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T700**(E)**(M31)T
APRIL EXAMINATION

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N2

(8080602)

31 March 2016 (Y-Paper)
13:00–16:00

This question paper consists of 7 pages and 1 formula sheet of 3 pages.

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
INDUSTRIAL ELECTRONICS N2
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. ALL the sketches and diagrams must be in pencil, large, clear and neat.
5. ALL answers with decimals must be rounded off to the third decimal place after the comma.
6. Write neatly and legibly.

QUESTION 1

Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (1.1–1.5) in the ANSWER BOOK.

1.1 Electrons that orbit the outermost shell of an atom are called valence electrons.

1.2 The hydrogen atom is an example of an atom that can exist on its own as a stable element.

1.3 Insulators are also called non-conductors or dielectrics.

1.4 Free electrons are those electrons that have left the outermost shell a parent atom.

1.5 The energy level of any electron is proportional to that electron's distance from the nucleus.

(5 x 1) **[5]**

QUESTION 2

Draw the IEC symbol of each of the following diodes:

2.1 P-N junction semiconductor diode

2.2 Zener diode

2.3 Varactor diode

2.4 Light-emitting diode

(4 x 1) **[4]**

QUESTION 3

3.1 Study FIGURE 1 below and answer the questions.

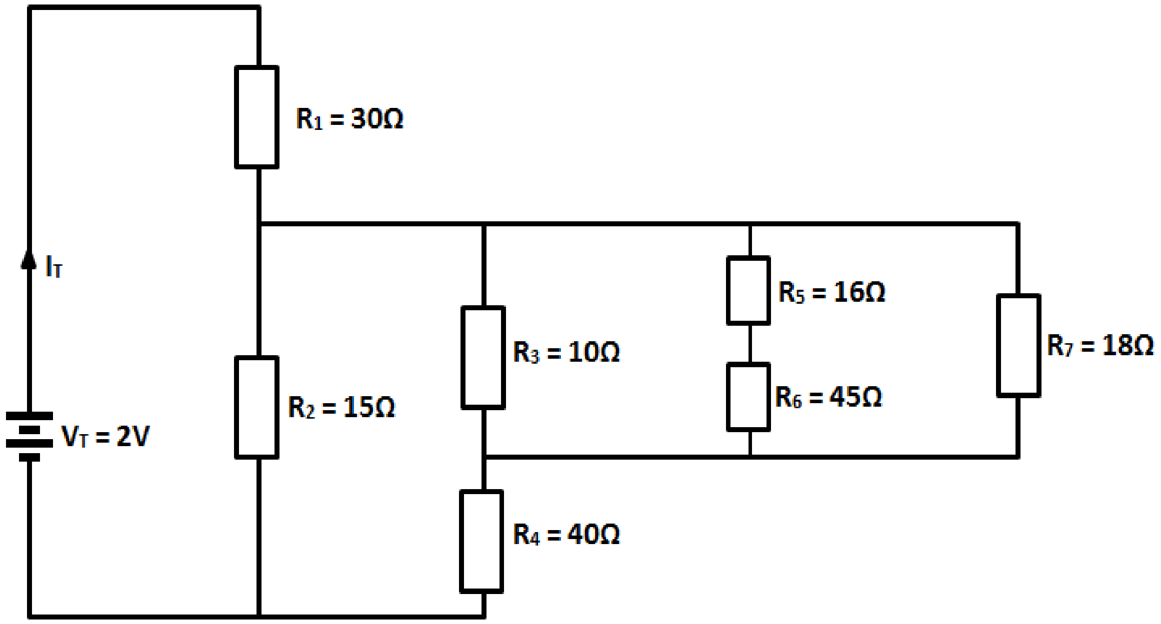

FIGURE 1

Calculate:

3.1.1 Total resistance R_T (11)

3.1.2 Total current I_T (2)

3.1.3 The power dissipated in R_1 (2)

3.2 Study FIGURE 2 below and then use KCL to calculate the unknown current I_T.

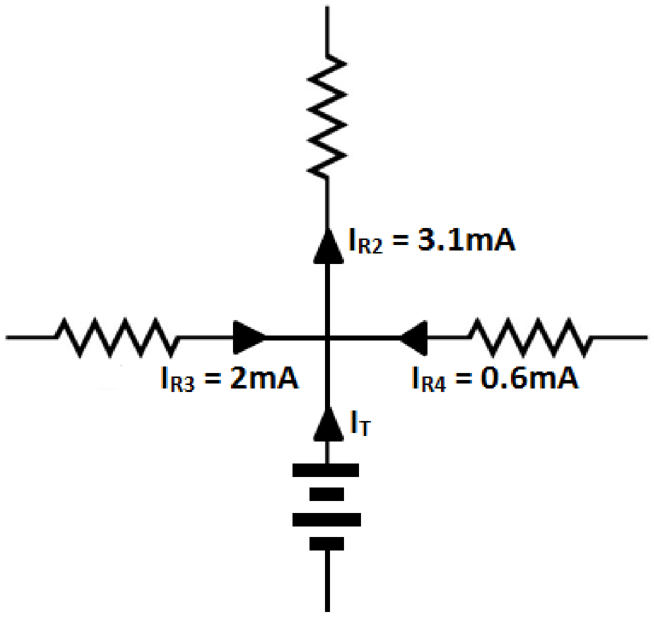

FIGURE 2 (5)

[20]

QUESTION 4

4.1 Give the value of the standard frequency supplied by power companies in South Africa as well as the standard voltage supplied for home use. (2)

4.2 Define the *form factor* and the *crest factor* of a waveform. (2)

4.3 Study FIGURE 3 below and answer the questions.

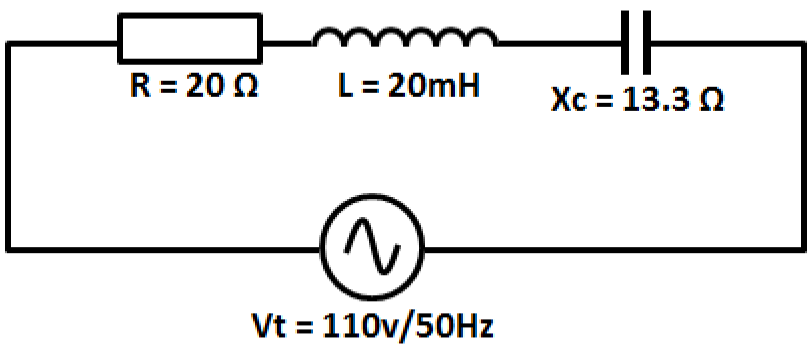

FIGURE 3

Calculate:

4.3.1 The value of the capacitor (3)

4.3.2 The inductive reactance (X_L) (2)

4.3.3 The total impedance (Z_T) (3)

4.3.4 The total current (I_T) (2)

4.3.5 The voltage drop across the resistor (V_R) (2)

4.3.6 The voltage drop across the inductor (2)

4.3.7 The phase angle (θ) (2)
[20]

QUESTION 5

5.1 A moving-coil measuring instrument with a resistance of 5 Ω gives a full scale deflection of 10 milliamperes.

Calculate:

5.1.1 The value of the shunt resistance (R_{SH}) required in order to use the instrument as an ammeter for a 2 A current flow (5)

5.1.2 The series resistance (R_S) required to use the instrument as a voltmeter of up to 12 V (3)

5.2 Name the TWO methods/means through which the damping process can be facilitated. (2)
[10]

QUESTION 6

6.1 In terms of the doping process, differentiate between the anode terminal and the cathode terminal of a semiconductor diode. (4)

6.2 Make a neat, labelled circuit diagram of a full-wave bridge rectifier circuit. (6)
[10]

QUESTION 7

7.1 Make a neat, labelled circuit diagram of an NPN transistor amplifier that is connected in the common collector configuration mode. (5)

7.2 Name the output current of a common emitter transistor amplifier and then compare it to the base current of the same amplifier in terms of magnitude. (3)

7.3 Name the THREE classes of operation of transistor amplifiers. (3)
[11]

QUESTION 8

8.1 Describe the operating principle of a thermocouple, by drawing a neat, labelled circuit diagram. Insert a voltmeter in your sketch to indicate a voltage which depends upon the difference in the temperature of the two junctions of the thermocouple. (7)

8.2 Describe in detail the difference between negative temperature coefficient and positive temperature coefficient of materials in terms of the resistance of a material. (4)

8.3 State THREE advantages of a synchro system over a mechanical system. (3)
[14]

QUESTION 9

A 6,6 V input signal to a car audio system produces a current of 5,6 A in a subwoofer speaker system which has an impedance 7,6 Ω. The impedance on the input of the amplifier is 7,6 Ω.

Calculate:

9.1 The input power of the amplifier

9.2 The output power of the amplifier

9.3 The gain of the amplifier

(3 x 2) **[6]**

TOTAL: 100

INDUSTRIAL ELECTRONICS N2

FORMULA SHEET

DC THEORY

(i) $V = I \times R$

(ii) $R_T = R_1 + R_2$

(iii) $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$

(iv) $P = V \times I$

(v) $P = I^2 \times \mathrm{R}$

(vi) $P = \frac{V^2}{R}$

AC THEORY

(i) $t = \frac{1}{f}$

(ii) $e = E_m \, Sin \, 2\pi ft$

(iii) $i = I_m \, Sin \, 2\pi ft$

(iv) $\theta = 2\pi ft$

(v) $I_{AVE} = \frac{I_1 + I_2 + I_3}{n}$

(vi) $I_{RMS} = \sqrt{\frac{I_1^2 + I_2^2 + I_3^2}{n}}$

(vii) $V_{AVE} = \frac{V_1 + V_2 + V_3}{n}$

(viii) $V_{RMS} = \sqrt{\frac{V_1^2 + V_2^2 + V_3^2}{n}}$

(ix) $V_{AVE} = V_M \times 0{,}637$

(x) $V_{RMS} = V_M \times 0{,}707$

(xi) Form factor = $\frac{RMS\ value}{AVE\ value}$

(xii) Crest factor = $\frac{Maximum\,value}{RMS\ value}$

(xiii) $\omega = 2\pi f$

(xiv) $X_C = \frac{1}{2\pi fC}$

(xv) $X_L = 2\pi fL$

(xvi) $V_T = \sqrt{V_R^2 + V_L^2}$

(xvii) $V_T = \sqrt{V_R^2 + V_C^2}$

(xviii) $V_T = \sqrt{V_R^2 + (V_L \simeq V_C)^2}$

(xix) $Z = \sqrt{R^2 + X_C^2}$

(xx) $Z = \sqrt{R^2 + X_L^2}$

(xxi) $Z = \sqrt{R^2 + (X_L \simeq X_C)^2}$

(xxii) $I_T = \frac{V_T}{Z}$

(xxiii) $V_C = I_T \times X_C$

(xxiv) $V_R = I_T \times R$

(xxv) $V_L = I_T \times X_L$

(xxvi) $\theta = Cos^{-1}\frac{R}{Z}$

(xxvii) $fo = \frac{1}{2\pi\sqrt{LC}}$

MEASURING INSTRUMENTS

(i) $R_{SH} = \frac{I_M \times R_M}{I_{SH}}$

(ii) $R_S = \frac{V_T}{I_M} - R_M$

TRANSISTORS

(iii) $I_e = I_c + I_b$

DECIBEL RATIOS

(iv) $N = 10\log\frac{P_0}{P_1}$

(v) $N = 20\log\frac{I_0}{I_1} + 10\log\frac{R_0}{R_1}$

(vi) $N = 20\log\frac{V_0}{V_1} + 10\log\frac{R_1}{R_0}$

If/As $R_1 = R_0$

(vii) then $N = 20\log\frac{I_0}{I_1}$

(viii) $N = 20\log\frac{V_0}{V_1}$

(ix) RESISTANCE

$R = \frac{p\ell}{a}$

(x) $a = \frac{\pi d^2}{4}$

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MARKING GUIDELINE

NATIONAL CERTIFICATE

APRIL EXAMINATION

INDUSTRIAL ELECTRONICS N2

31 MARCH 2016

This marking guideline consists of 9 pages.

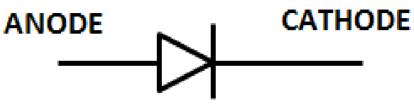
QUESTION 1

1.1 True
1.2 True
1.3 True
1.4 True
1.5 True

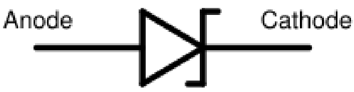
(5 x 1) **[5]**

QUESTION 2

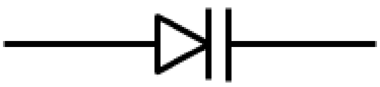
2.1



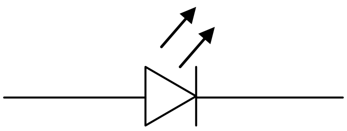
2.2



2.3



2.4



(4 x 1) **[4]**

QUESTION 3

3.1 3.1.1 (a) $R_{s1} = R_5 + R_6$

$= 16 + 45$

$= 61\,\Omega$ ✓

(b) $\frac{1}{R_{p1}} = \frac{1}{R_3} + \frac{1}{R_{s1}} + \frac{1}{R_7}$

$= \frac{1}{10} + \frac{1}{61} + \frac{1}{18}$ ✓

$= 0\,172$ ✓

$= R_{p1} = 5{,}816\ \Omega$ ✓

(c) $R_{s2} = R_{p1} + R_4$

$= 5{,}816 + 40$ ✓

$= 45{,}816\ \Omega$ ✓

(d) $R_{p2} = \frac{R_{s2} \times R_2}{R_{s2} + R_2}$

$= \frac{45{,}816 \times 15}{45{,}816 + 15}$

$= 11{,}3\,\Omega$ ✓✓

(e) $R_T = R_1 + R_{P2}$

$= 30 + 11{,}3$ ✓

$= 41{,}3\,\Omega$ ✓

(11)

3.1.2 $I_T = V_T/R_T$

$=2/41{,}3$ ✓

$= 48{,}426$ mA ✓

(2)

3.1.3 $P = I^2 \times R$
$= (48,426 \times 10^{-3})^2 \times 30$ ✓
$= 0,07$ w ✓
(2)

3.2 $I_1 + I_{R3} + I_{R4} = I_{R2}$✓
$I_1 = I_{R2} - (I_{R3} + I_{R4})$ ✓
$= 3,1 \times 10^{-3} - (2 \times 10^{-3} + 0,6 \times 10^{-3})$✓
$= 3,1 \times 10^{-3} - (2,6 \times 10^{-3})$✓
$= 0,5$ mA✓ (5)
[20]

QUESTION 4

4.1 Frequency = 50 Hz✓
Voltage = 220 V – 240 V✓ (220V is acceptable) (2)

4.2 The form factor of a wave refers to ratio of the RMS value relative to the average of the wave while the crest factor refers to ratio of the maximum value to the RMS value of the wave. ✓✓ (2)

4.3 4.3.1 $X_c = \frac{1}{2\pi FC}$

$C = \frac{1}{2\pi F X_C}$ ✓

$C = \frac{1}{2\pi \times 50 \times 13,3}$ ✓

$C = 239,33 \times 10^{-6} F$ ✓ (3)

4.3.2 $X_L = 2\pi FL$

$= 2\pi(50)(20 \times 10^{-3})$ ✓

$= 6,283\,\Omega$ ✓ (2)

4.3.3 $Z_T = \sqrt{R^2 + (X_L - X_C)^2}$ ✓

$= \sqrt{20^2 + (13{,}3 - 6{,}283)^2}$ ✓

$= 21{,}195\,\Omega$ ✓ (3)

4.3.4 $I_T = \frac{V_T}{Z_T}$

$= \frac{110}{21{,}195}$ ✓

$= 5{,}189\text{ A}$ ✓ (2)

4.3.5 $V_R = I_T R$

$= 5{,}189 \times 20$ ✓

$= 103{,}780\text{ V}$ ✓ (2)

4.3.6 $V_L = I_T \times X_L$

$= 5{,}189 \times 6{,}283$ ✓

$= 32{,}602\text{ V}$ ✓ (2)

4.3.7 $\theta = \cos^{-1}\frac{R}{Z}$

$= \cos^{-1}\frac{20}{21{,}195}$ ✓

$= 19{,}333^\circ$ ✓ (2)

[20]

QUESTION 5

5.1 5.1.1 Using an instrument as an ammeter

$I_{SH} = I_T - I_M$ ✓

$= 2 - 10 \times 10^{-3}$ ✓

$= 1{,}99\ A$ ✓

Then

$R_{SH} = \frac{I_M \times R_M}{I_{SH}}$

$= \frac{10 \times 10^{-3} \times 5}{1{,}99}$ ✓

$= 25 \times 10^{-3}\ \Omega$ ✓ (5)

5.1.2 Using an instrument as a voltmeter

$I_M = I_{SH}$

$R_S = \frac{V_T}{I_M} - R_M$ ✓

$= \frac{12}{10 \times 10^{-3}} - 5$ ✓

$= 1{,}195\ k\Omega$ ✓ (3)

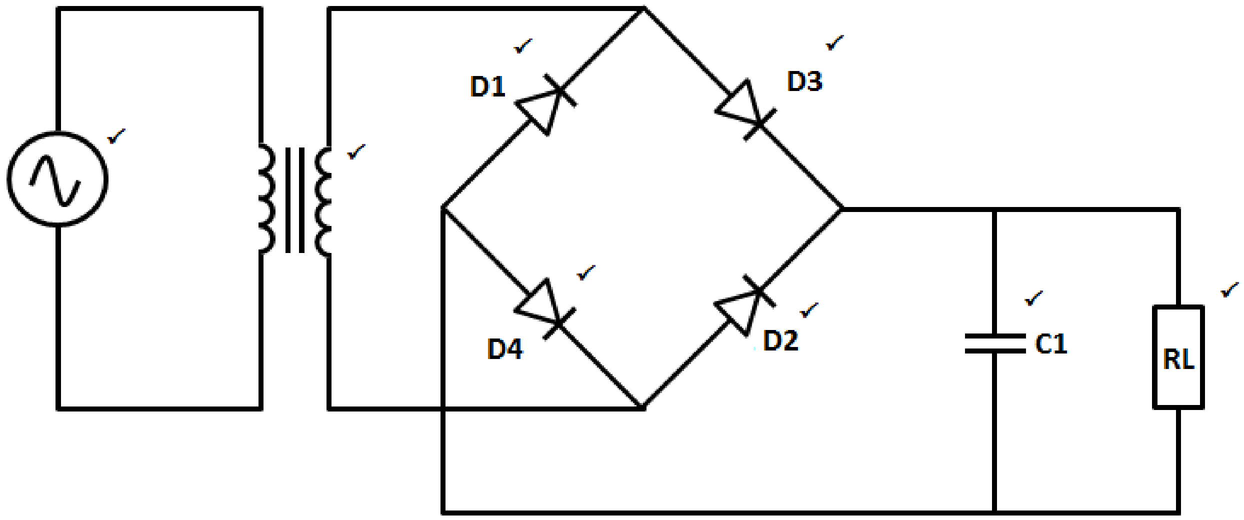
5.2
- Electromagnetic damping
- Mechanical damping (2)

[10]

QUESTION 6

6.1
- The anode terminal is heavily doped with P-type material, wherein trivalent impurity atoms are added to pure intrinsic semiconductor material.
- The cathode terminal is heavily doped with N-type material, wherein pentavalent impurity atoms are added to pure intrinsic semiconductor material. (2 x 2) (4)

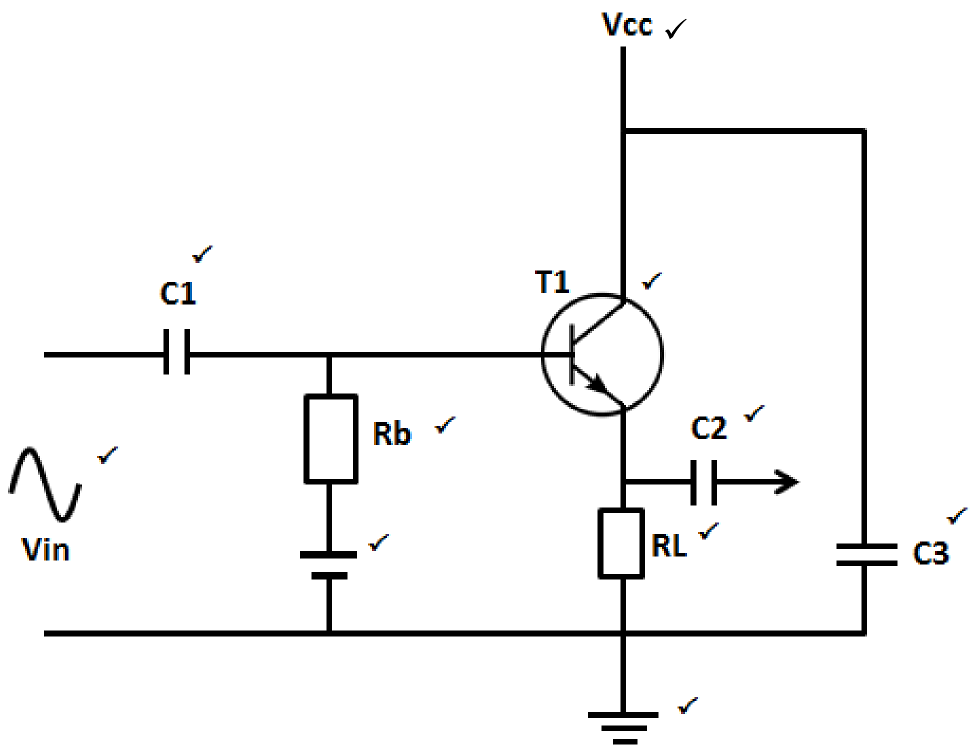
6.2



(one full mark per diode, half marks for the other components) (6)
[10]

QUESTION 7

7.1



(Each tick = half a mark) (5)

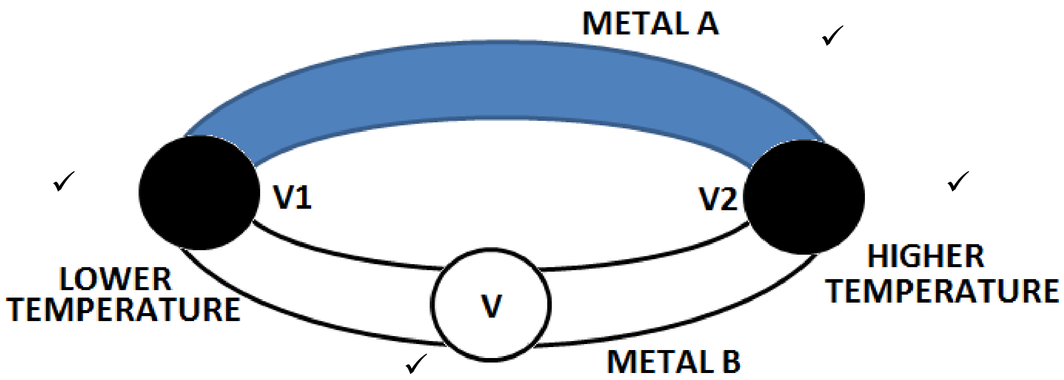
7.2
- Collector current✓
- In terms of magnitude, the collector current of a common emitter transistor amplifier configuration is much larger in value than the corresponding base current, such that the base current is in the order of micro-amperes while the collector current is in the order of milliamperes.✓✓ (3)

7.3
- Class A
- Class B
- Class C (3)

[11]

QUESTION 8

8.1



- When a temperature difference exists between the hot and cold junctions, a potential difference is produced (V2-V1) ✓ , causing a current flow✓
- When the meter is connected as shown, the meter reading will be proportional to the difference in temperature between the hot and cold junctions✓ (7)

8.2
- Positive temperature coefficient – The resistance of a material increases with an increase in temperature.
- Negative temperature coefficient – The resistance of a material decreases with an increase in temperature. (2 x 2) (4)

8.3
- The controlling shaft and the controlled shaft can be very far apart. ✓
- Contact between the systems can be through wires, radio or telemetering.✓
- A synchro system uses very little electrical energy compared to the energy used by a mechanical system. ✓ (3)

[14]

QUESTION 9

9.1 $P_{IN} = \frac{V_{IN}{}^2}{R_{IN}}$

$= \frac{(6,6)^2}{7,6}$ ✓

$= 5,732\ W$ ✓

9.2 $P_{OUT} = I_{OUT}{}^2 \times R_{OUT}$

$= (5,6)^2 \times 7,6$ ✓

$= 238,336\ W$ ✓

9.3 $N = 10 Log \frac{P_{OUT}}{P_{IN}}$

$= 10 Log \frac{238,336}{5,732}$ ✓

$= 16,189\ dB$ ✓

(3 x 2) **[6]**

TOTAL: 100

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