UNIVERSITY OF ALASKA FAIRBANKS

COLLEGE OF ENGINEERING AND MINES
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

COURSE CODE	EE F102 F01 (CRN: 34544)
COURSE NAME	INTRODUCTION TO ELECTRICAL AND COMPUTER ENGINEERING
SEMESTER	SPRING
YEAR	2022
TYPE AND NUMBER OF SUBMISSION	HOMEWORK 1
METHOD OF SUBMISSION	ONLINE TO : maher.albadri@alaska.edu
DATE OF ASSIGNMENT	THURSDAY 13 JAN 2022

DUE DATE OF SUBMISSION	FRIDAY 21 JAN 2022	**DUE TIME OF SUBMISSION**	23:59

STUDENT NAME	Jacob Guenther

MAKE THIS FORM A "COVER PAGE" FOR YOUR HOMEWORK SUBMISSION.

FOR THE TA USE ONLY

REMARKS:

FOR THE TA USE ONLY

PROBLEM NUMBER	MAXIMUM POINTS POSSIBLE	POINTS EARNED
PROBLEM 1	75	
PROBLEM 2	75	
TOTAL	150	

1 Problem HW-1-1

(a) 500 N force is used to move an object over a distance of 1000 cm. Calculate the energy, in kJ, required to do this work. 15pts

Note:

$$1\text{m} = 100\text{cm} \tag{1}$$

$$\text{J} = \text{N} \cdot \text{m} \tag{2}$$

$$1\text{kJ} = 1000\text{J} \tag{3}$$

Solution:
Convert cm to m using equation (1).

$$1000\text{cm} \cdot \frac{1\text{m}}{100\text{cm}} = 10\text{m}$$

Calculate energy in J using equation (2).

$$500\text{N} \cdot 10\text{m} = 5000\text{J}$$

Convert J to kJ using equation (3).

$$5000\text{J} \cdot \frac{1\text{kJ}}{1000\text{J}} = 5\text{kJ}$$

Answer: The energy required to move the object is **5kJ**.

(b) 5kJ of energy is utilized to move an object a distance of 10 m. Calculate the applied force, in newtons (N). 15pts

Solution:

Convert kJ to J using equation (3).

$$5\text{kJ} \cdot \frac{1000\text{J}}{1\text{kJ}} = 5000\text{J}$$

Calculate force in N using equation (2).

$$5000\text{J}/10\text{m} = 500\text{N}$$

Answer: The force applied to the object is **500N**.

(c) How many significant digits are in the following numbers: 15pts

1. 69.00056 m
2. 0.01225600 ft
3. 123.80000 in
4. 1.0×10^2 J

Note:

- All non-zero digits (1-9) are significant[1].
- Zeros that have any non zero digit anywhere to the left of them are considered significant zeros[1].
- All other zeros are not considered significant[1].

Answer

1. 69.00056 m has **7** significant digits. All of the digits are significant.
2. 0.01225600 ft has **7** significant digits. The two leading zeros are not significant.
3. 123.80000 in has **8** significant digits. All of the digits are significant.
4. 1.0×10^2 J has **2** significant digits. Both digits are significant.

(d) Three methods were used to measure a 5 Ω resistor. Each measurement was repeated 4 times and tabulated in the following table. Determine the method with the highest accuracy. You can use a spreadsheet tool to perform quick calculations. 15pts

Table 1: Measured Values

Method I (Ω)	Method II (Ω)	Method III (Ω)
5.0041	5.0022	5.1012
5.0151	5.0011	5.1112
5.0991	5.0101	5.1023
5.0261	5.0041	5.1022

Note:

$$\text{absolute error} = |x - x_i| \tag{4}$$

Solution:

Table 2: Absolute error using equation (4)

	Method I (Ω)	Method II (Ω)	Method III (Ω)
sample 1	0.14440	0.00220	0.10120
sample 2	0.01510	0.00110	0.11120
sample 3	0.09910	0.01010	0.10230
sample 4	0.02610	0.00410	0.10220
total error	0.14440	0.01750	0.41690

Answer: Method II has the smallest absolute error so method II is the most accurate.

(e) In the previous problem, determine which method has the highest precision. 15pts

Note:

$$\text{range} = x_{max} - x_{min} \tag{5}$$

Mean

$$\mu = \frac{\Sigma x_i}{N} \tag{6}$$

Deviation

$$\text{deviation} = (x_i - \mu)^2 \tag{7}$$

Sample variance

$$\sigma^2 = \frac{1}{N-1}\Sigma(x_i - \mu)^2 \tag{8}$$

Sample standard deviation

$$\sigma = \sqrt{\sigma^2} \tag{9}$$

`https://en.wikipedia.org/wiki/Standard_deviation`

Solution:

Table 3: Range using equation (5)

	Method I (Ω)	Method II (Ω)	Method III (Ω)
min	5.0041	5.0011	5.1012
max	5.0991	5.0101	5.1112
range	0.095	0.009	0.01

We can also use sample variance or sample standard deviation to measure precision. To calculate standard deviation first calculate the mean.

$$\begin{aligned}\mu_I &= \frac{5.0041 + 5.0151 + 5.0991 + 5.0261}{4} \\ &= 5.0361 \\ \mu_{II} &= \frac{5.0022 + 5.0011 + 5.0101 + 5.0041}{4} \\ &= 5.004375 \\ \mu_{III} &= \frac{5.1012 + 5.1112 + 5.1023 + 5.1022}{4} \\ &= 5.004375\end{aligned}$$

Table 4: Standard deviation using equations (7), (8), and (9)

	Method I	Method II	Method III
sample 1 deviation	0.001024	4.7306E-06	9.1506E-06
sample 2 deviation	0.000441	1.0726E-05	4.8651E-05
sample 3 deviation	0.003969	3.2776E-05	3.7056E-06
sample 3 deviation	0.0001	7.5625E-08	4.1006E-06
sample variance	0.0018447	1.6103E-05	2.1869E-05
sample standard deviation	0.042950	0.0040128	0.0046764

Answer: Method II is the most precise. Method II has the smallest range of values and the smallest sample standard deviation. Method III is nearly as precise as method II.

2 Problem HW-1-2

(a) Determine the result to the correct number of significant digits for the following computations: 25pts

1. $0.0012584 \cdot 50.1 =?$

$$\begin{aligned} 0.0012584 \cdot 50.1 &= 0.06304584 \\ &= 0.0630 \end{aligned}$$

2. $(5.0 \cdot 105)/40.1 =?$

$$\begin{aligned} (5.0 \cdot 105)/40.1 &= 13.09226932668 \\ &= 13 \end{aligned}$$

3. $55.685 + 3.2 - 7.01 =?$

$$\begin{aligned} 55.685 + 3.2 - 7.01 &= 51.875 \\ &= 51.9 \end{aligned}$$

(b) Fill out the right column with the correct value that match the unit shown in the column title 25pts

feet	in
5	60

Note:

$$1\text{ft} = 12\text{in} \tag{10}$$

Solution:

$$5\text{ft} \cdot \frac{12\text{in}}{1\text{ft}} = 60\text{in}$$

kilometer	mile
5	3.106855961

Note:

$$1\text{km} = 0.6213711922\text{miles} \tag{11}$$

Equation (11) is an approximation.
Assumptions: 5km is exact.
Solution:

$$5\text{km} \cdot \frac{0.6213711922\text{miles}}{1\text{km}} = 3.106855961\text{miles}$$

Ω	mΩ
0.35	350

Note:

$$1\Omega = 1000\text{m}\Omega \tag{12}$$

Solution:

$$0.35\Omega \cdot \frac{1000\text{m}\Omega}{1\Omega} = 350\Omega$$

volt	kilovolt
120	0.12

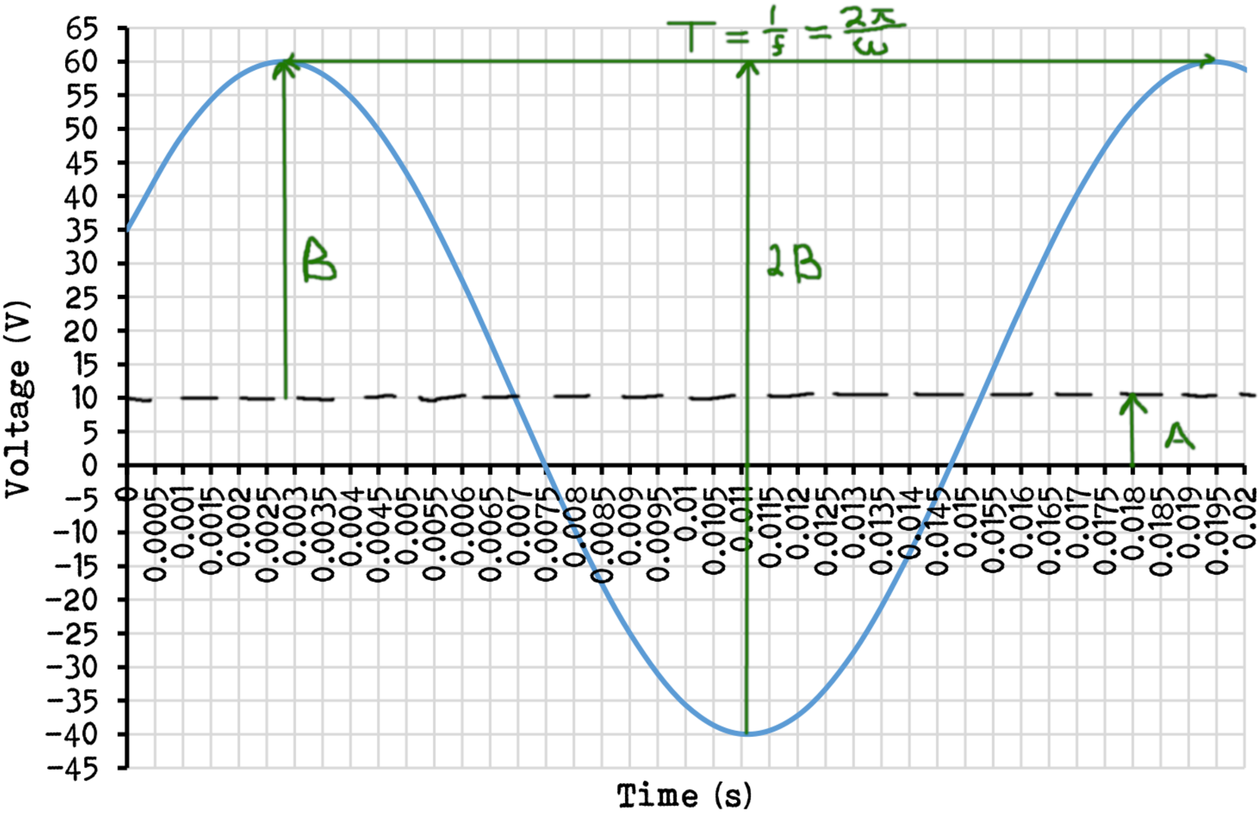
Note:

$$1\text{V} = 1000\text{kV} \tag{13}$$

Solution:

$$120\text{V} \cdot \frac{1000\text{kV}}{1\text{V}} = 0.12\text{kV}$$

(c) Determine the value of the DC offset "A", in volts, the amplitude "B", in volts, the period "T", in seconds, and the phase angle "Φ", in radians, of the voltage signal seen in the following figure. 25pts



Note:

$$v(t) = \mathrm{A} + \mathrm{B}sin(\omega t + \Phi) \tag{14}$$

$$max_V = 60\mathrm{V}$$

$$min_V = -40\mathrm{V}$$

$$v(0) = 35\mathrm{V}$$

Assumptions:

$$t_1 = 0.003\mathrm{s}$$

$$t_2 = 0.0195\mathrm{s}$$

Its unclear where the peaks are exactly.
Solution:

Determine B

$$\begin{aligned}\mathrm{B} &= \frac{max_V - min_V}{2}\\ &= \frac{60\mathrm{V} - (-40\mathrm{V})}{2}\\ &= 50\mathrm{V}\end{aligned}$$

Determine A

$$\begin{aligned}\mathrm{A} &= \frac{max_V + min_V}{2}\\ &= \frac{60\mathrm{V} - 40\mathrm{V}}{2}\\ &= 10\mathrm{V}\end{aligned}$$

Determin T

$$\begin{aligned}\mathrm{T} &= t_2 - t_1\\ &= 0.0195\mathrm{s} - 0.003\mathrm{s}\\ &= 0.0165\mathrm{s}\end{aligned}$$

Determin Φ

$$\begin{aligned}
v(t) &= \mathrm{A} + \mathrm{B}sin(\omega t + \Phi) \\
\frac{v(t) - \mathrm{A}}{\mathrm{B}} &= sin(\omega t + \Phi) \\
\omega t + \Phi &= sin^{-1}(\frac{v(t) - \mathrm{A}}{\mathrm{B}}) \\
\Phi &= sin^{-1}(\frac{v(t) - \mathrm{A}}{\mathrm{B}}) - \omega t \\
&= sin^{-1}(\frac{35\mathrm{V} - 10\mathrm{V}}{50\mathrm{V}}) - 380.8\mathrm{rad/s} \cdot 0\mathrm{s} \\
&= sin^{-1}(\frac{1}{2}) \\
&= \frac{\pi}{6}
\end{aligned}$$

Answer:

- A = 10 V
- B = 50 V
- T = 0.065 s
- $\Phi = \frac{\pi}{6}$

3 References

[1] Denise Thorsen, Maher Al-Badri, INTRODUCTION TO ELECTRICAL AND COMPUTER ENGINEERING, University of Alaska Fairbanks, 2022.