \frac{\epsilon_{ox}}{t_{ox}}$

$C_{ox,new} = \frac{1}{\alpha} C_{ox,old}$

So technology scaling $250 \to 180 \to 130 \to 90$

$C_{ox,90} = \frac{1}{\alpha} \cdot \frac{1}{\alpha} \cdot \frac{1}{\alpha} C_{ox,250} = \frac{1}{\alpha^3} C_{ox,250}$

This has been given wrong.

4. (2 marks) Choose the correct statement(s) in regard to the constant voltage scaling.

A. Supply voltage (V_{dd}) was scaled the same as the dimensions of the MOSFET.

B. Supply voltage (V_{dd}) was kept constant to maintain sufficient high and low noise margins (NM_h and NM_l).

C. Threshold voltage (V_T) was scaled down to double the dimensions of the MOSFET.

D. Both supply (V_{dd}) and threshold (V_T) voltages were increased.

E. Threshold voltage (V_T) was kept constant to maintain high I_{ON}/I_{OFF} ratio.

5. (2 marks) In a short channel MOSFET, as V_{DS} is increased -

A. Effective channel length L_{eff} $\downarrow$ and total drain current I_D $\downarrow$

B. Effective channel length L_{eff} $\downarrow$ and total drain current I_D $\uparrow$

C. Effective channel length L_{eff} $\uparrow$ and total drain current I_D $\uparrow$

D. Effective channel length L_{eff} $\uparrow$ and total drain current I_D $\downarrow$

E. Effective channel length L_{eff} $\downarrow$ and total drain current I_D remains constant

F. Effective channel length L_{eff} remains constant and total drain current I_D $\downarrow$

6. (2 marks) Consider two nMOSFETs $M1$ and M_2 with the following dimensions:

   $M1$: Length $L1 = 8\mu m$, Width $W1 = 2\mu m$, and gate oxide thickness $t_{ox,1} = 200nm$

   $M2$: Length $L1 = 0.8\mu m$, Width $W1 = 8\mu m$, and gate oxide thickness $t_{ox,1} = 180nm$

   The electron diffusion length is $1\ \mu m$. Choose the correct option(s) from the below.

   A. $M1$ is a short channel MOSFET.

   B. $M2$ is a short channel MOSFET.

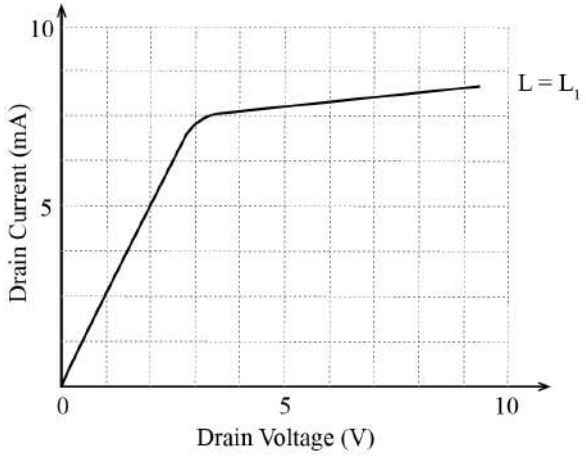
   C. $M1$ is a long channel MOSFET.

   D. $M2$ is a long channel MOSFET.

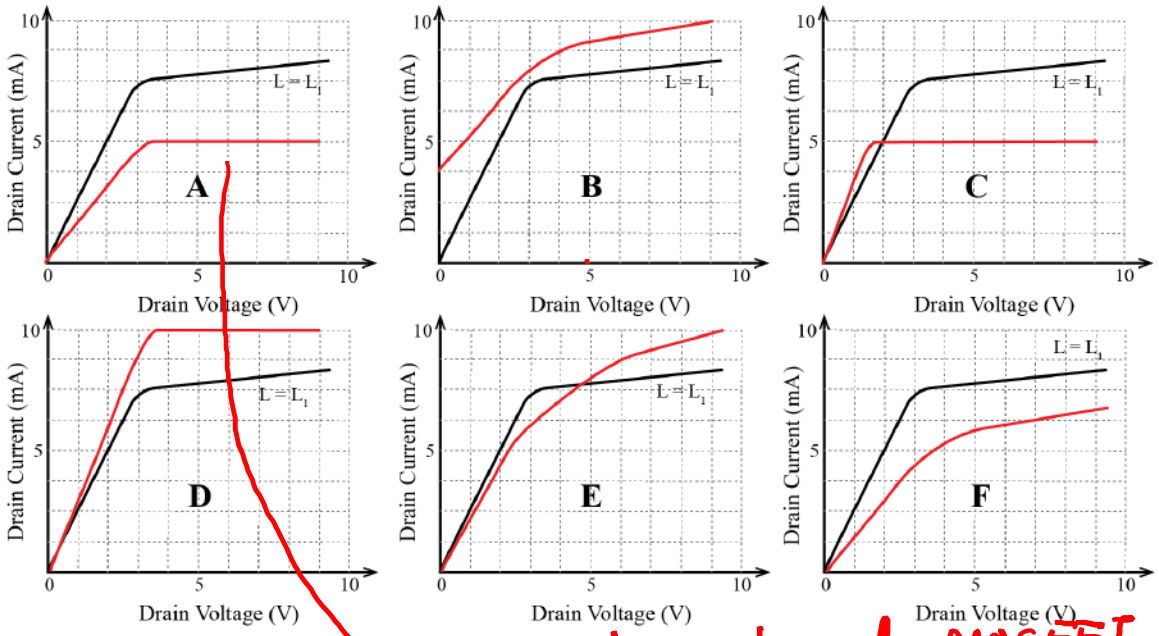
   E. $M1$ is a tunnel FET.

   F. $M2$ is a tunnel FET.

(For Q7-Q8) The measured IV of a short-channel MOSFET is shown to scale in the figure below.



7. (2 marks) If the channel length is tripled to $3L_1$, choose the correct IV characteristics from the options given below. (You may assume that all other parameters are the same)



In a long channel MOSFET, current remains constant after saturation and saturation voltage also occurs at higher voltage due to the absence of velocity saturation & DIBL

A. **A**
B. B
C. C
D. D
E. E
F. F

8. (2 marks) Choose the correct reasoning(s) for your answer in the previous question.

A. **The current for a long channel MOSFET saturates at a larger V_{DS} as compared to short channel MOSFET**
B. **The long channel MOSFET reaches the critical field at larger applied biases in the absence of velocity saturation.**
C. The current for a long channel MOSFET saturates at a smaller V_{DS} as compared to short channel MOSFET
D. The long channel MOSFET reaches the critical field at smaller applied biases leading to velocity saturation.

E. The I_{ON}/I_{OFF} current ratio for a long channel MOSFET is lower as compared to short channel MOSFET

F. The current in a long channel MOSFET follows the square law theory.

9. (2 marks) Given below are a few statements regarding the FinFET technology. Choose the correct statement(s).

A : FinFET offers better electrostatic control over the gate than planar MOSFETS

B : FinFET has lower I_{ON} to I_{OFF} ratio than planar MOSFETS

C : FinFET has lower leakage current than planar MOSFETS

D : For a similar operating voltage, planar MOSFETS offer much lower delays than FinFET.

A. B, C, D

B. A, B, D

C. A, C, D

D. A, B, C, D

E. A, C

10. (2 marks) What technological node is currently being used in Samsung smartphone Snapdragon Gen 8 processors?

A. Intel's 250 nm

B. Intel's 7 nm

C. Samsung's 14 nm

D. TSMC's 4 nm

E. Samsung's 10 nm