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 Department of Physics
ENGLISH

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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 parenthesizes.

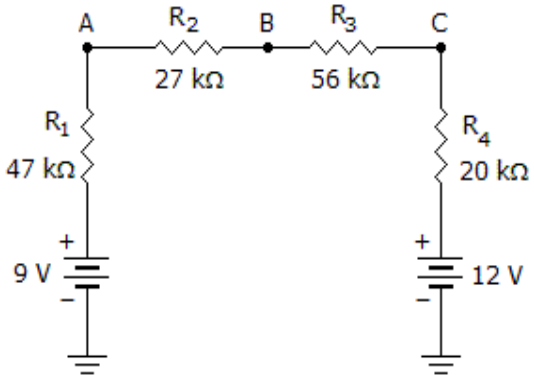
Multiple Choice Questions-1 (40% total).

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:

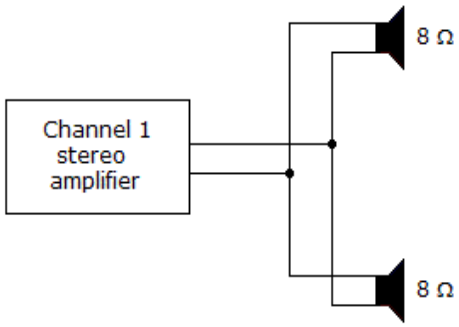
Question	1	2	3	4	5	6	7	8	9	10
Answer										

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



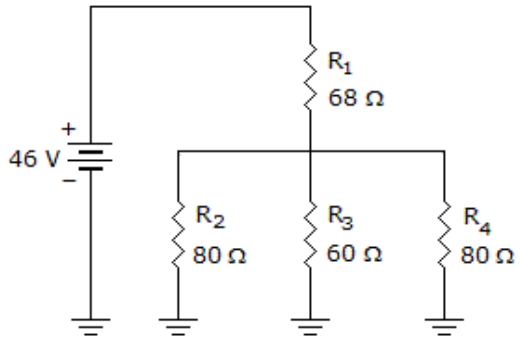
A) 10.5 V B) 0.9 V C) 2.6 V D) 3.0 V

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?**



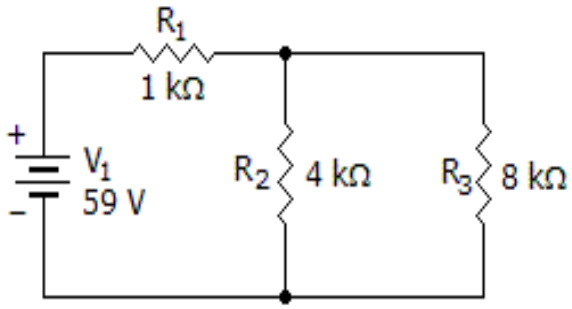
A) 0.75 A B) 1.5 A C) 3.0 A D) Not enough information given

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



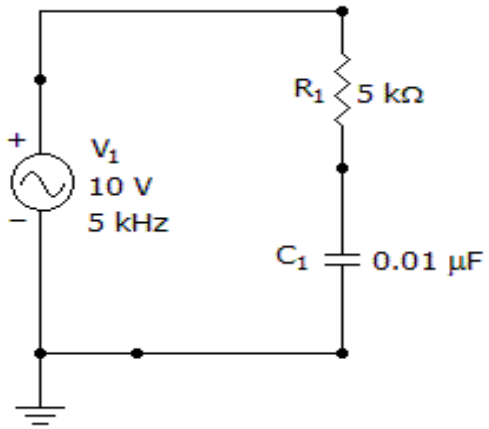
A) 46 V B) 21 V C) 34 V D) 12 V

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



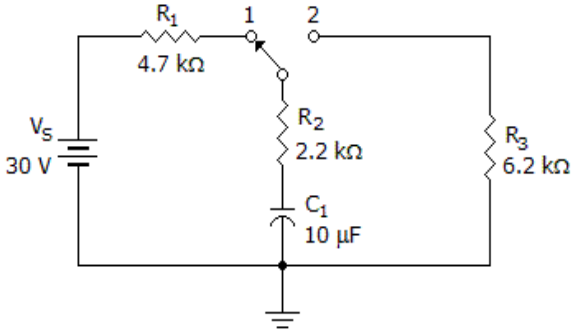
A) P1 = 0.13 W, P2 = 0.26 W, P3 = 0.12 W
B) P1 = 0.26 W, P2 = 0.52 W, P3 = 0.23 W
C) P1 = 0.52 W, P2 = 0.92 W, P3 = 0.46 W
D) P1 = 1.04 W, P2 = 1.84 W, P3 = 0.92 W

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



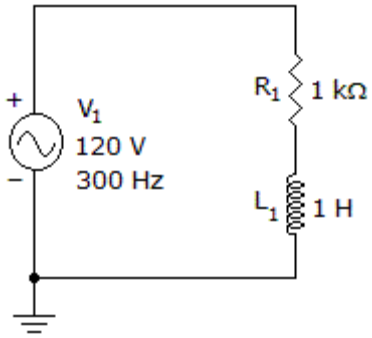
A) 5928 Ω B) 8183 Ω C) 20 kΩ D) 126 kΩ

6. In the following circuit, what with the voltage be across R3 at a time t = 25 ms after the switch is moved to position 2?



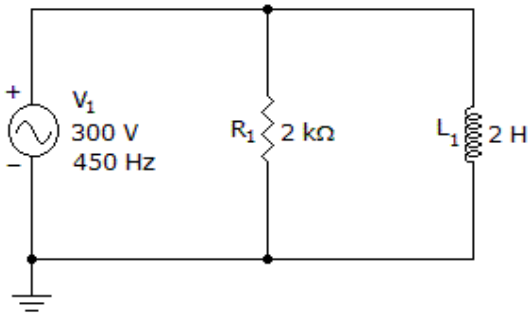
A) 2.7 V B) 5.8 V C) 16.4 V D) 22.3 V E) 30.0 V

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



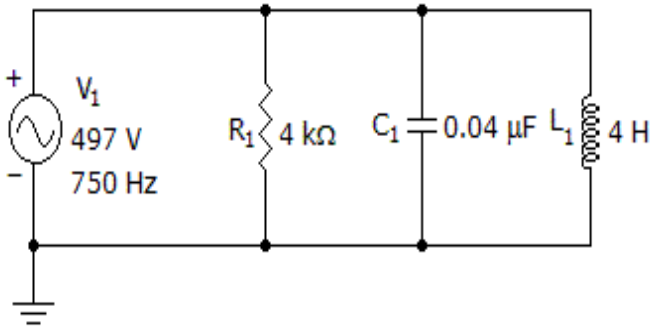
A) V_R = 41.6 V, V_L = 78.4 V
B) V_R = 48 V, V_L = 110 V
C) V_R = 56 V, V_L = 106 V
D) V_R = 60 V, V_L = 60 V

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



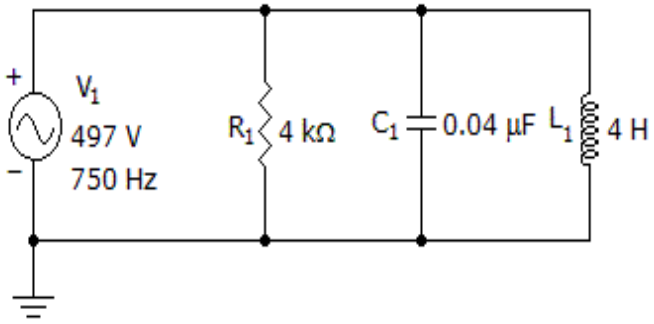
A) I_R = 50 mA, I_L = 109 mA, I_T = 159 mA
B) I_R = 150 mA, I_L = 9 mA, I_T = 159 mA
C) I_R = 50 mA, I_L = 151 mA, I_T = 201 mA
D) I_R = 150 mA, I_L = 53 mA, I_T = 159 mA

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°

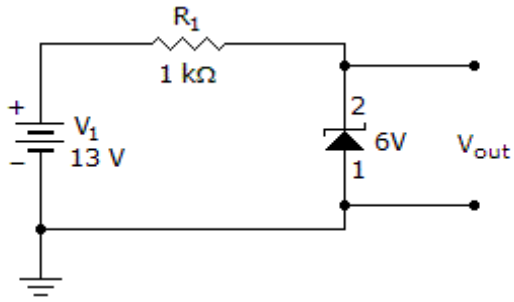
Multiple Choice Questions-2 (40% total).

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:

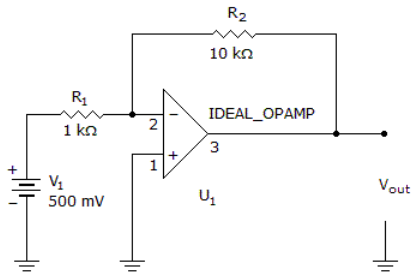
Question	11	12	13	14	15	16	17	18	19	20
Answer										

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
B) 50 mV
C) 5V
D) -15 V
E) -50 mV
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 Juntion 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 $Y = A\overline{B}D + A\overline{\overline{B}D}$:

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

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

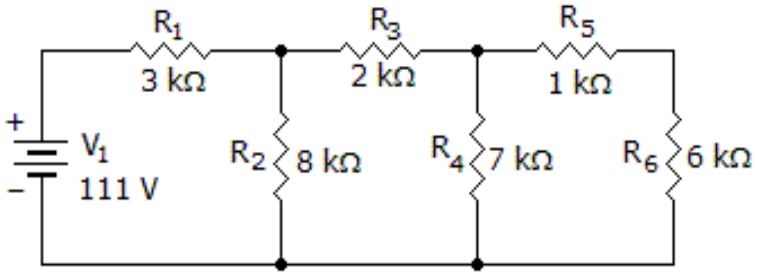
A) 4% B) 64% C) 1.56% D) 15.6% E) 7.8%

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

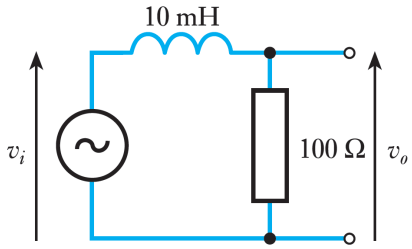
A) 144 B) 512 C) 2048 D) 4096

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})	$\Delta V_{CE} / \Delta V_{BE}$	

$$h_{FE} = \frac{I_C}{I_B}$$

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

$$\text{but because } h_{FE} >> 1,$$

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

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

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

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

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