ELECTRONICS AND TELECOMMUNICATION ENGINEERING

PAPER - I

Time Allowed: 3 hours *Maximum Marks: 200*

INSTRUCTIONS

Candidates should attempt any FIVE questions.

Assume suitable data, if necessary, and indicate them clearly.

Values of the following constants may be used wherever necessary.

Electronic charge = -1.6×10^{-19} Coulomb.

Free space permeability = $4\pi \times 10^{-7}$ Henry/m.

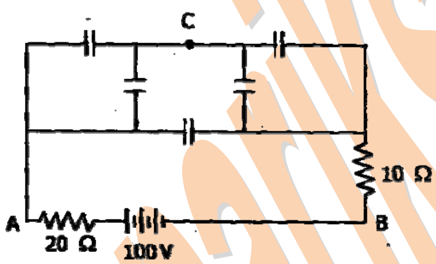
Free space permittivity = $(1/36\pi) \times 10^{-9}$ Farad/m;

Velocity of light in free space = 3×10^{8} m/sec.

Boltzmann constant = 1.38×10^{-23} Joule/K.

Planck's constant = 6.626×10^{-34} Joule.sec.

1. (a)



Derive the equation of a cylindrical capacitor in terms of the radii of core sheet and length. In the circuit given in the above figure find the potential difference between A and C and B and C, under steady state conditions.

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(b) In intrinsic Ga As, the electron and hole mobilities are 0.85 and 0.04 m^2/V-S respectively and corresponding effective masses are 0.068 mo and 0.5 mo respectively, where mo is the rest mass of an electron. If the energy gap of Ga As at 300^0 K is 1.43 eV, calculate the intrinsic carrier concentration and conductivity. mo 9.11×10^{-28} gm.

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(c) Derive the Clausius-Mossotti relation between atomic polarisability & dielectric constant for a dielectric material.

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2. (a) Sketch the variation of the density of states function, Fermi Dirac probability distribution function and electron and hole concentration for n-type silicon where $N_d = 10^{17}$/c.c. and $N_a = 10^{16}$/c.c. Write down the condition for charge neutrality in a compensated semiconductor at T = 300° K.

In an n-type semiconductor at T = 300^0 K, the electron concentration varies linearly from 2×10^{18} to 5×10^{17} per c.c. over a distance of 1.5 mm and the diffusion current density is 360 A/cm^2. Find the mobility of electrons.

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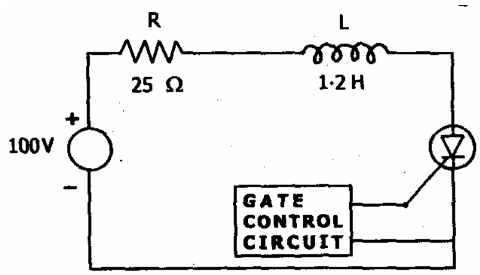
(b) Discuss the constructional features of a thyristor. Discuss how the two transistor equivalent of a thyristor can be used to explain the turn-ON switching. Mention why a controlled rectifier cannot be fabricated using Germanium.



The thyristor shown in the above figure has a holding current of 100 mA and a latching current of 250 mA. If the forward voltage drop across the thyristor from the instant of commencement of gate pulse is zero, then find the minimum value of gate pulse duration necessary to ensure turn-ON.

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(c) Draw and explain the drain and transfer characteristics of a p-channel enhancement type MOSFET. What is meant by threshold voltage ? Discuss three different ways by which the threshold voltage can be reduced.

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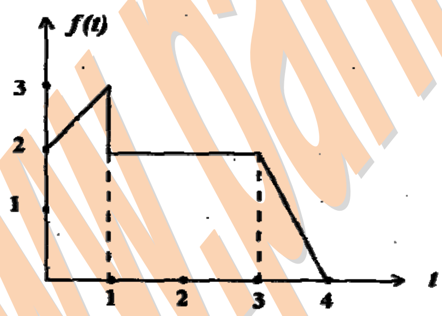
3. (a) Determine the convolution of the following pair of signals by means of the z-transform $x_1(n) = (1/4)^n u(n-1)$, $x_2(n) = \left[1 + \left(\frac{1}{2}\right)^n\right] u(n)$.

(b)



Express the signal of the above figure in terms of standard signals and hence determine the Laplace transform of the signal in the figure. State the properties of Laplace transforms used in this process.

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(c) State and prove time shifting property of Fourier Transforms.

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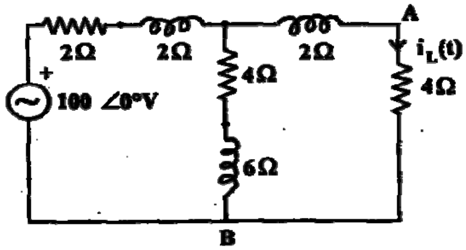
4. (a)



Derive the Thevenin equivalent circuit as seen from the terminal-pair (A, B), for the network shown in the above figure. Hence compute the current $i_L(t)$ and power P_L in the 4 ohm resistance.

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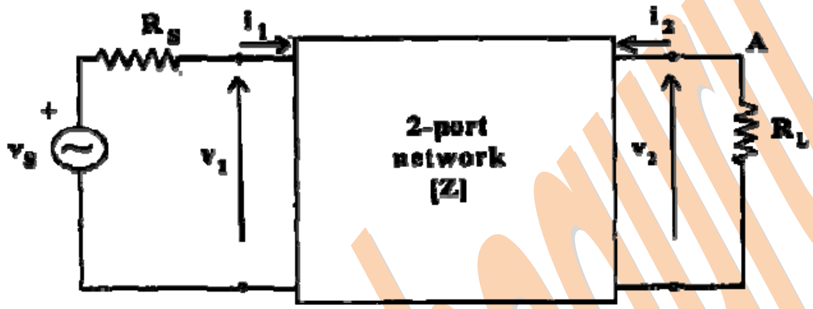

In the network shown in the above figure, the impedance matrix of 2-port is given as:

$$[Z]=\begin{bmatrix} \dfrac{2}{s+1} & \dfrac{1}{s+1} \\ \dfrac{1}{s+1} & \dfrac{6}{s+1} \end{bmatrix}$$

with $R_S = 2\Omega$ and $R_L = 1\Omega$.

Determine the zero-state response v_2 to a unit step input.

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(c) Draw an oriented graph whose node-to-branch incidence matrix A_a is given by:

$$A_a = \begin{bmatrix} 1 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & -1 & 1 & 0 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -1 & 1 & 0 & 0 & 0 & 1 \\ 0 & -1 & 0 & -1 & 0 & 1 & 0 & -1 & 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 1 & -1 \end{bmatrix}$$

and obtain fundamental circuit (tie-set) matrix for this graph.

5. (a) A uniform transmission line has constants $R = 24 \times 10^{-3}$ ohms/m, $G = 2.1 \times 10^{-6}$ ohms/m, $L = 1.5 \times 10^{-6}$. Henry/m and $C = 1.4 \times 10^{-9}$ Farads/m. Find the characteristic impedance of the transmission line at a frequency of 14 kHz.

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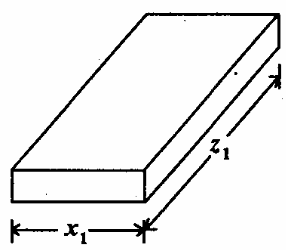
(b)



What is meant by the term cavity resonator? Write the expression for the resonant wavelength of a TE mode. Sketch the electric and magnetic field configurations in square wave cavity resonator with TE_{110} mode. Show also the variation of Ey and Hz field components across the centre line of the cavity.

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(c) Find the wavelength and phase velocity for propagation through copper at a frequency of 50 MHz if $\mu = 4\pi \times 10^{-7}$ Henry/m and σ = conductivity = 5.8×10^{7} mho/m.

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6. (a) A unity ratio d.c. Wheatstone bridge network has two matched resistive transducers working in push pull fashion and making two of the arms. Show that the bridge unbalance voltage is twice that of the bridge using only one transducer.

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(b) Draw the schematic diagram of a successive approximation ADC. Explain its working.

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(c) A resistive strain gauge with a gauge factor 2 is fastened to a steel bar subject to a stress of 1050 kg/cm^2. The modulus of elasticity of steel is 2.1×10^{6} kg/cm^2. Calculate the change in the resistance (ΔR) of the strain gauge element due to the applied stress.

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7. (a) What are vericap capacitors ? How does it vary with applied voltage? Determine the transition capacitance of a diffused junction vericap diode at reverse potential of 4.2 V, if $C_{(0)}$ = 80 pF and V_T=0.7 V.

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(b) Derive the equation for gauge factor of a resistive strain gauge in terms of Poisson ratio.

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(c) An alloyed junction is formed by melting a pellet of indium on to an n-type Si of conductivity 200 $(\Omega m)^{-1}$. If the conductivity of the alloyed regrown region is 3.6×10^{4} $(\Omega m)^{-1}$ and intrinsic carrier concentration of Si is 15×10^{16}/m^3, determine the built in voltage at 27°C. The mobility of electrons and holes are 0.135 and 0.048 m^2/V-S respectively.

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I.E.S-(Conv.)-2006

ELECTRONICS AND TELECOMMUNICATION ENGINEERING

PAPER - II

Time Allowed: 3 hours *Maximum Marks : 200*

Candidates should attempt Question No. I which is compulsory

and FOUR more questions taking TWO each from Section 'A' and Section 'B'

Assume suitable data, if required.

Some useful constants are given below :

Electron charge	: $e = 1.6 \times 10^{-19}$ Coulomb
Electron mass	: $M = 9.1 \times 10^{-31}$ kg
Planck's constant	: $h = 6.625 \times 10^{-34}$ J-s
Velocity of light	: $c = 3 \times 10^{8}$ m/s
Universal constant of gravitation	: $G = 6.668 \times 10^{-11}$ $m^3/kg\text{-}s^2$
Mass of earth	: $M = 5.997 \times 10^{24}$ kg
Radius of earth	: R = 6,378 km
Permeability of vaccum	: $\mu_0 = 4\pi \times 10^{-7}$ H/m
Permittivity of vaccum	: $\varepsilon_0 = 10^{-9}/36\pi$ F/m.

1. (a) For the circuits shown in Fig. 1 and Fig. 2, sketch and explain the output waveforms. Assume the diodes to be ideal.

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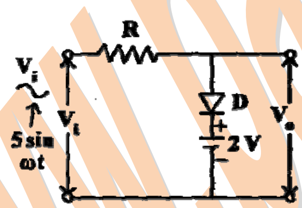

Fig. 1

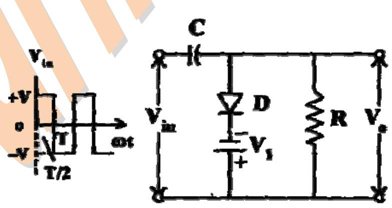

Fig. 2

(b) What do you understand by thermal resistance of a BJT? Explain its significance. To ensure thermal stability of a BJT, it is necessary that $V_{CE} < 1/2\ V_{CC}$. Justify by drawing the load line and the constant power curves of the BJT.

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(c) Use the K-map to simplify the expression

$$x = \bar{A}\bar{B}\bar{C} + \bar{B}C + \bar{A}B$$

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(d) An analog voltage signal whose highest significant frequency is 1 kHz is to be digitally encoded with a resolution of 0.0l percent covering the voltage range 0–10 V. To avoid loss of information, determine –

(i) the minimum sampling rate;

(ii) the minimum number of bits in the digital code,

(iii) the analog value of the least significant bit;

(iv) the r.m.s. value of the quantization noise;

(v) the aperture time required for the A/D converter;

(vi) the dynamic range of the A/D converter in dB.

Suggest a suitable method of A/D conversion with reason.

8

(e) State and explain the terms ‘gain margin’ and ‘phase margin’. With neat sketches, explain how you can obtain gain margin and phase margin from Nyquist diagram and Bode plot.

8

(f) A 25 m long centre-fed vertical dipole has a half power point E field of 2 mV/m at 1 km distance. Calculate the transmitted power and the corresponding H field at 600 kHz. Also find the radiation efficiency, if its loss resistance is 1.5 ohms.

8

(g) An optical fiber cable has a core of 1.45 refractive index and 10 μm diameter, with a fractional index difference of 0.3%. Determine the numerical aperture, permissible wavelengths for single-mode and multi-mode operations, acceptance and critical angles.

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(h) An amplifier has a noise figure of 4 dB, a bandwidth of 500 kHz and an input resistance of 50 Ω. Calculate the input signal voltage needed to yield an output SNR = 1 when the amplifier is connected to a signal source of 50 Ω at 290 K.

(i) A memory system contains a cache, a main memory and a virtual memory. The access time of the cache is 5 ns and it has an 80 percent hit rate. The access time of the main memory is 100 ns and it has a 99.5 percent hit rate. The access time of the virtual memory is 10 ms. What is the average access time of the hierarchy?

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(j) How is subtraction done by ALU using -

(i) one’s complement;

(ii) two’s complement?

Illustrate with examples.

4+4

SECTION A

2. (a) The amplifier given in Fig. 3 uses an OPAMP. Assume its input impedance to be infinity, output impedance to be zero and finite differential gain $A_\upsilon = \dfrac{V_0}{(V_1 - V_2)}$.

(i) Obtain the expression for the feedback gain, $A_{\upsilon f} = \dfrac{V_0}{V_s}$

(ii) Calculate $A_{\upsilon f}$, if $A \to \infty$.

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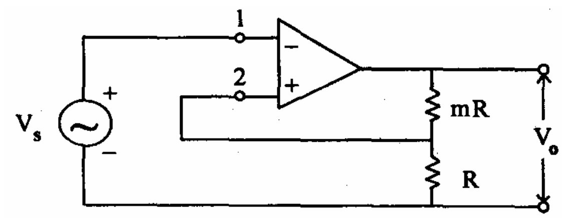

Fig. 3

(b) Determine the input power, output power and efficiency resulting in a class-B push-pull amplifier providing a signal of 20 V peak to a 16 Ω load, using a single supply of V_{CC} = 30 V.

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(c) Explain the principle of operation of the short-circuit overload protection circuit shown in Fig. 4. Find the limiting current I_S and the current that will flow under the short- circuit condition in the load. Assume $r_0 = 0$.

Assuming D_1 and D_2 to be silicon diodes with $V_{\gamma_1} = V_{\gamma_2} = 0.7$ volt and T_1 to be a silicon transistor having $V_{BE(active)} = 0.7$ V, calculate the values of I_S and maximum load current , if $R_S = 10\ \Omega$, $V_i = 15$ volts and $R_3 = 100\ \Omega$.

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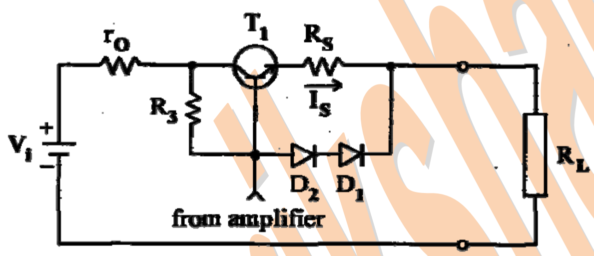

Fig. 4

3. (a) What two types of input does a clocked FF have ? Explain. What is meant by edge-triggering? Define set-up time and hold-time for a clocked FF.

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(b) A flip-flop is shown in Fig. 5. Explain its operation and construct a truth table to characterize its performance.

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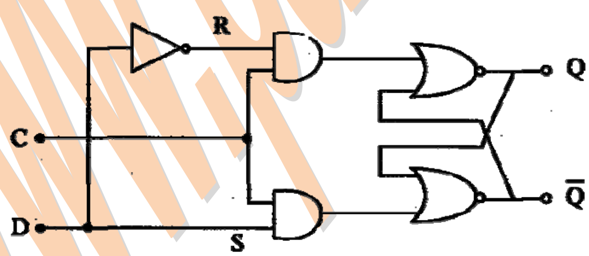

Fig. 5

(c) Draw a circuit of CMOS NOR gate and explain its complete operation.

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4. (a) Find the value of gain k for the feedback control system shown in Fig. 6, such that the system will be Underdamped and will respond with 16% overshoot.

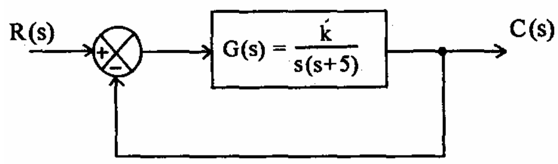

Fig. 6

Then calculate the following parameters of the system:

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(i) Undamped natural frequency, ω_n

(ii) Damping ratio, ζ

(iii) Time required to reach the first maximum or peak, T_p

(iv) Time required for the transient to reach within 2% of the steady-state value, i.e., settling time, T_s

(v) Damped natural frequency, ω_d.

(b) Using the root-locus technique, discuss the stability of unity feedback first-order and second-order control systems of gain k.

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5. (a) Draw the asymptotic Bode diagram for

$$G(s) = \frac{10^3(s+20)}{s^2+210s+2000}$$

and determine the value of G(j1000).

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(b) What are the effects of negative voltage series feedback on the characteristics of an amplifier? Derive an expression for input resistance of such an amplifier with feedback in terms of input resistance without feedback and feedback factor.

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(c) For the bias circuit shown in Fig. 7, determine the value of R_B to yield an operating point at $I_C = 5$ mA. Assume β_0=60, V_{EB}=0.7V, R_C=500Ω, R_E=100 and $-V_{CC} = -6$V.

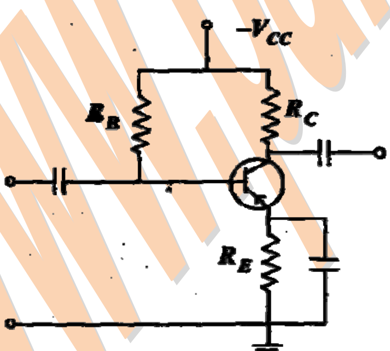

Fig. 7

What is one advantage and one limitation of this type of biasing?

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SECTION B

6. (a) An FSK system transmits binary data at the rate of 25×10^6 bits per second. During the course of transmission, white Gaussian noise of zero mean and power spectral density 10^{-20} watt per hertz is added to the signal. In the absence of noise, the amplitude of the received sinusoidal wave for digit 1 or 0 is 1 microvolt. Determine the average probability of symbol error, assuming coherent detection.

[You may use the approximation $erf_c(u) \simeq \dfrac{\exp(-u^2)}{\sqrt{\pi}u}$].

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(b) Determine the internal noise power (P_n) of a microwave amplifier operating with a bandwidth of 500 MHz and a specified noise figure of 2.5 dB.

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(c) Why is companding used in PCM transmission ? Discuss the two common companding laws and explain how they are used with analog and digital companding.

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7. (a) A uniform linear array of 16 elements has a quarter wavelength spacing between successive elements and a progressive phase difference of a. Determine its normalized array factor, half-power beam width, directivity, actual values of first and second side-lobe levels in dB, if α = –90°. What happens to these results if α = 0?

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(b) A 2-cavity klystron operates at 4GHz, with a beam voltage of 900 V, beam current of 20 mA and a cavity gap spacing of 15 mm each. Find the beam coupling coefficients, depth of velocity modulation, maximum and minimum velocities of electrons leaving the input gap, and the input gap voltage at maximum output condition, for a drift spacing of 3 mm. What are reentrant cavities ? Sketch and explain their significances.

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8. (a) Calculate the received electric field strength of a tropospheric wave at 50 km distance, if the field strength of the directly transmitted wave is 0.1 V/cm at 500 MHz. The transmitting and receiving antenna heights are 100 m and 20 m respectively.

Derive the relations used. What approximations can be used here ?

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(b) A relay satellite at 40000 km height, has an antenna of 30 cm diameter, for an uplink frequency of 6 GHz transmitted from an earth station paraboloid of 20 m diameter. If both antennas and the ground transmitter power is 10 kW, estimate (in dB) the power received at the satellite receiver, path loss and EIRP for earth station. Derive the formula used.

What is the significance of G/T ratio for earth station ?

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9. (a) A system is designed to monitor the temperature of a furnace and uses 8085 A microprocessor. Temperature readings are recorded in 16 bits and stored in memory locations starting at XX60 H. The high order byte is stored first and the low order byte is stored in the next consecutive memory location. However, the high order byte of all the temperature readings is constant. Write an assembly language program to transfer low order readings to consecutive memory locations starting at XX80 H and discard the high order bytes.

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(b) A system has 48-bit virtual addresses, 36-bit physical addresses and 128 MB of main memory. If the system uses 4096-byte pages, how many virtual and physical pages can the address space support ? How many page frames of main memory are there?

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(c) Which simple data structure you may use for representing a directed graph ? What is it called and how it works ? Show that the number of edges in a unidirectional fully n(n–l) connected directed graph with n nodes is $\frac{n(n-1)}{2}$.

3+3+4

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