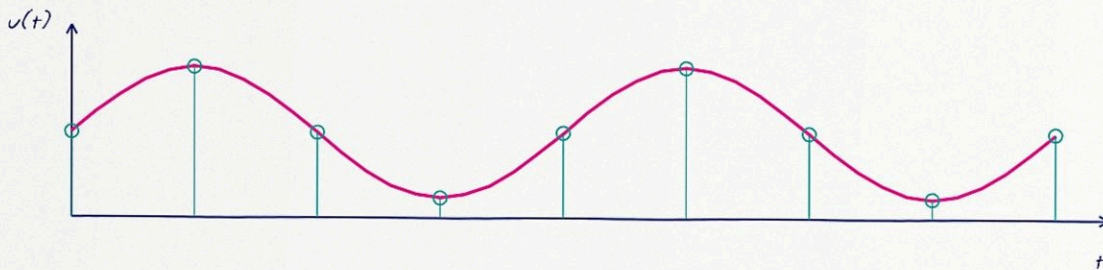


GATE EC HANDWRITTEN NOTES

SIGNALS SAMPLING AND SEMICONDUCTOR DEVICES

Topics :-

- discrete-time signals and sampling
- semiconductor physics
- diodes and optoelectronics
- bjt and mosfet devices



Keep in mind :-

Understand the idea before learning the equation. Write units with every value and check the final sign.

First formula :-

sampling rate $>$ 2 times highest frequency

First check :-

Nyquist rate is a boundary, not a practical anti-aliasing margin.

- say the meaning once without looking
- write the formula again from memory

Discrete-Time Signals and Sampling

Meaning :-

Sampling maps a continuous signal to a sequence.

Main idea :-

DTFT, DFT and z-transform analyze discrete systems; aliasing occurs when shifted spectra overlap.

sampling rate > 2 times highest frequency

Why it matters :-

Most questions become simple once the definition, assumptions and required quantity are written clearly.

Remember :-

Nyquist rate is a boundary, not a practical anti-aliasing margin.

- write symbols before putting numbers
- keep the sign convention on the page
- check the unit of the final answer

Related idea :-

Next: Semiconductor Physics. Carrier concentration and transport create device current.

Quick test :-

Can I explain discrete-time signals and sampling without looking at the formula? Then can I state when the formula is valid?

Discrete-Time Signals and Sampling : IMPORTANT POINTS

In one line :-

Sampling maps a continuous signal to a sequence.

What is happening :-

DTFT, DFT and z-transform analyze discrete systems; aliasing occurs when shifted spectra overlap.

sampling rate > 2 times highest frequency

How I remember it :-

Write the meaning first. The formula is much easier to recall after that.

Conditions :-

Use the relation only for the model stated in the question. Start* from the general law if one condition changes.

- mark all known values with their units
- draw the figure when direction matters
- do not round values in the middle

Quick check :-

Nyquist rate is a boundary, not a practical anti-aliasing margin.

Compare :-

Do not mix this with semiconductor physics. Band structure, drift, diffusion, generation and recombination explain junction and transistor behaviour.

Discrete-Time Signals and Sampling : WORKING

Given in the question :-

Write every known value in one place. Put its unit beside it and underline the quantity to be found.

Formula :-

sampling rate $>$ 2 times highest frequency

Steps :-

- convert all values to one unit system
- rearrange the equation before substitution
- put values carefully with brackets
- round only the final answer

Final check :-

Myquist rate is a boundary, not a practical anti-aliasing margin.

Small thought :-

Change one quantity mentally and read the equation again. The answer should follow the same physical or mathematical trend.

Also revise :-

Semiconductor Physics: Carrier concentration and transport create device current.

Discrete-Time Signals and Sampling : QUICK PRACTICE

Try without looking :-

1. Define discrete-time signals and sampling in one clear sentence.
2. Write the main formula and name every quantity.
3. Explain this idea: DTFT, DFT and z-transform analyze discrete systems; aliasing occurs when shifted spectra overlap.
4. Why is this warning important: Nyquist rate is a boundary, not a practical anti-aliasing margin.
5. State one difference between discrete-time signals and sampling and semiconductor physics.

Hints :-

Sampling maps a continuous signal to a sequence.

sampling rate > 2 times highest frequency

Before moving on :-

- definition recalled without help
- formula written with correct symbols
- units and limiting case checked

One last reminder :-

Nyquist rate is a boundary, not a practical anti-aliasing margin.

Semiconductor Physics

Meaning :-

Carrier concentration and transport create device current.

Main idea :-

Band structure, drift, diffusion, generation and recombination explain junction and transistor behaviour.

$$J = q n \mu E$$

Why it matters :-

Most questions become simple once the definition, assumptions and required quantity are written clearly.

Remember :-

Use consistent carrier sign and electric-field direction.

- write symbols before putting numbers
- keep the sign convention on the page
- check the unit of the final answer

Related idea :-

Next: Diodes and Optoelectronics. A p-n junction controls carrier flow through its depletion region.

Quick test :-

Can I explain semiconductor physics without looking at the formula? Then can I state when the formula is valid?

Semiconductor Physics : IMPORTANT POINTS

In one line :-

Carrier concentration and transport create device current.

What is happening :-

Band structure, drift, diffusion, generation and recombination explain junction and transistor behaviour.

$$J = q n \mu E$$

How I remember it :-

Keep the sketch beside the formula. It prevents sign and direction mistakes.

Conditions :-

Use the relation only for the model stated in the question. Start from the general law if one condition changes.

- mark all known values with their units
- draw the figure when direction matters
- do not round values in the middle

Quick check :-

Use consistent carrier sign and electric-field direction.

Compare :-

Do not mix this with diodes and optoelectronics. Bias changes barrier width and current; Zener, LED, photodiode and solar-cell operation follow junction physics.

Semiconductor Physics : WORKING

Given in the question :-

Write every known value in one place. Put its unit beside it and underline the quantity to be found.

Formula :-

$$J = q n \mu E$$

Steps :-

- convert all values to one unit system
- rearrange the equation before substitution
- put values carefully with brackets
- round only the final answer

Final check :-

Use consistent carrier sign and electric-field direction.

Small thought :-

Change one quantity mentally and read the equation again. The answer should follow the same physical or mathematical trend.

Also revise :-

Diodes and Optoelectronics: A p-n junction controls carrier flow through its depletion region.

Semiconductor Physics : QUICK PRACTICE

Try without looking :-

1. Define semiconductor physics in one clear sentence.
2. Write the main formula and name every quantity.
3. Explain this idea: Band structure, drift, diffusion, generation and recombination explain junction and transistor behaviour.
4. Why is this warning important: Use consistent carrier sign and electric-field direction.
5. State one difference between semiconductor physics and diodes and optoelectronics.

Hints :-

Carrier concentration and transport create device current.

$$J = q n \mu E$$

Before moving on :-

- definition recalled without help
- formula written with correct symbols
- units and limiting case checked

One last reminder :-

Use consistent carrier sign and electric-field direction.

Diodes and Optoelectronics

Meaning :-

A p-n junction controls carrier flow through its depletion region.

Main idea :-

Bias changes barrier width and current; Zener, LED, photodiode and solar-cell operation follow junction physics.

$$I = I_s(\exp(V/(\eta V_T)) - 1)$$

Why it matters :-

Most questions become simple once the definition, assumptions and required quantity are written clearly.

Remember :-

Identify the operating region before applying a diode approximation.

- write symbols before putting numbers
- keep the sign convention on the page
- check the unit of the final answer

Related idea :-

Next: BJT and MOSFET Devices. Transistors control current using junction injection or electric field.

Quick test :-

Can I explain diodes and optoelectronics without looking at the formula? Then can I state when the formula is valid?

Diodes and Optoelectronics : IMPORTANT POINTS

In one line :-

A p-n junction controls carrier flow through its depletion region.

What is happening :-

Bias changes barrier width and current; Zener, LED, photodiode and solar-cell operation follow junction physics.

$$I = I_s(\exp(V/(\eta V_T)) - 1)$$

How I remember it :-

Circle the final unit. A wrong unit usually means one step was missed.

Conditions :-

Use the relation only for the model stated in the question. Start from the general law if one condition changes.

- mark all known values with their units
- draw the figure when direction matters
- do not round values in the middle

Quick check :-

Identify the operating region before applying a diode approximation.

Compare :-

Do not mix this with bjt and mosfet devices. Device regions, small-signal parameters and bias points connect physical operation to amplifier models.

Diodes and Optoelectronics : WORKING

Given in the question :-

Write every known value in one place. Put its unit beside it and underline the quantity to be found.

Formula :-

$$I = I_s(\exp(V/(\eta V_T)) - 1)$$

Steps :-

- convert all values to one unit system
- rearrange the equation before substitution
- put values carefully with brackets
- round only the final answer

Final check :-

Identify the operating region before applying a diode approximation.

Small thought :-

Change one quantity mentally and read the equation again. The answer should follow the same physical or mathematical trend.

Also revise :-

BJT and MOSFET Devices: Transistors control current using junction injection or electric field.

Diodes and Optoelectronics : QUICK PRACTICE

Try without looking :-

1. Define diodes and optoelectronics in one clear sentence.
2. Write the main formula and name every quantity.
3. Explain this idea: Bias changes barrier width and current; Zener, LED, photodiode and solar-cell operation follow junction physics.
4. Why is this warning important: Identify the operating region before applying a diode approximation.
5. State one difference between diodes and optoelectronics and bjt and mosfet devices.

Hints :-

A p-n junction controls carrier flow through its depletion region.

$$I = I_s(\exp(V/(\eta V_T)) - 1)$$

Before moving on :-

- definition recalled without help
- formula written with correct symbols
- units and limiting case checked

One last reminder :-

Identify the operating region before applying a diode approximation.

BJT and MOSFET Devices

Meaning :-

Transistors control current using junction injection or electric field.

Main idea :-

Device regions, small-signal parameters and bias points connect physical operation to amplifier models.

$$g_m = I_C / V_T$$

Why it matters :-

Most questions become simple once the definition, assumptions and required quantity are written clearly.

Remember :-

Do not use saturation-region MOS equations outside saturation.

- write symbols before putting numbers
- keep the sign convention on the page
- check the unit of the final answer

Related idea :-

Next: Discrete-Time Signals and Sampling. Sampling maps a continuous signal to a sequence.

Quick test :-

Can I explain bjt and mosfet devices without looking at the formula? Then can I state when the formula is valid?

BJT and MOSFET Devices : IMPORTANT POINTS

In one line :-

Transistors control current using junction injection or electric field.

What is happening :-

Device regions, small-signal parameters and bias points connect physical operation to amplifier models.

$$g_m = I_C / V_T$$

How I remember it :-

Read the assumptions once more before using the short formula.

Conditions :-

Use the relation only for the model stated in the question.
Start from the general law if one condition changes.

- mark all known values with their units
- draw the figure when direction matters
- do not round values in the middle

Quick check :-

Do not use saturation-region MOS equations outside saturation.

Compare :-

Do not mix this with discrete-time signals and sampling.
DTFT, DFT and z-transform analyze discrete systems;
aliasing occurs when shifted spectra overlap.

BJT and MOSFET Devices : WORKING

Given in the question :-

Write every known value in one place. Put its unit beside it and underline the quantity to be found.

Formula :-

$$g_m = I_C / V_T$$

Steps :-

- convert all values to one unit system
- rearrange the equation before substitution
- put values carefully with brackets
- round only the final answer

Final check :-

Do not use saturation-region MOS equations outside saturation.

Small thought :-

Change one quantity mentally and read the equation again. The answer should follow the same physical or mathematical trend.

Also revise :-

Discrete-Time Signals and Sampling: Sampling maps a continuous signal to a sequence.

BJT and MOSFET Devices : QUICK PRACTICE

Try without looking :-

1. Define bjt and mosfet devices in one clear sentence.
2. Write the main formula and name every quantity.
3. Explain this idea: Device regions, small-signal parameters and bias points connect physical operation to amplifier models.
4. Why is this warning important: Do not use saturation-region MOS equations outside saturation.
5. State one difference between bjt and mosfet devices and discrete-time signals and sampling.

Hints :-

Transistors control current using junction injection or electric field.

$$g_m = I_C / V_T$$

Before moving on :-

- definition recalled without help
- formula written with correct symbols
- units and limiting case checked

One last reminder :-

Do not use saturation-region MOS equations outside saturation.

FORMULAS I MUST REMEMBER

Discrete-Time Signals and Sampling :-

sampling rate $>$ 2 times highest frequency

Sampling maps a continuous signal to a sequence.

Semiconductor Physics :-

$$J = q n \mu E$$

Carrier concentration and transport create device current.

Diodes and Optoelectronics :-

$$I = I_s (\exp(V/(\eta V_T)) - 1)$$

A p-n junction controls carrier flow through its depletion region.

BJT and MOSFET Devices :-

$$g_m = I_C / V_T$$

Transistors control current using junction injection or electric field.

While using them :-

- write the condition beside each formula
- keep units consistent from the first line
- check the sign and final magnitude

COMMON MISTAKES

Do not forget :-

Discrete-Time Signals and Sampling: Nyquist rate is a boundary, not a practical anti-aliasing margin.

Semiconductor Physics: Use consistent carrier sign and electric-field direction.

Diodes and Optoelectronics: Identify the operating region before applying a diode approximation.

BJT and MOSFET Devices: Do not use saturation-region MOS equations outside saturation.

My usual checks :-

- read the exact quantity asked
- copy every value with its unit
- write the sign convention before working
- use brackets during substitution
- round only after the final step

Before submitting :-

Read the answer once as a sentence. The value, unit and direction should all make sense together.

Good habit :-

Keep one clean line between the given data, formula, substitution and final answer. It makes rechecking much faster.

MIXED PRACTICE

Short questions :-

1. Write the meaning and main formula for discrete-time signals and sampling.
2. Write the meaning and main formula for semiconductor physics.
3. Write the meaning and main formula for diodes and optoelectronics.
4. Write the meaning and main formula for bjt and mosfet devices.

Think a little :-

5. Compare discrete-time signals and sampling with diodes and optoelectronics.
6. Which condition is most important in semiconductor physics?
7. Draw a small figure or flow sketch for bjt and mosfet devices.

Answer reminders :-

- Nyquist rate is a boundary, not a practical anti-aliasing margin.
- Use consistent carrier sign and electric-field direction.
- Identify the operating region before applying a diode approximation.
- Do not use saturation-region MOS equations outside saturation.

Final line :-

If an option has the wrong unit, sign or physical trend, reject it before doing a long calculation.