Task1 : Pass Grade – P2.1

Your supervisor forwarded to you the following problems requiring graphical sketching solutions as demanded by the clients:

(A) One of the most important parameters of an amplifier is the amount of amplification or *gain* that it provides. Gain is simply the ratio of output voltage to input voltage or output current to input current. The voltage gain can be expressed in decibels (dB) as:

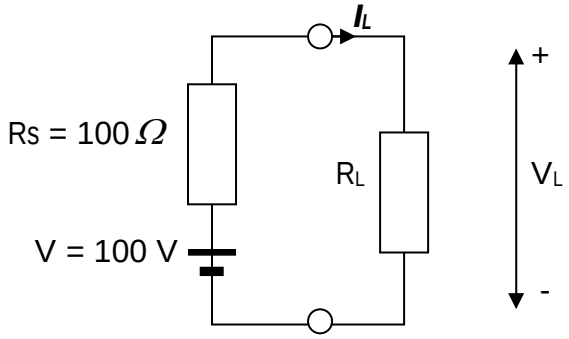
$$A_{V(dB)} = 20\log_{10}\left(\frac{V_0}{V}\right)$$

Where V_0 and V are output and input signal voltages respectively.

Your client is a local telephone company who asked you to solve the following problem using **graphical estimation techniques**:

A telephone line amplifier provides a voltage gain of **6 dB**. Determine the input signal voltage required to produce an output of **4 V**.

(B) A source consists of a 100 V battery having an internal resistance ***Rs*** of $100\,\Omega$. A Load resistance R_L is connected to this source as shown in the following figure:



You were asked to answer the following questions:

1. Find an expression for the power P_L received by R_L in terms of ***V***, ***Rs*** and R_L.
2. Plot the graph of P_L against R_L and use the graph to determine the maximum power received by the load resistance.

(C) Sketch the graphs of

$$v_1 = 10\sin\left(100\pi t + \frac{\pi}{4}\right)$$

and $$v_2 = 5\sin\left(200\pi t - \frac{2\pi}{3}\right)$$

on the same axes and hence sketch the graph of $v_3 = v_1 + v_2$

then use the graph to estimate the peak-to-peak voltage (v_{pp}) for v_3.

(This feedback sheet must be completed by the ASSESSOR where appropriate)

Task2 : Pass Grade – P2.2

You were asked to estimate and determine some engineering parameters from the following data presentations :

(A) Consider the graph of the *universal resonance curve* which can be used for any value of the Q-factor :

The horizontal axis shows values of α where $\alpha = Q \times \frac{\Delta f}{f_0}$

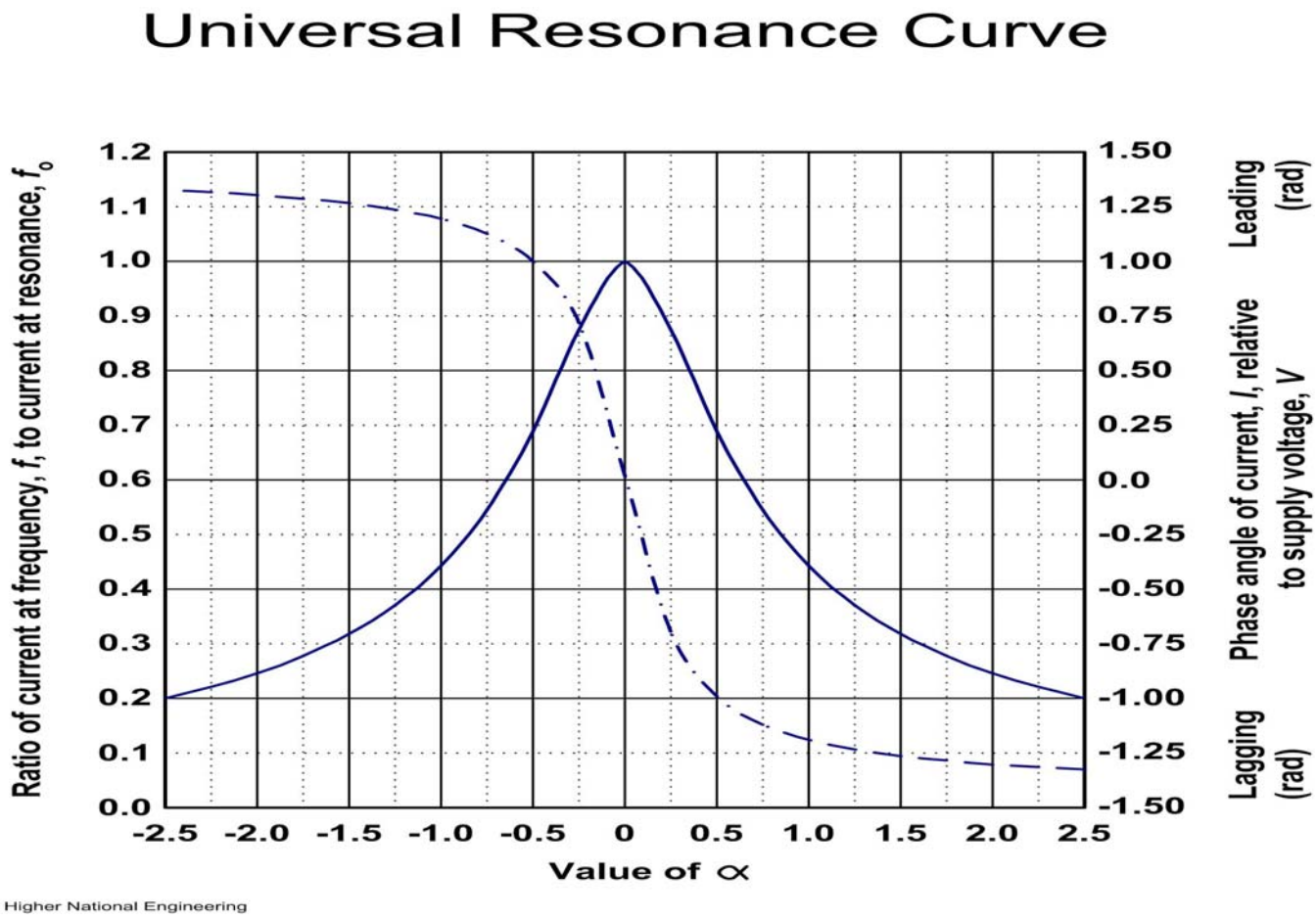


Fig. 1. universal resonance curve
Source Higher National Engineering

Where Q is the Q-factor of the circuit ($Q = \omega L / R$) , Δf is the deviation from the resonant frequency , f_0 .

You were asked to answer the following question:

A tuned circuit has a Q-factor of **10** and a resonant frequency of **100kHz**. If the current at resonance is **100 mA** , use the universal resonance curve to determine the current and phase angle at **102.5 kHz** .

(This feedback sheet must be completed by the ASSESSOR where appropriate)

(B) For a grounding system to be safe, the maximum touch and step voltages should not exceed postulated safety criteria. The method presented in this problem is applicable to the safety criteria of the IEEE Standard 80 as well as the 1EC-479-1. Both standards define safety criteria in terms of allowable body current $i_{b,allowable}$.

The allowable body current is then translated into the allowable touch and step voltages. Thus, safety assessment of a grounding system is referred to a procedure by which the actual maximum touch and step voltages are computed and compared to the maximum allowable (safe) touch and step voltages.

The actual body current is determined by the following equation:

$$V_{touch} = V_b + r_{eq}\, i_b$$

Table 1. Electrical Shock Model Differences between IEEE Std 80 and IEC-479-1

	IEEE Std 80	**IEC 479- 1**
Body Resistance r_b	**1000** Ω	Voltage dependent and Path dependent
Thevenin Equivalent Resistance r_{eq}	$1.5 C_S \rho_S$ for touch voltage $6.0 C_S \rho_S$ for step voltage	No Guidance
Thevenin Equivalent Voltage	Use of computer models is suggested	No Guidance
Permissible body voltage $V_{touch,allowable}$	$0.1116\ (r_{eq} + r_b)/\sqrt{t}$ for 50 kg person $0.157\ (r_{eq} + r_b)/\sqrt{t}$ for 70 kg person	Independent of human size

Note: Cs is the reduction factor , ρ_s is the resistivity of the surface material (Ω .m) and t is the duration of electric shock in seconds(s).

Use **Table 1** to solve the following problem referred to your company by a substation manager:

The grounding of a substation consists of a mesh ground mat buried in soil. A gravel layer of 2000 ohmmeter resistivity covers the substation area. The actual touch voltage has been computed to be **390 volts**. The maximum fault duration is 24 cycles **(0.40 seconds)**.

You were asked to answer the following questions:

1. Determine whether the voltage is below allowable, per IEEE Std 80 given that the reduction factor C_S **= 0.572 , V_b =175 volts** and $i_{b,allowable}$ **= 150 mA** .

2. Compute the maximum allowable touch voltage per IEEE Std 80.

(This feedback sheet must be completed by the ASSESSOR where appropriate)

(C) One of the clients, a railway company, is having a difficulty to use algebraic methods in solution of railway problems involving the characteristics of the motive power , principally because it is impossible to obtain a satisfactory general equation for the curves of an engine or motor of any specified type.

The performance characteristics of a railway motor are ordinarily furnished by the manufacturer for the normal potential and are usually assumed to be accurate under such conditions. Often it is desirable to find the motor performance when abnormal potential is impressed on the terminals, since in practice the line pressure is subject to wide fluctuations, and the motors are always operating at subnormal potential while the controller is being turned to the full-speed position.

Your supervisor came up with the following diagram for obtaining motor speeds at different potentials (Fig. 2.) :

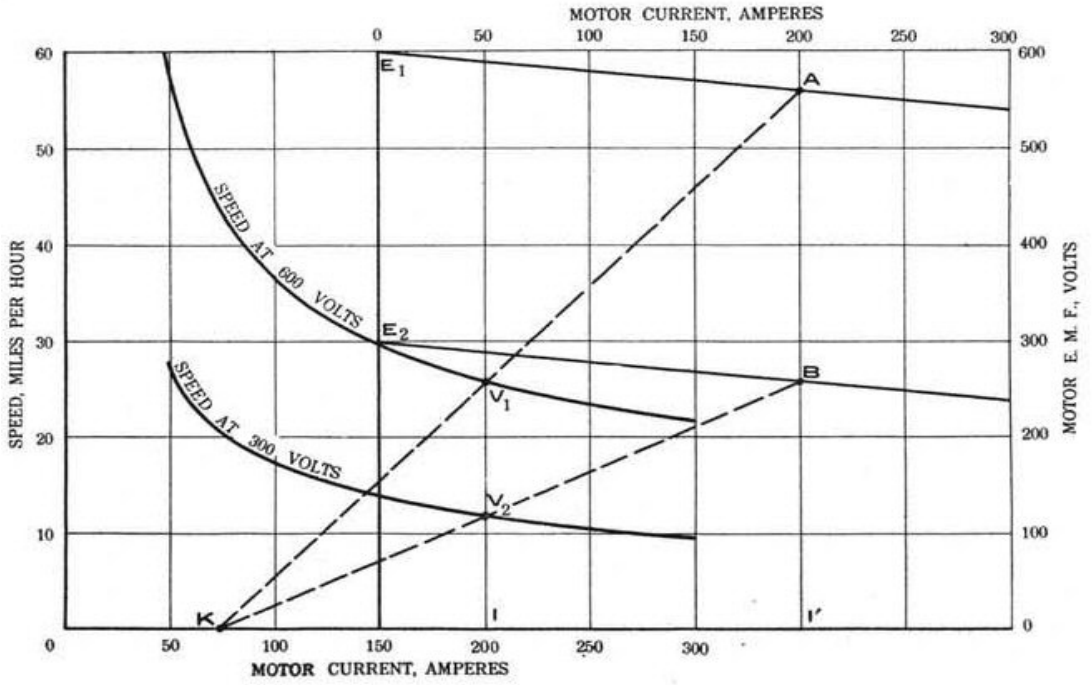


FIG. 2. CONSTRUCTION FOR OBTAINING MOTOR SPEEDS AT DIFFERENT POTENTIALS.

Source K M Yung Electrical railways

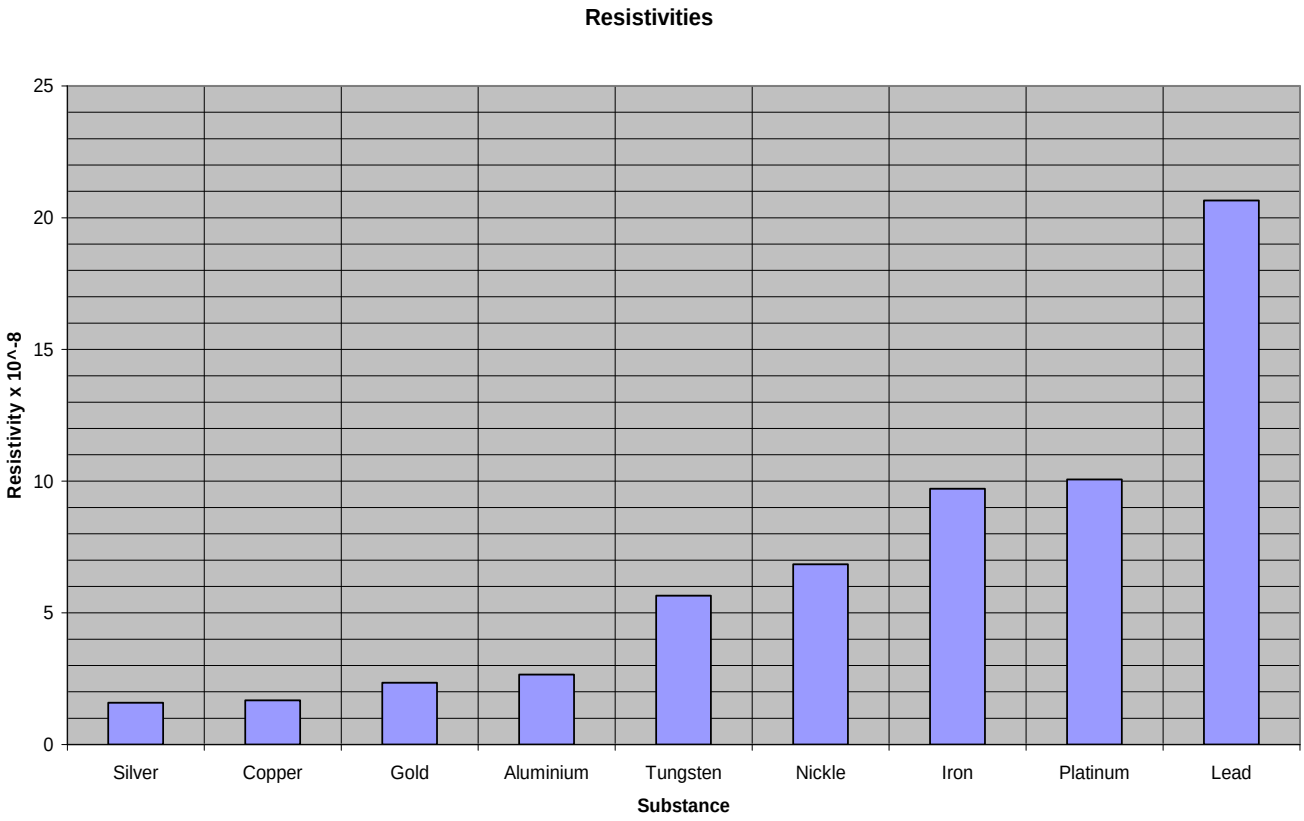
The speeds of the motor at the terminal pressure E_1 and E_2 at the same current ***I*** are represented by the ordinates V_1 and V_2 respectively.

You were asked to answer the following question:

Use the above diagram to estimate the percentage change between the speeds at **300 volts** and **600 volts**.

(This feedback sheet must be completed by the ASSESSOR where appropriate)

(D) The following chart shows the resistivities $\rho = R\frac{A}{l}$ of some substances (x 10^{-8}) at 20^0 C



You were asked to answer the following questions:

1. Use the above chart to estimate the values of ρ for each substance. Construct a table showing your estimates for each substance.

2. A wire of length $l = 1.7$ m and cross-sectional area $A = 1.8 \times 10^{-6}$ m² has a resistance of $R = 6.46 \times 10^{-2}\,\Omega.m$ .This material is one of those appeared in the chart. Which one? Justify your answer.

(This feedback sheet must be completed by the ASSESSOR where appropriate)

Task3 : Pass Grade – P2.3

(A) The distance covered by an electron from $t = 8$ to $t = 30$ is given by

$$x = \int_{8}^{30} \left(2000 \ln \left[\frac{140000}{140000 - 2100t} \right] - 9.8t \right) dt$$

Find the approximate value of x :

1. Using Simpson's Rule.
2. Using the mid-ordinate method.

(B) The electric current charging a capacitor is related to time by the following Law:

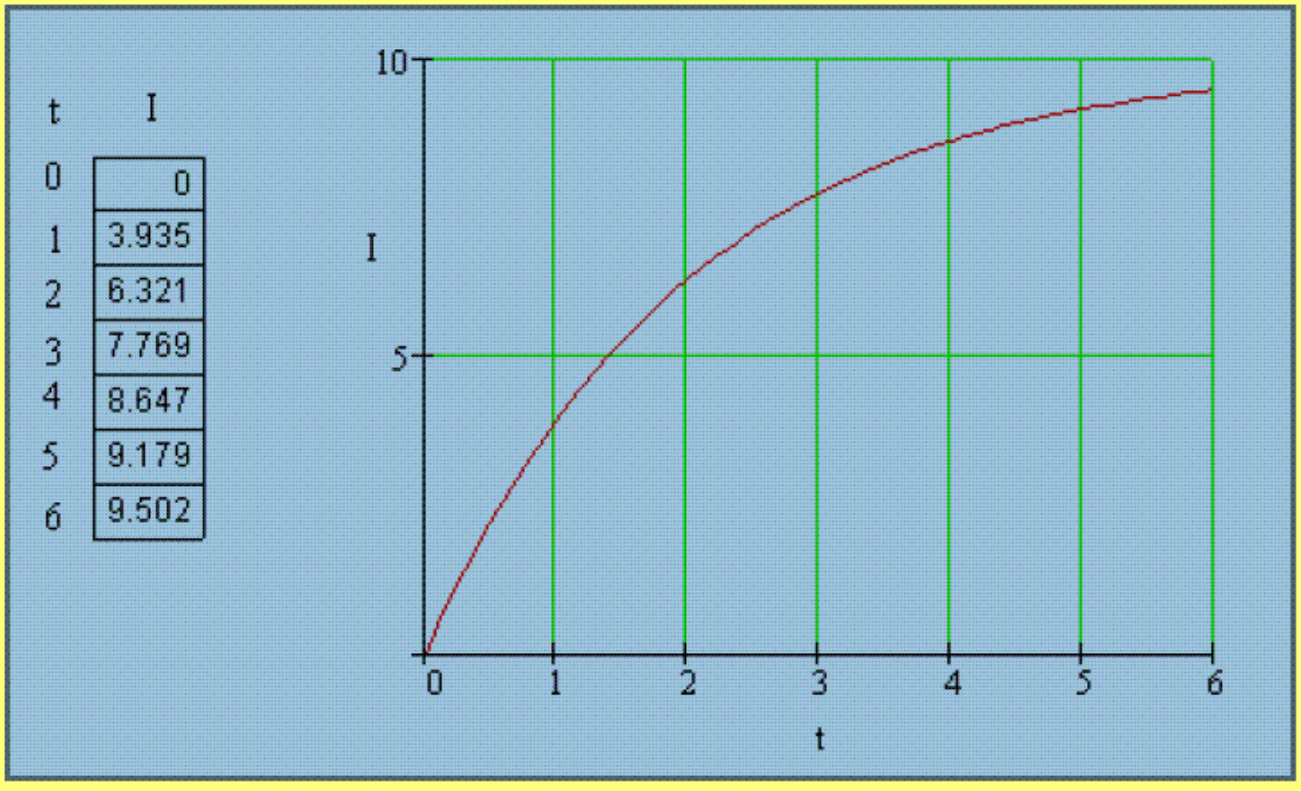
$$I = 10(1 - e^{\frac{-t}{2}}) \text{ Amperes}$$

Determine the approximate value of the charge **Q** (the area under the graph)

Between the limits **t = 0** and **t = 6** seconds using :

1. The **trapezoidal rule** .(graph and the ordinates are calculated for you below)
2. Direct integration using calculus.

t	I
0	0
1	3.935
2	6.321
3	7.769
4	8.647
5	9.179
6	9.502



(This feedback sheet must be completed by the ASSESSOR where appropriate)

Task4 : Pass Grade – P2.4

(A) The equation that gives the heat x of a certain current is given by

$$x^3 - 0.165x^2 + 3.993\times10^{-4} = 0$$

Find the heat current x using the following methods of finding roots of equations, conducting **three iterations** to estimate the root of the above equation in both of the following methods:

1. Using the bisection method with $0 \le x \le 0.11$

2. Using the Newton-Raphson method.

(B) In an experiment to verify Ohm's law, the voltage and current acting on a resistor were measured and the following results obtained:

V	0	2	4	6	8	10
I	0	0.19	0.42	0.62	0.72	0.92

Assuming the law should be linear, find the best fit straight line law using linear regression.