



NTNU – Trondheim
Norwegian University of
Science and Technology

Department of Physics

Examination paper for TFY4185 Measurement Technique/ Måleteknikk

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Examination date: 2 December 2015

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

Permitted examination support material:

Single or Bi-lingual dictionary permitted

All calculators permitted

1 side of an A5 sheet with printed or handwritten formulas permitted

Other information:

Language: English

Number of pages:

Number of pages enclosed:

Checked by:

Date

Signature

The Norwegian University of Science and Technology
ENGLISH

Department of Physics

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EXAM IN TFY 4185 Measurement Technique/Måleteknikk

December 2015

Time: 09:00-13:00

Number of pages: 10

Permitted aids: 1) Dictionary (ordinary or bi-lingual)
 2) All calculators
 3) 1 side of an A5 sheet with printed or handwritten formulas permitted

Last page contains a listing of parameters for BJT transistors

You can answer in either Norwegian or English. The weight for each multiple-choice question is 4%, the weight for each calculation problem is given in parentheses.

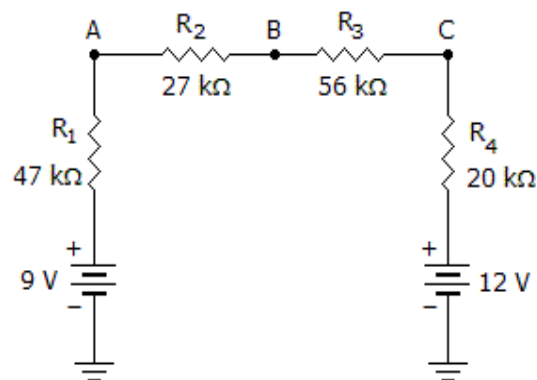
Multiple Choice Questions-1 (40% total).

There is only **one** correct answer so you must **choose the best answer**. Answer A, B, C... (Capital letters). Correct answers give +4; incorrect or blank answers give 0.

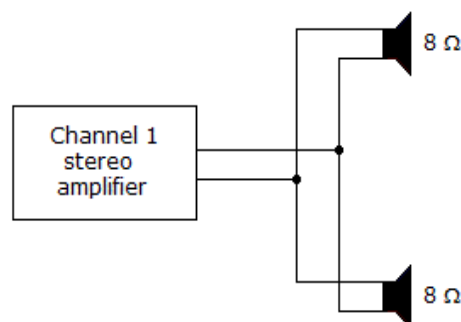
Write the answers for the multiple choice questions **on the answer sheet you turn in** using a table similar to the following:

Question	1	2	3	4	5	6	7	8	9	10
Answer										

1. Calculate the voltage at point B in the following circuit:

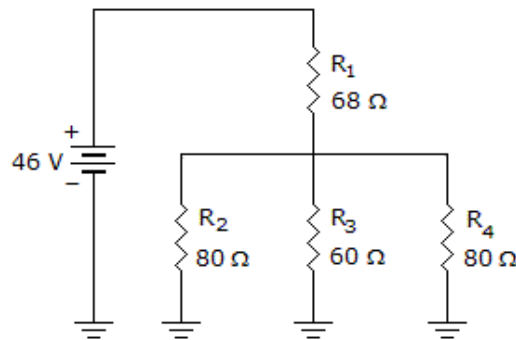


- A) 10.5 V B) 0.9 V C) 2.6 V D) 3.0 V
2. In the following circuit, Channel 1 of the stereo amplifier outputs 12 V to the speakers. How much total current is the amplifier providing to the speakers?



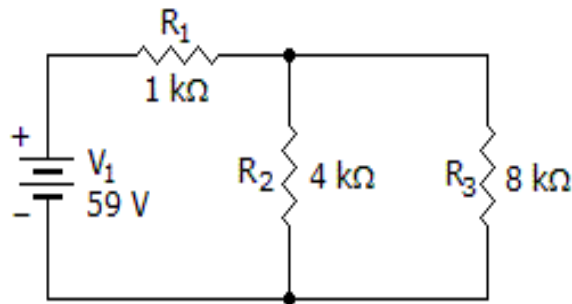
- A) 0.75 A B) 1.5 A C) 3.0 A D) Not enough information given

3. How much voltage is dropped across R3 in the given circuit?



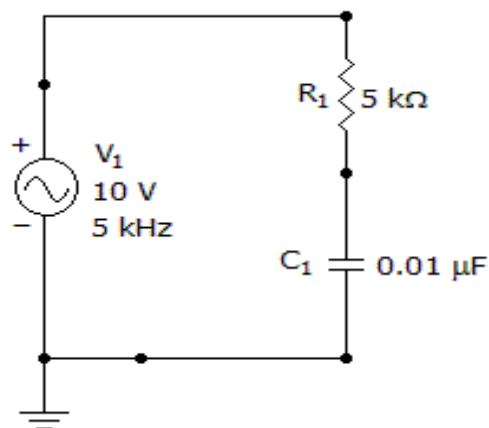
- A) 46 V B) 21 V C) 34 V D) 12 V

4. What is the power dissipated by R1, R2, and R3?



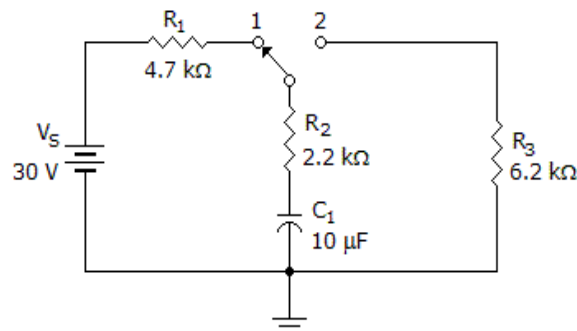
- A) $P_1 = 0.13 \text{ W}$, $P_2 = 0.26 \text{ W}$, $P_3 = 0.12 \text{ W}$
 B) $P_1 = 0.26 \text{ W}$, $P_2 = 0.52 \text{ W}$, $P_3 = 0.23 \text{ W}$
 C) $P_1 = 0.52 \text{ W}$, $P_2 = 0.92 \text{ W}$, $P_3 = 0.46 \text{ W}$
 D) $P_1 = 1.04 \text{ W}$, $P_2 = 1.84 \text{ W}$, $P_3 = 0.92 \text{ W}$

5. What is the magnitude of the impedance in the following circuit?



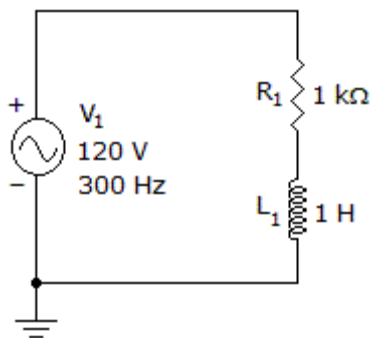
- A) 5928 Ω B) 8183 Ω C) 20 kΩ D) 126 kΩ

6. In the following circuit, what with the voltage be across R_3 at a time $t = 25$ ms after the switch is moved to position 2?



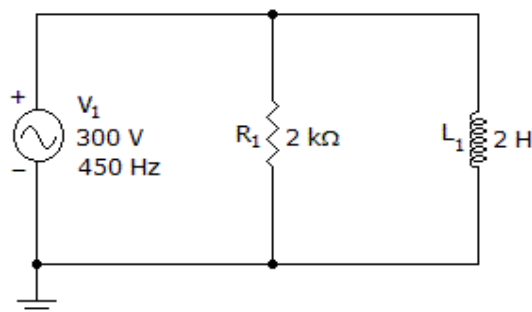
- A) 2.7 V B) 5.8 V C) 16.4 V D) 22.3 V E) 30.0 V

7. Find the voltage across the resistor (V_R) and the voltage across the inductor (V_L) in the following circuit?



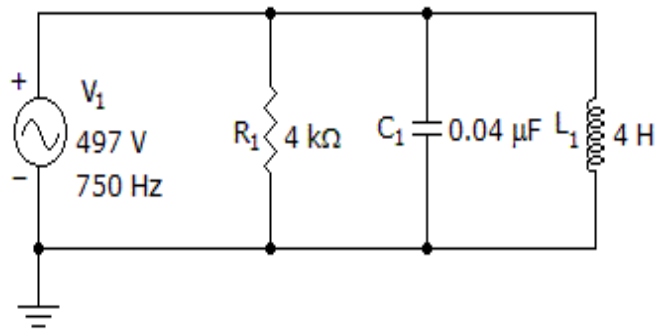
- A) $V_R = 41.6$ V, $V_L = 78.4$ V B) $V_R = 48$ V, $V_L = 110$ V
C) $V_R = 56$ V, $V_L = 106$ V D) $V_R = 60$ V, $V_L = 60$ V

8. Find the currents through R_1 and L_1 (I_R and I_L), and the total current, I_T .



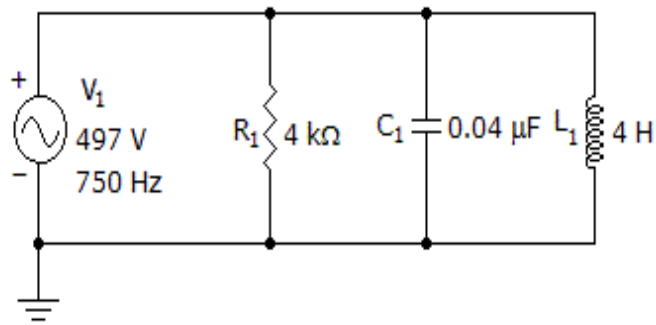
- A) $I_R = 50$ mA, $I_L = 109$ mA, $I_T = 159$ mA
B) $I_R = 150$ mA, $I_L = 9$ mA, $I_T = 159$ mA
C) $I_R = 50$ mA, $I_L = 151$ mA, $I_T = 201$ mA
D) $I_R = 150$ mA, $I_L = 53$ mA, $I_T = 159$ mA

9. What is the total current in the following circuit?



- A) 56.6 mA B) 141 mA C) 91 mA D) 244 mA

10. What is the phase angle between the current and the source voltage in the circuit of problem 9?



- A) 61.4° B) 28.5° C) -28.5° D) -61.4°

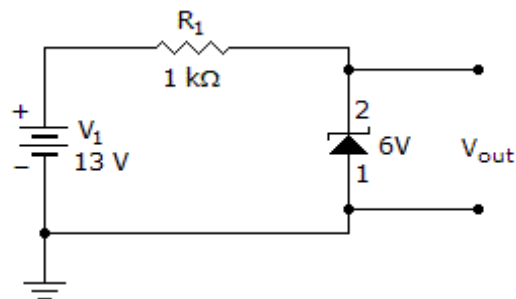
Multiple Choice Questions-2 (40% total).

There is only **one** correct answer so you must **choose the best answer**. Answer A, B, C, ... (Capital letters). Correct answers give +4; incorrect or blank answers give 0.

Again, **on the answer sheet you turn in** use a table similar to the following:

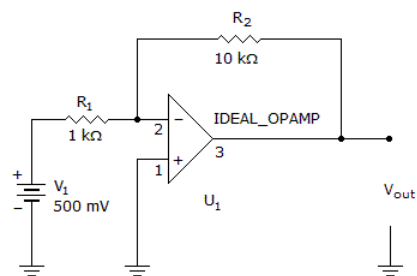
Question	11	12	13	14	15	16	17	18	19	20
Answer										

11. What is the current through the Zener diode?



- A) 0 mA B) 7 mA C) 8.3 mA D) 13 mA

12. What is the output voltage of the following circuit?



- A) 15 V D) -15 V
B) 50 mV E) -50 mV
C) 5V F) -5 V

13. If the input to a comparator is a sine wave, the output is a:

- A) ramp voltage
B) sine wave
C) rectangular wave
D) saw-tooth wave
E) All of the above

14. A Bi-Polar Junction Transistor is a _____-controlled device. The JFET is a _____ - controlled device:

- A) current, voltage
- B) current, current
- C) voltage, voltage
- D) voltage, current

15. How will electrons flow through a p-channel JFET?

- A) from source to drain
- B) from source to gate
- C) from drain to gate
- D) from drain to source

16. What is meant by 'pink noise'?

- A) The noise has a frequency equal to that of pink light.
- B) Most of the noise power is concentrated at low frequencies.
- C) Most of the noise power is concentrated at high frequencies.
- D) The noise has a uniform spectrum.

17. The logic gate that will have HIGH or "1" at its output when any one of its inputs is HIGH is:

- A) an OR gate
- B) an AND gate
- C) a NOR gate
- D) a NOT gate

18. Simplify the expression $Y = \overline{A}BD + A\overline{B}D$:

- A) $Y = AB$
- B) $Y = \overline{D}$
- C) $Y = BCD$
- D) $Y = A\overline{B}$
- E) $Y = \overline{A}BD$

19. What is the resolution of a 6-bit analogue (0-5V) to digital data converter?

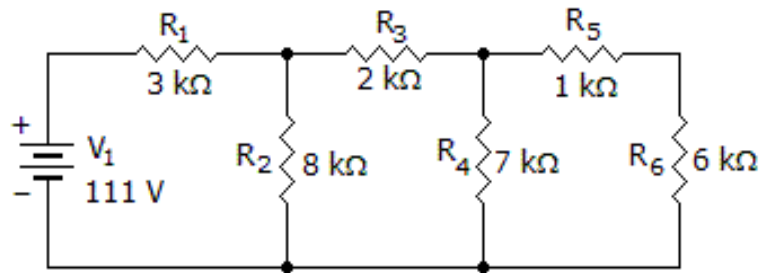
- A) 4%
- B) 64%
- C) 1.56%
- D) 15.6%
- E) 7.8%

20. How many storage locations are available when a memory device has twelve address lines?

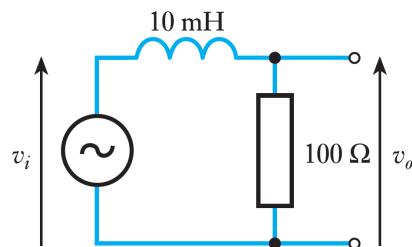
- A) 144
- B) 512
- C) 2048
- D) 4096

Calculations (20% total)

21. What is the power dissipated by R_2 , R_4 , and R_6 ? (7%)



22. For the circuit below, with $v_{in}(t) = V_{in} \cdot \cos(\omega \cdot t)$ Volts, find the transfer function $H(\omega) = V_{out}/V_{in}$, and sketch the response versus frequency. (4%)



23. Write a truth table, Boolean expression and design a logic circuit to take three inputs, A, B and C, and produce a single output X, such that X is true if, and only if, precisely two of its inputs are true. (9%)

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 $h_{FE} \gg 1$,

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

$$I_B = I_{BS} \cdot e^{40 \cdot V_{BE}} \quad \text{where } I_{BS} \text{ is constant}$$

$$I_C = h_{FE} \cdot I_B = h_{FE} \cdot I_{BS} \cdot e^{40 \cdot V_{BE}}$$

$$g_m = \frac{\Delta I_C}{\Delta V_{BE}} = \frac{dI_C}{dV_{BE}} = 40 \cdot h_{FE} \cdot I_{BS} \cdot e^{40 \cdot V_{BE}}$$

$$g_m = \quad \quad \quad = 40 \cdot I_C \approx 40 \cdot I_E$$