

i Cover Sheet

Department of Physics

Examination paper for TFY4185 Measurement Technique / Måleteknikk

Examination date: 13 August 2021

Examination time (from-to):09:00-13:00

Permitted examination support material: All support material is allowed

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Technical support during examination: Orakel support services:

Link: innsida.ntnu.no/wiki/-/wiki/English/Orakel+Support+Services

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OTHER INFORMATION

Only contact academic contact in case of errors or insufficiencies in the question set.

Saving: Answers written in Inspira are automatically saved every 15 seconds. If you are working in another program remember to save your answer regularly.

Cheating/Plagiarism: The exam is an individual, independent work. *Examination aids are permitted.* All submitted answers will be subject to plagiarism control. Read more about cheating and plagiarism here: innsida.ntnu.no/wiki/-/wiki/English/Cheating+on+exams

Notifications: If there is a need to send a message to the candidates during the exam (e.g. if there is an error in the question set), this will be done by sending a notification in Inspira. A dialogue box will appear. You can re-read the notification by clicking the bell icon in the top right-hand corner of the screen. All candidates will also receive an SMS to ensure that nobody misses out on important information. Please keep your phone available during the exam.

Weighting: *Each correct answer is weighted 4 points. Each incorrect or blank answer is 0 points. Answers are not necessarily exact. You must choose the best or closest answer.*

ABOUT SUBMISSION

Your answers will be submitted automatically when the examination time expires and the test closes, if you have answered at least one question. This will happen even if you do not click “Submit and return to dashboard” on the last page of the question set. You can reopen and edit your answer as long as the test is open. If no questions are answered by the time the examination time expires, your answers will not be submitted.

Withdrawing from the exam: If you wish to submit a blank test/withdraw from the exam, go to the menu in the top right-hand corner and click “Submit blank”. This **can not** be undone, even if the test is still open.

Accessing your answer post-submission: You will find your answer in Archive when the examination time has expired.

i Information about the exam

Other information:

All questions are 4 points for correct answer, 0 for incorrect or blank answer

Answers may not be exact, so **choose the best answer**

The course will be graded pass/fail (bestått/ikke bestått).
This year, in accordance with advice from the NTNU administration, the pass level for the course will be set at the E-level or above. That is, 41% or better will be a pass. You will have to pass both the laboratory section as well as this exam to receive a pass for the course.

i Logic Help Sheet

Help pages

Boolean identities		
AND function	OR function	NOT function
$0 \cdot 0 = 0$	$0 + 0 = 0$	$\overline{0} = 1$
$0 \cdot 1 = 0$	$0 + 1 = 1$	$\overline{1} = 0$
$1 \cdot 0 = 0$	$1 + 0 = 1$	$\overline{\overline{A}} = A$
$1 \cdot 1 = 1$	$1 + 1 = 1$	
$A \cdot 0 = 0$	$A + 0 = A$	
$0 \cdot A = 0$	$0 + A = A$	
$A \cdot 1 = A$	$A + 1 = 1$	
$1 \cdot A = A$	$1 + A = 1$	
$A \cdot A = A$	$A + A = A$	
$A \cdot \overline{A} = 0$	$A + \overline{A} = 1$	
Boolean laws		
Commutative law	Absorption law	
$AB = BA$	$A + AB = A$	
$A + B = B + A$	$A(A + B) = A$	
Distributive law	De Morgan's law	
$A(B + C) = AB + AC$	$\overline{A + B} = \overline{A} \cdot \overline{B}$	
$A + BC = (A + B)(A + C)$	$\overline{A \cdot B} = \overline{A} + \overline{B}$	
Associative law	Note also	
$A(BC) = (AB)C$	$A + \overline{A}B = A + B$	
$A + (B + C) = (A + B) + C$	$A(\overline{A} + B) = AB$	

Function	Symbol	Alternative symbol	Boolean expression	Truth table															
Buffer			$B = A$	<table><tr><th>A</th><th>B</th></tr><tr><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td></tr></table>	A	B	0	0	1	1									
A	B																		
0	0																		
1	1																		
NOT			$B = \overline{A}$	<table><tr><th>A</th><th>B</th></tr><tr><td>0</td><td>1</td></tr><tr><td>1</td><td>0</td></tr></table>	A	B	0	1	1	0									
A	B																		
0	1																		
1	0																		
AND			$C = A \cdot B$	<table><tr><th>A</th><th>B</th><th>C</th></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td><td>1</td></tr></table>	A	B	C	0	0	0	0	1	0	1	0	0	1	1	1
A	B	C																	
0	0	0																	
0	1	0																	
1	0	0																	
1	1	1																	
OR			$C = A + B$	<table><tr><th>A</th><th>B</th><th>C</th></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>1</td></tr></table>	A	B	C	0	0	0	0	1	1	1	0	1	1	1	1
A	B	C																	
0	0	0																	
0	1	1																	
1	0	1																	
1	1	1																	

Function	Symbol	Alternative symbol	Boolean expression	Truth table
NAND			$C = \overline{A \cdot B}$	A B C
				0 0 1
				0 1 1
				1 0 1
				1 1 0
NOR			$C = \overline{A + B}$	A B C
				0 0 1
				0 1 0
				1 0 0
				1 1 0
Exclusive OR			$C = A \oplus B$	A B C
				0 0 0
				0 1 1
				1 0 1
				1 1 0
Exclusive NOR			$C = \overline{A \oplus B}$	A B C
				0 0 1
				0 1 0
				1 0 0
				1 1 1

i

Transistor Help Sheet

BJT parameters for common emitter configuration (subscript _e)
other subscripts: Input_i Output_o Forward_f Reverse_r

h_{FE}	DC gain	I_C / I_B	
h_{fe}	AC gain	i_c / i_b	$h_{FE} \approx h_{fe}$ (mostly)
g_m	Transconductance	$\Delta I_C / \Delta V_{BE} = i_c / v_{be}$	$\sim 40 \cdot I_C \approx 40 \cdot I_E$
h_{ie}	Small signal input resistance	$\Delta V_{BE} / \Delta I_B = v_{be} / i_b$	$\sim 1 / (40 \cdot I_B) \, \Omega \approx h_{fe} / (40 \cdot I_C)$
h_{oe}	Output admittance (1/ r_o) where r_o = Slope in the active region	$\Delta I_C / \Delta V_{CE} = i_c / v_{ce}$	
r_e	Emitter resistance	$\Delta V_{BE} / \Delta I_C = v_{be} / i_c = 1/g_m$	$\approx v_{be} / i_e$ that is, $h_{ie} = h_{fe} \cdot r_e$
h_{re}	Early effect (V_{CE} affects bias V_{BE})	$\Delta V_{CE} / \Delta V_{BE}$	

$$h_{FE} = \frac{I_C}{I_B}$$
$$I_E = I_C + I_B = (h_{FE} + 1) \cdot I_B$$

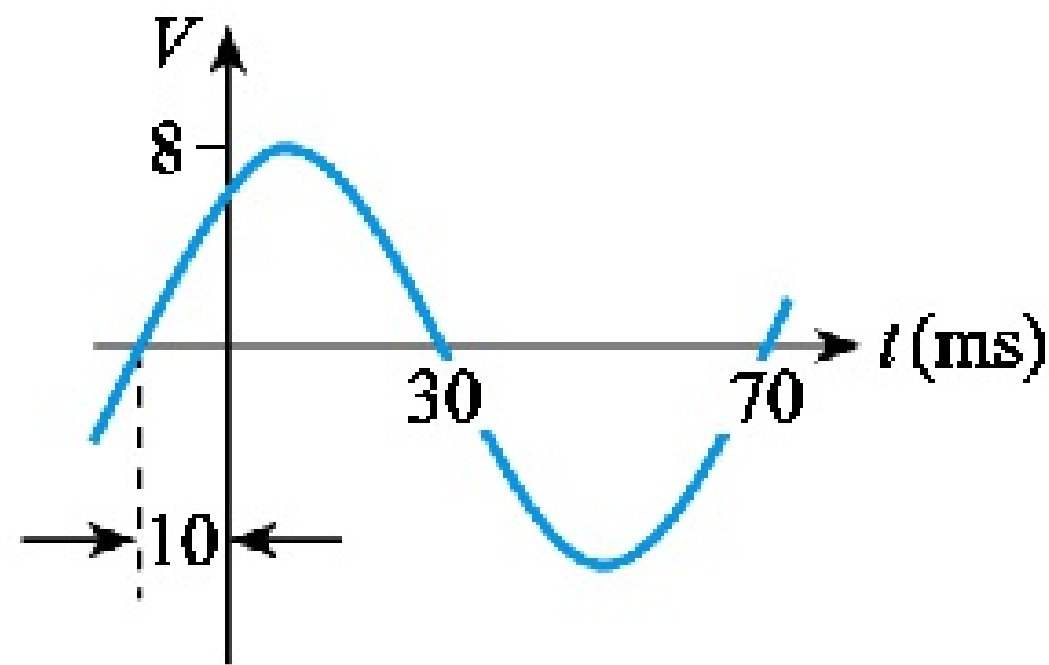
but because $h_{FE} \gg 1$,

$$I_E \approx h_{FE} \cdot I_B = I_C$$

$$I_B = I_{BS} \cdot e^{40 \cdot V_{BE}} \quad \text{where } I_{BS} \text{ is constant}$$
$$I_C = h_{FE} \cdot I_B = h_{FE} \cdot I_{BS} \cdot e^{40 \cdot V_{BE}}$$
$$g_m = \frac{\Delta I_C}{\Delta V_{BE}} = \frac{dI_C}{dV_{BE}} = 40 \cdot h_{FE} \cdot I_{BS} \cdot e^{40 \cdot V_{BE}}$$
$$g_m = \hspace{10em} = 40 \cdot I_C \approx 40 \cdot I_E$$

1 **TFY4185 2021S AC Fundamentals 1**

Which of the following equations describes the waveform shown here?



Select one alternative:

- ☐ $v = 8 \sin (79t - \pi / 4)$
- ☐ $v = 8 \sin (90t + \pi / 4)$
- ☐ $v = 8 \sin (90t - \pi / 4)$
- ☐ $v = 8 \sin (79t + \pi / 4)$

Maximum marks: 4

2 **TFY4185 2021S AC Power 2**

The voltage across a component is measured as 80 V r.m.s. and the current through it is 4 A r.m.s. If the current leads the voltage by 20° what is the apparent power in the component?

Select one alternative:

- ☐ 116 VA
- ☐ 301 VA
- ☐ 320 VA
- ☐ 109 VA

Maximum marks: 4

3

TFY4185 2021S BJT 1

In a bipolar junction transistor the base region is made very thin so that:
Select one alternative:

- ☐ recombination in base region is minimum
- ☐ the base can be easily biased
- ☐ the electric field gradient in base is high
- ☐ the base can be easily fabricated

Maximum marks: 4

4

TFY4185 2021S BJT 5

When bi-polar transistors are used in digital circuits they usually operate in the:
Select one alternative:

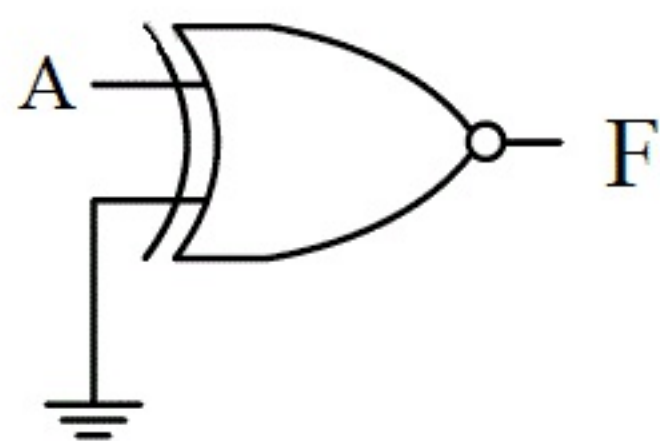
- ☐ Active region
- ☐ Saturation and cutoff regions
- ☐ Linear region
- ☐ Breakdown region

Maximum marks: 4

5

TFY4185 2021S Logic Combinational 6

The output of the logic gate in figure is



Select one alternative:

- ☐ 1
- ☐ 0
- ☐ $\overline{A}$
- ☐ A

Maximum marks: 4

6

TFY4185 2021S Op Amp 5

The ideal Op–Amp has the following characteristics:

Select one alternative:

- ☐ $R_i = \infty, A = \infty, R_o = \infty$
- ☐ $R_i = 0, A = \infty, R_o = 0$
- ☐ $R_i = \infty, A = \infty, R_o = 0$
- ☐ $R_i = 0, A = \infty, R_o = \infty$

Maximum marks: 4

7 **TFY4185 2021S Op amp 2**

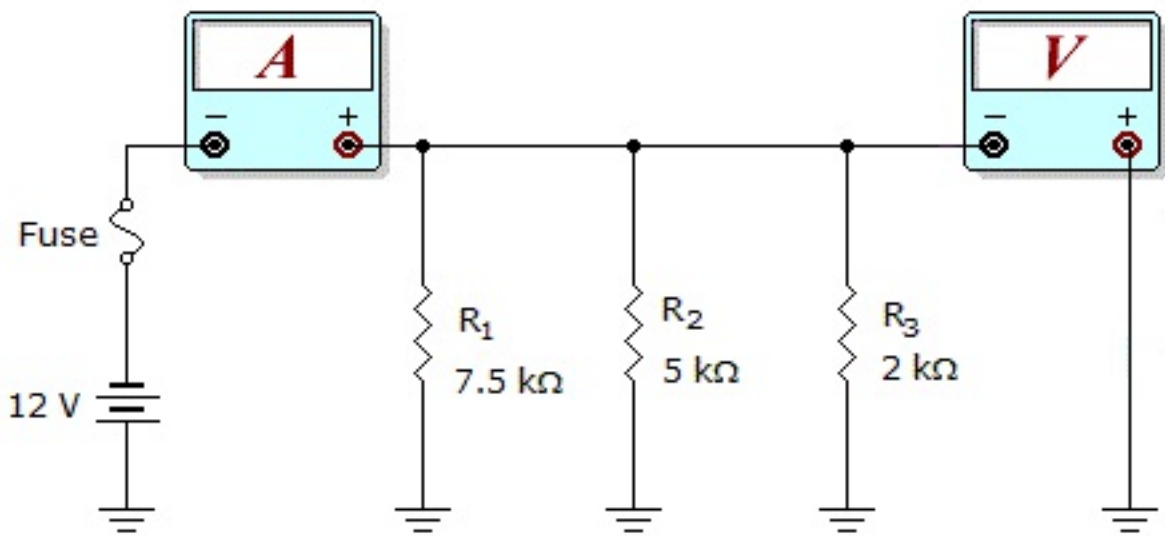
What does negative feedback derived from the output voltage do to a voltage amplifier?
Select one alternative:

- ☐ It decreases the output impedance and bandwidth.
- ☐ It increases the input impedance and bandwidth.
- ☐ It increases the input and output impedances.
- ☐ It does not affect impedance or bandwidth.

Maximum marks: 4

8 **TFY4185 2021S Resistance 17**

What would meter readings of $I = 10.0\text{ mA}$ and $V=12\text{ V}$ indicate about the circuit in the circuit given below?



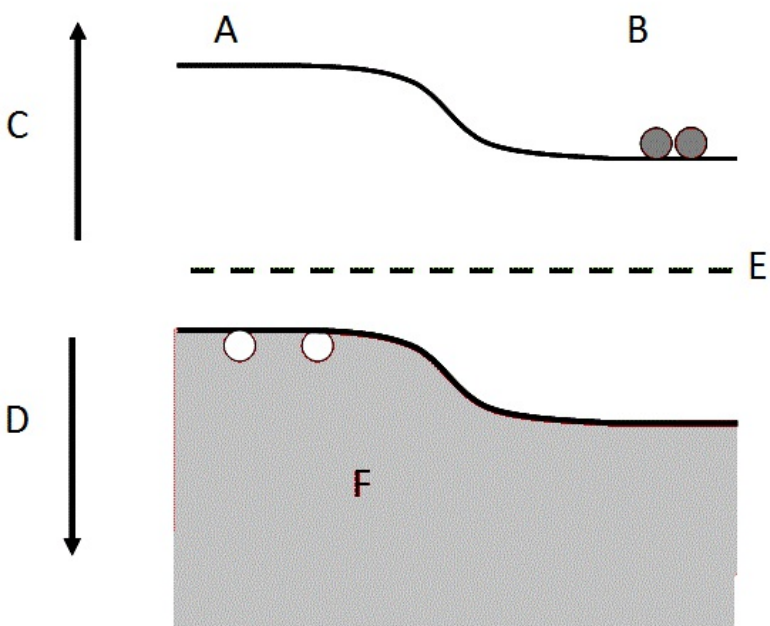
Select one alternative:

- ☐ R_2 is open
- ☐ There is nothing wrong with the circuit, it is functioning normally
- ☐ R_3 is shorted
- ☐ R_3 is open
- ☐ R_1 is open
- ☐ The fuse is open

Maximum marks: 4

9 **TFY4185 2021S Semiconductors and diodes 4**

The diagram below shows a p-n junction that is not connected to an external circuit. Enter the letter labelling the n-type material.



Select one alternative:

- ☐ A
- ☐ B
- ☐ C
- ☐ D
- ☐ E
- ☐ F

Maximum marks: 4

10 **TFY4185 2021S Semiconductors and diodes 6**

The diffusion potential across an unbiased p-n junction

Select one alternative:

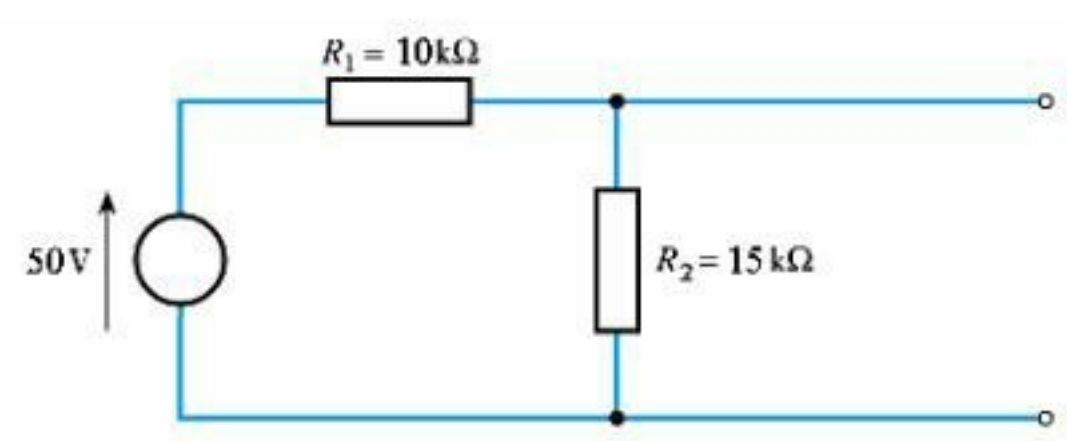
- ☐ does not depend on doping concentrations
- ☐ decreases with increasing doping concentration
- ☐ increases with decreasing band gap
- ☐ increases with increased doping concentrations

Maximum marks: 4

11

TFY4185 2021S Solving Circuits 3

Determine the short-circuit current of the following circuit.



Select one alternative:

- ☐ 3.33 mA
- ☐ 6.67 mA
- ☐ 5 mA
- ☐ 2 mA

Maximum marks: 4

12

TFY4185 2021S AC Power 4

The voltage across a component is measured as 80 V r.m.s. and the current through it is 4 A r.m.s. If the current leads the voltage by 20° what is the active power in the component?

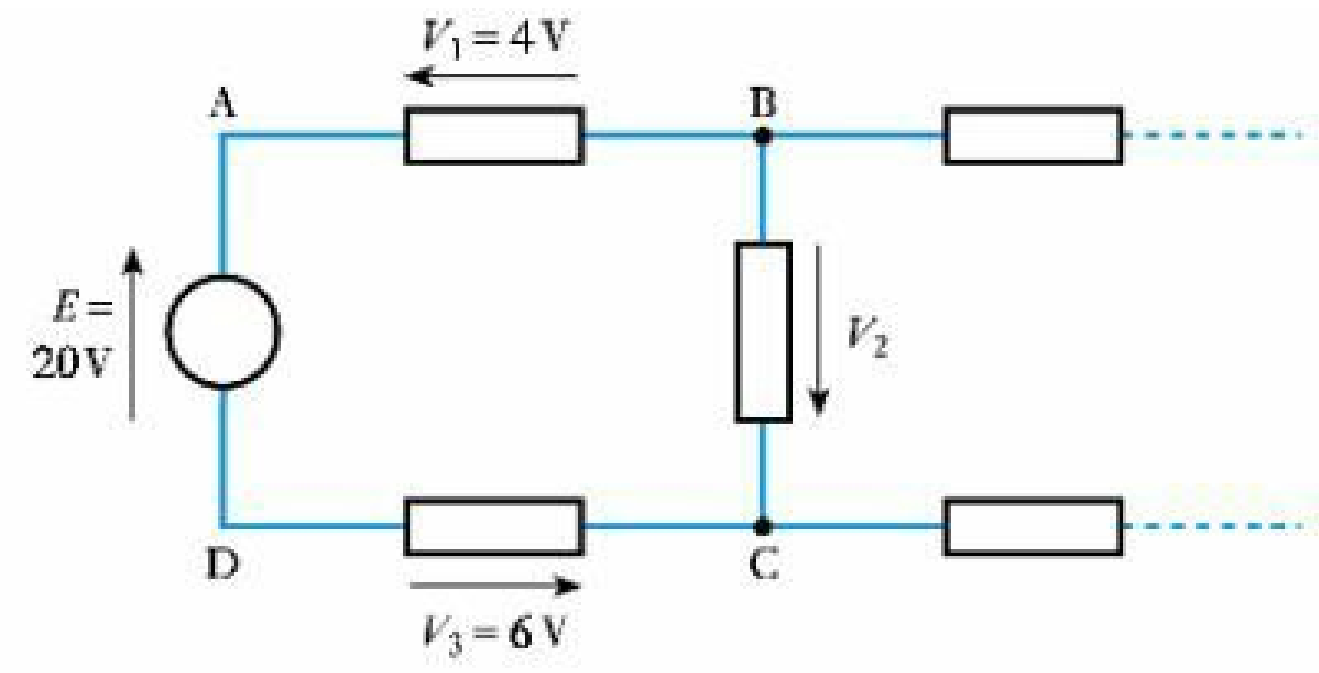
Select one alternative:

- ☐ 320 W
- ☐ 301 W
- ☐ 116 W
- ☐ 109 W

Maximum marks: 4

13 **TFY4185 2021S Solving Circuits 1**

Calculate the voltage V_2 in the following circuit.



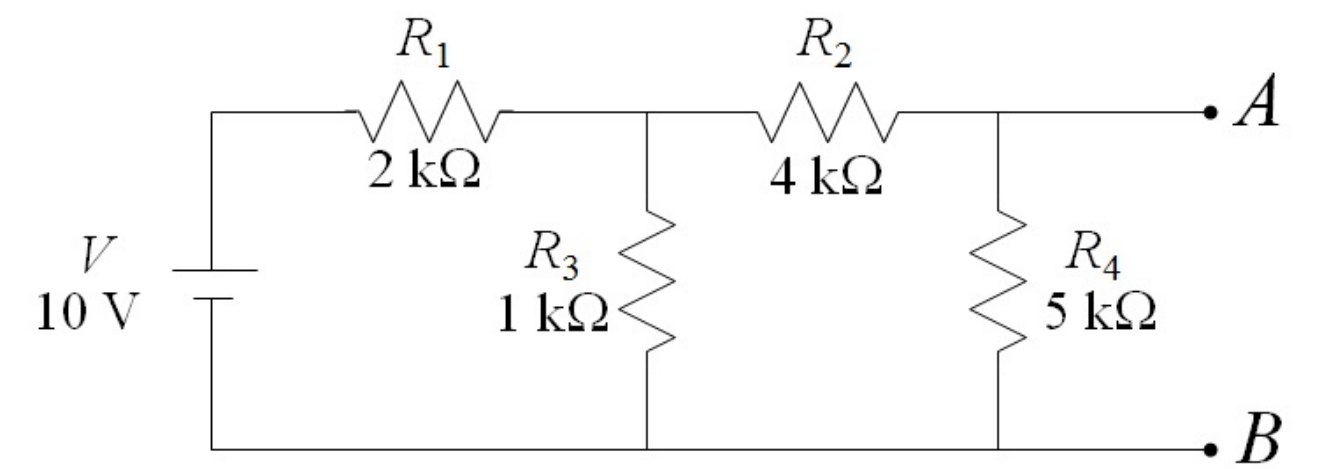
Select one alternative:

- ☐ -10
- ☐ 10
- ☐ 10
- ☐ 12

Maximum marks: 4

14 **TFY4185 2021S Thevenin Norton 1**

In the circuit below, what is the Thevenin voltage and resistance?



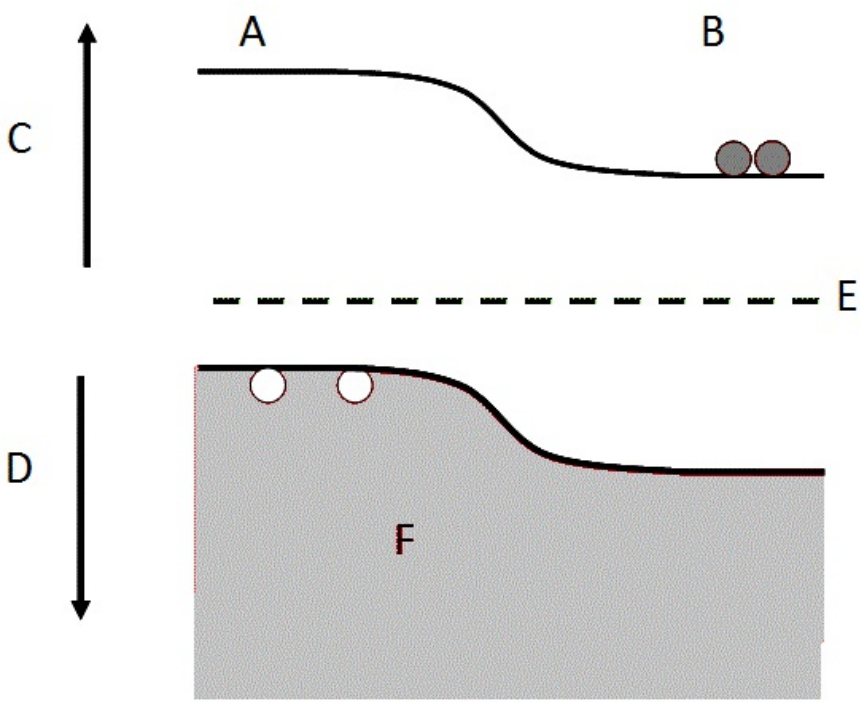
Select one alternative:

- ☐ 1.72 V and 666 Ω
- ☐ 3.10 V and 9.90 k Ω
- ☐ 3.10 V and 2.41 k Ω
- ☐ 1.72 V and 2.41 k Ω

Maximum marks: 4

15 **TFY4185 2021S Semiconductors and diodes 2**

The diagram below shows a p-n junction that is not connected to an external circuit. Enter the letter labelling the Valence band.



Select one alternative:

- ☐ A
- ☐ B
- ☐ C
- ☐ D
- ☐ E
- ☐ F

Maximum marks: 4

16 **TFY4185 2021S Reactance 3**

What is the capacitive reactance if $I = 1$ amp, $V = 2$ volts, $C = 5$ F, and frequency = 10 Hz?

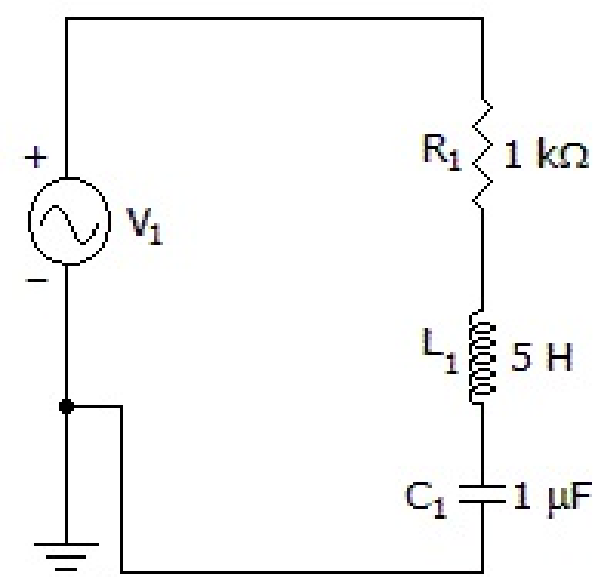
Select one alternative:

- ☐ 0.02 Ω
- ☐ 0.2 Ω
- ☐ 0.003 Ω
- ☐ 0.5 Ω

Maximum marks: 4

17 **TFY4185 2021S RLC and Transients 6**

What is the resonant frequency of the circuit below?



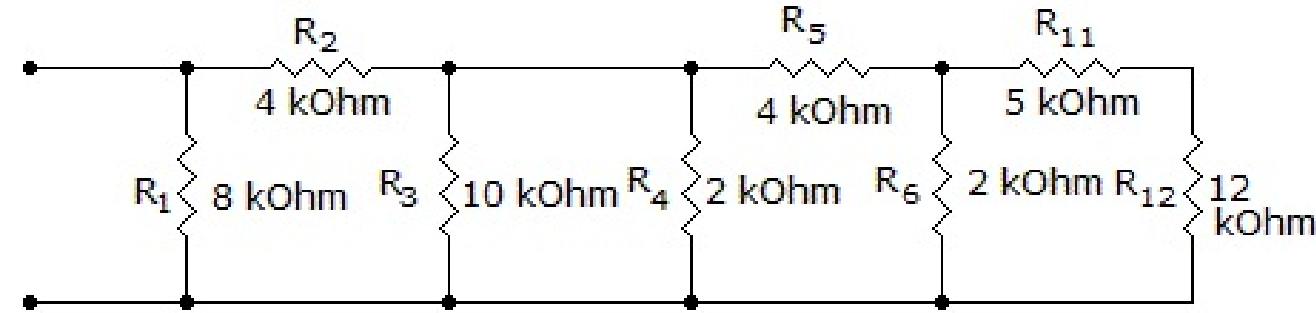
Select one alternative:

- ☐ 447 Hz
- ☐ 200 Hz
- ☐ 32 Hz
- ☐ 71 Hz

Maximum marks: 4

18 **TFY4185 2021S Resistance 12**

What is the total resistance of the circuit below?



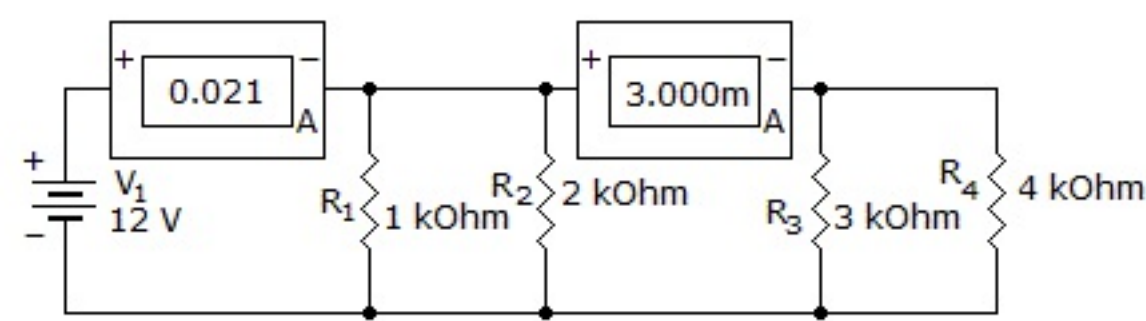
Select one alternative:

- ☐ 5.2 kΩ
- ☐ 2.2 kΩ
- ☐ 3.2 kΩ
- ☐ 4.2 kΩ

Maximum marks: 4

19 **TFY4185 2021S Resistance 10**

Which component is open in the circuit below?



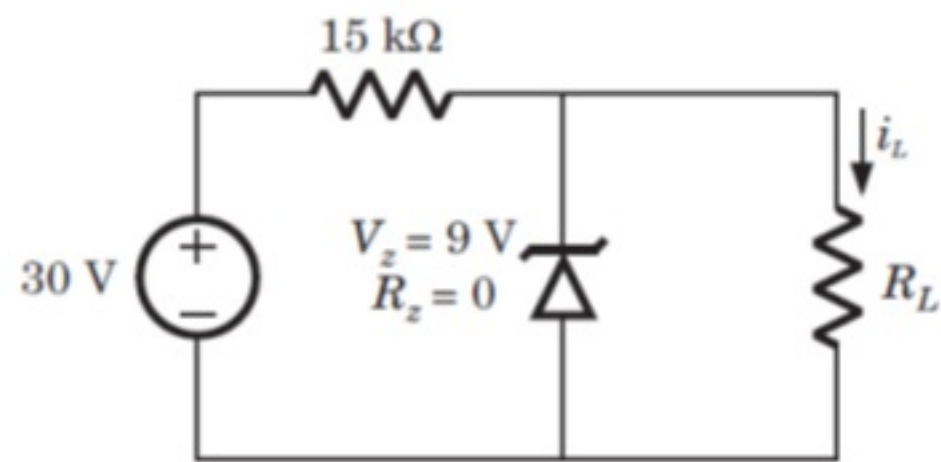
Select one alternative:

- ☐ R₁
- ☐ R₄
- ☐ R₂
- ☐ R₃

Maximum marks: 4

20 **TFY4185 2021S Zener Diodes**

In the voltage regulator circuit in the figure below, what is the maximum load current, i_L , that can be drawn?



Select one alternative:

- ☐ 2.3 mA
- ☐ 1.4 mA
- ☐ 2.5 mA
- ☐ 1.8 mA

Maximum marks: 4

21

TFY4185 2021S Semiconductors and diodes

An ideal pn junction diode is operating in the forward bias region ($V_d > 0.1\text{V}$). The change in diode voltage, that will cause a factor of 9 increase in current, is

Select one alternative:

- ☐ 85 mV
- ☐ 35 mV
- ☐ 55 mV
- ☐ 45 mV

Maximum marks: 4

22

TFY4185 2021S FET 2

What are the three terminals of an FET transistor called:

Select one alternative:

- ☐ source, gate, drain
- ☐ cathode, anode, grid
- ☐ none of the answers are correct
- ☐ emitter, base, collector

Maximum marks: 4

23

TFY4185 2021S Digital Devices 3

As compared to TTL, CMOS logic has

Select one alternative:

- ☐ Smaller physical size
- ☐ Higher power dissipation
- ☐ All answers are correct
- ☐ Higher speed of operation

Maximum marks: 4

24

TFY4185 2021S Logic Combinational 7

Decimal number 9 in Gray code is:
Select one alternative:

- ☐ 1100
- ☐ 1101
- ☐ 1001
- ☐ 111

Maximum marks: 4

25

TFY4185 2021S Logic Combinational 4

The output of a logic gate is ‘1’ when all its input are at logic 0. The gate is either
Select one alternative:

- ☐ an AND or an EX-OR gate
- ☐ a NOR or an EX-NOR gate
- ☐ a NAND or an EX-OR gate
- ☐ an OR or an EX-NOR gate

Maximum marks: 4