**Question 1**

a) Draw the circuit diagram of an inductance L and capacitor C in parallel and derive a formula for the equivalent impedance. [4 Marks]

b) Explain what happens to the parallel circuit at resonant frequency. [4 Marks]

c) Draw the circuit diagram of a radio receiver input stage consisting of an aerial, inductor, variable capacitor and an earth. [4 Marks]

d) If the inductor used in part 3 of this question is 1 µH what value capacitor will tune to 102.4 MHz? [4 Marks]

e) What is the equivalent impedance of an inductor and capacitor in series? [1 Mark]

f) Explain what happens to the impedance of an LC series circuit at resonant frequency? [3 Marks]

g) A 50 Hz 250 volt single phase AC electric motor has a DC resistance of 1.5Ω and a power factor of 0.96. What value of capacitor will give a power factor of 1.0? Should the capacitor be connected in series or parallel with the motor? [5 Marks]

**Question 2**

Explain the following:

(a) Peak Inverse Volts
(b) Thyristors, Diacs and Triacs
(c) Bridge rectifiers
(d) Integrated circuits
(e) Operational Amplifiers

[25 Marks]
Question 3

(a) Explain:-
   i) Kirchhoff’s current law
   ii) Kirchhoff’s voltage law

[2 Marks]

(b) Determine the voltage $V_x$. All equations etc must be clearly written down.

(c) Draw the circuit diagram of a Wheatstone Bridge and explain clearly how it works.

[10 Marks]
Question 4

a) A traditional automobile ignition system consists of a) 12 volt battery, b) ignition coil with primary and secondary windings, c) one capacitor, d) contact breakers, e) distributor, f) 4 spark plugs

i) Draw the circuit diagram of the ignition system [6 Marks]

ii) Explain clearly how the circuit generates sparks of several kV from the 12 volt battery. [6 Marks]

b) Explain how a transistor, a fly-wheel diode and an optical switch were used to eliminate the contact breakers and capacitor. [7 Marks]

c) Draw a block diagram of a modern micro processor based engine management system and explain the advantages over your answers to part a and part b of this question. [6 Marks]

Question 5

a) Write down the circuit symbol, governing equation (i.e voltage-current law), and normal SI units for:

i) Resistor
ii) Capacitor
iii) Inductor [3 Marks]

b) A 0.1mF capacitor and a 10kΩ resistor are connected in series across a 12V power supply. Calculate the time taken for the capacitor to fully charge. [4 Marks]

c) A 100mH inductor and 100kΩ resistor are connected in series across a 12V power supply. Sketch a graph of current through the resistor as a function of time. [4 Marks]

d) Draw the circuit diagram of an inverting operational amplifier, explain where the virtual earth is and explain how to calculate the amplifier gain. [14 Marks]
Question 6

(a) What is the most efficient method of generating and distributing large amounts of electrical power? [4 Marks]
(b) Why do most European railways use 25kV AC single phase overhead wires? [1 Mark]
(c) Why does the London Underground railway use 440V DC 4 rail? [1 mark]
(d) Sketch the torque-speed graph of a DC traction motor and explain how to start such a motor. [5 Marks]
(e) A diesel electric railway locomotive is rated at 2700 Horse Power. The locomotive has two 1500 Horse Power diesel engines, two 1000V DC generators and six DC traction motors.
   i) Calculate the maximum possible current in the motors. [5 Marks]
   ii) Should the motors be connected in series or parallel? [4 Marks]
   iii) Should the generators be connected in series or parallel? [4 Marks]

(f) Is this railway locomotive a new or old design? Explain your answer. [2 Marks]

Note: - 1 Horse Power = 746 watts

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