ASSIGNMENT 6: GATE 2020 BM:BIOMEDICAL ENGINEERING

AI25BTECH11010 - Dhanush Kumar

1) Rajiv Gandhi Khel Ratna Award was conferred _____. Mary Kom, a six-time world champion in boxing, recently in a ceremony _____. the Rashtrapati Bhawan (the President's official residence) in New Delhi.

(GATE BM 2020)

a) with, at
b) on, in
c) on, at
d) to, at

2) Despite a string of poor performances, the chances of K. L. Rahul's selection in the team are _____.

(GATE BM 2020)

a) slim
b) bright
c) obvious
d) uncertain

3) Select the word that fits the analogy:
Cover : Uncover :: Associate : _____.

(GATE BM 2020)

a) Unassociate
b) Inassociate
c) Misassociate
d) Dissociate

4) Hit by floods, the kharif (summer sown) crops in various parts of the country have been affected. Officials believe that the loss in production of the kharif crops can be recovered in the output of the rabi (winter sown) crops so that the country can achieve its food-grain production target of 291 million tons in the crop year 2019–20 (July–June). They are hopeful that good rains in July–August will help the soil retain moisture for a longer period, helping winter sown crops such as wheat and pulses during the November–February period.
Which of the following statements can be inferred from the given passage?

(GATE BM 2020)

a) Officials declared that the food-grain production target will be met due to good rains.

b) Officials want the food-grain production target to be met by the November–February period.
c) Officials feel that the food-grain production target cannot be met due to floods.
d) Officials hope that the food-grain production target will be met due to a good rabi produce.

5) The difference between the sum of the first $2n$ natural numbers and the sum of the first n odd natural numbers is _____.

(GATE BM 2020)

a) $n^2 - n$ b) $n^2 + n$ c) $2n^2 - n$ d) $2n^2 + n$

6) Repo rate is the rate at which Reserve Bank of India (RBI) lends commercial banks, and reverse repo rate is the rate at which RBI borrows money from commercial banks.
Which of the following statements can be inferred from the above passage?

(GATE BM 2020)

a) Increase in repo rate will increase cost of borrowing and decrease lending by commercial banks.
b) Increase in repo rate will decrease cost of borrowing and increase lending by commercial banks.
c) Increase in repo rate will decrease cost of borrowing and decrease lending by commercial banks.
d) Decrease in repo rate will decrease cost of borrowing and increase lending by commercial banks.

7) P, Q, R, S, T, U, V, and W are seated around a circular table.

(GATE BM 2020)

a) S is seated opposite to W.
b) U is seated at the second place to the right of R.
c) T is seated at the third place to the left of R.
d) V is a neighbour of S.

Which of the following must be true?

(GATE BM 2020)

a) P is a neighbour of R.
b) Q is a neighbour of R.
c) P is not seated opposite to Q.
d) R is the left neighbour of S.

8) The distance between Delhi and Agra is 233 km. A car P started travelling from Delhi to Agra and another car Q started from Agra to Delhi along the same road 1 hour after the car P started. The two cars crossed each other 75 minutes after the car Q started. Both cars were travelling at constant speed. The speed of car P was 10 km/hr more than the speed of car Q. How many kilometers the car Q had travelled when the cars crossed each other?

(GATE BM 2020)

a) 66.6 b) 75.2 c) 88.2 d) 116.5

9) For a matrix $M = [m_{ij}]$, $i, j = 1, 2, 3, 4$, the diagonal elements are all zero and $m_{ij} = -m_{ji}$. The minimum number of elements required to fully specify the matrix is _____.

(GATE BM 2020)

a) 6 b) 8 c) 10 d) 16

10) The profit shares of two companies P and Q are shown in the figure. If the two companies have invested a fixed and equal amount every year, then the ratio of the total revenue of company P to the total revenue of company Q, during 2013–2018 is _____.

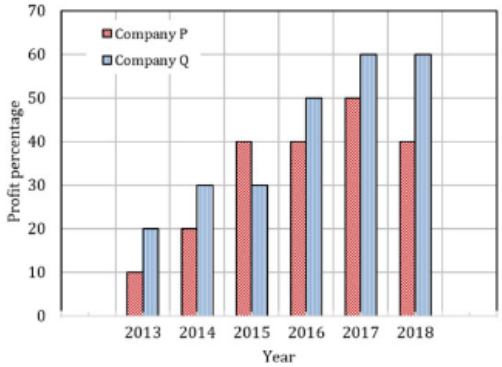


Fig. 10

(GATE BM 2020)

a) 15 : 17
b) 16 : 17
c) 17 : 15
d) 17 : 16

11) m_1 and m_2 are the roots of the characteristic equation of a linear second order physical system. Match the nature of the roots with the natural response of the system.

Nature of roots	Systen respones
P. m_1 and m_2 are real and distinct	K. Critically damped
Q. m_1 and m_2 are equal	L. Overdamped
R. m_1 and m_2 are complex	M. Underdamped

TABLE 11

(GATE BM 2020)

a) P-L, Q-M, R-K
b) P-M, Q-L, R-K
c) P-L, Q-K, R-M
d) P-M, Q-K, R-L

12) A person is sitting in a chair with feet on the ground. While rising up on his feet, the kinematic motion **NOT** occurring is:

(GATE BM 2020)

a) Hip extension
b) Plantar flexion
c) Hip flexion
d) Knee extension

13) The equipment that measures elasticity of blood vessel *in vivo* is:

(GATE BM 2020)

a) Rheometer
b) Dimension analyser
c) Thermomechanical analyser
d) Dynamic mechanical analyser

14) Biomaterials with shape memory effects are NOT used in:

(GATE BM 2020)

a) Intracranial aneurysm clips
b) Arterial blood vessel closure devices
c) Orthopedic total joint replacements
d) Orthodontic dental wires

15) The MRI scanner parameter of long T_{rep} or short T_{echo} will generate a _____ contrast image.

(GATE BM 2020)

a) Proton Density–weighted
b) T2–weighted
c) T1–weighted
d) T2*–weighted

16) In diagnostic X-ray imaging, the following is NOT a part of primary EM radiation interaction in soft tissue:

(GATE BM 2020)

a) Photoelectric effect
b) Characteristic radiation production
c) Compton scattering
d) Pair-production

17) A 5 MHz ultrasound pulse is used to image a tumor at a depth of 2 cm in a soft tissue. It takes time t for the reflected echo from the tumor to come back to the receiver. Instead, if a 2.5 MHz wave is used, how long will it take for the echo from the same tumor to arrive at the receiver?

(GATE BM 2020)

a) $t/2$ b) t c) $2t$ d) $4t$

18) $X(s)$ is the Laplace transform of a signal $x(t)$. The Laplace transform of $\frac{dx(t)}{dt}$ assuming $x(0) = 0$, is:

(GATE BM 2020)

a) $sX(s)$ b) $\frac{X(s)}{s}$ c) $tX(s)$ d) $\frac{dx}{ds}$ e) $\frac{1}{s}\frac{dx}{ds}$

19) Which of the following are odd functions?

P: $\sin(t)$
Q: $\cos(t)$
R: $\sin(t) + \cos(t)$
S: $\sin(t)\cos(t)$

(GATE BM 2020)

a) Q and S b) P and Q c) P and R d) P and S

20) State-space model of a system is given as:

$$\dot{\mathbf{X}} = \begin{pmatrix} a & 2 \\ 0 & b \end{pmatrix} X + \begin{pmatrix} 1 \\ 0 \end{pmatrix} U, \quad vecY = \begin{pmatrix} 1 & 0 \end{pmatrix} X$$

The conditions for the system to be controllable are

(GATE BM 2020)

a) $a = 0,\ b \neq 0$ b) $a \neq 0,\ b = 0$ c) $a \neq 0,\ b \neq 0$ d) $a = 0,\ b = 0$

21) In microprocessor systems with memory mapped I/O, which of the following is true?

(GATE BM 2020)

a) Only I/O devices with internal memory can be interfaced.
b) I/O devices can be accessed using IN and OUT instructions.
c) Each I/O device can be addressed as a memory location.
d) Arithmetic and logic operations cannot be directly performed with the I/O data.

22) The number of electrodes used in recording standard 12-lead Electrocardiogram (ECG) is

(GATE BM 2020)

a) 13 b) 10 c) 11 d) 12

23) Which of the following is **NOT** a part of knee joint?

(GATE BM 2020)

a) Patella b) Tibia c) Femur d) Fibula

24) During a routine stethoscope examination at the left midclavicular-5th intercostal space, murmurs were noted between first and second heart sound. The possible abnormality among the following could be

(GATE BM 2020)

a) Aortic stenosis
b) Mitral regurgitation
c) Mitral stenosis
d) Aortic regurgitation

25) The thin filament of a muscle fiber is comprised of

(GATE BM 2020)

a) Troponin, Tropomyosin, Actin
b) Troponin, Tropomyosin, Titin
c) Tropomyosin, Titin, Actin
d) Actin, Myosin, Troponin

26) The value of the integral evaluated over the contour $C : |z| = 3/2$ is

$$\frac{1}{2\pi j} \oint_C \frac{z}{(z-1)(z-2)}\, dz$$

(GATE BM 2020)

27) The eigenvalues of a 3×3 non-singular matrix P are $1, 2, 3$. The trace of matrix P^{-1} (rounded off to two decimal places) is _____

(GATE BM 2020)

28) The following recursion relation, when started from a finite positive non-zero value, converges to _____

$$x_{n+1} = \frac{1}{2}\left(x_n + \frac{1}{x_n}\right)$$

(GATE BM 2020)

29) In a nuclear imaging system, sodium iodide (NaI) crystals are used to detect gamma rays of 120 keV. The percentage (%) of gamma-rays that will pass through 1 cm of NaI crystal, assuming the Half-Value-Layer (HVL) of NaI as 0.2 cm, is _____ (rounded off to one decimal place).

(GATE BM 2020)

30) The distal end of an endoscope is placed at a distance of 1 mm from the gastrointestinal wall. The refractive indices of the fiber core and cladding are 1.5 and 1.45, respectively. The maximum field of view for the endoscope is _____ degrees (rounded off to one decimal place).

(GATE BM 2020)

31) Two inductors with the details given below are wound separately on two identical ring type ferromagnetic cores.

Coil	Number of turns	Gauge of wire	Self-Inductance
Coil-1	N	G	L_1
Coil-2	2N	G/2	L_2

TABLE 31

The ratio L_2/L_1 is _____

(GATE BM 2020)

32) Two dyes X and Y having concentrations in the ratio 0.25 in identical cuvettes were subjected to absorption measurements in a spectrophotometer. The estimated ratio of their absorbance is 0.5. The ratio of their molar extinction coefficients is _____

(GATE BM 2020)

33) Hydrolysis of one ATP molecule provides an energy of _____ kilo calories (rounded off to one decimal place).

(GATE BM 2020)

34) An 830 nm laser Doppler flow meter probe is oriented at an angle of 60° to the flow axis. If the average flow velocity is 3 cm/s, the magnitude of Doppler shift frequency (kHz) is _____ (rounded off to one decimal place).

(GATE BM 2020)

35) A 100 mA single current pulse from a pulse generator is used for artificial pacing of heart at the right ventricle. If the delivered energy does not exceed the fibrillation threshold of 300 μJ, the safe duration of the pulse that could be applied to the tissue mass having an impedance of 500 Ω is _____ μs.

(GATE BM 2020)

36) The resting potential of a mammalian nerve cell is −80 mV. A certain drug administered to the body changes the intracellular K^+ concentration from 150 mmol/L to 55 mmol/L. The nearest value of cell membrane potential after the drug administration, assuming that the external equilibrium of K^+ does not get changed during the event, is

(Gas constant = 8.315 J/mol/K, core temperature = 37°C and Faraday constant = 96500 C/mol)

(GATE BM 2020)

a) −117.7 mV b) −18.77 mV c) −53.32 mV d) −141.20 mV

37) The arrangement of four resistors of equal value in the diaphragm of a physiological pressure measurement catheter is shown below. When applied pressure deforms the diaphragm, there is an increase in length of resistors R2 and R4 and a decrease in length of resistors R1 and R3. The changes in resistance value are proportional to the length of individual four resistors. Which among the configuration given below should be used to form a Wheatstone bridge circuit such that bridge output voltage is proportional to the change in resistance of individual resistors?

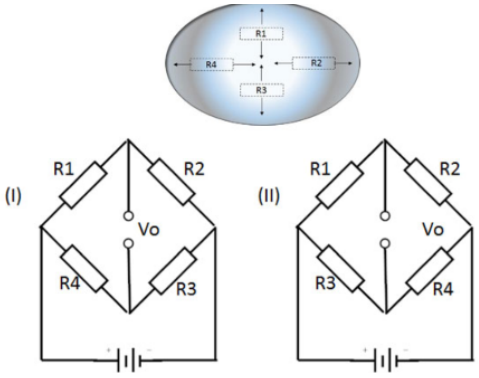


Fig. 37

(GATE BM 2020)

a) I only
b) II only
c) Neither I nor II
d) Both I and II

38) For the given input voltage, $V_{in} = 10\sin(2\pi t)$ to the functional circuit shown below, the output signal will be

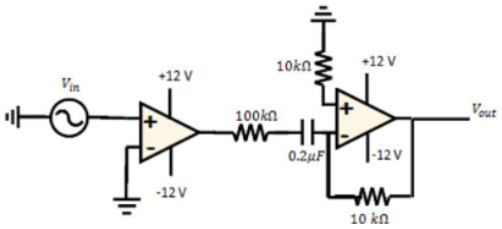
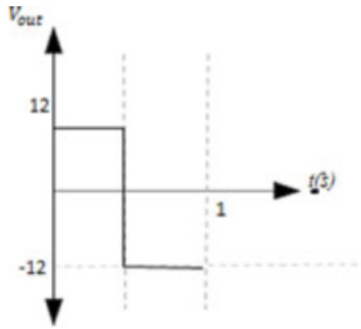
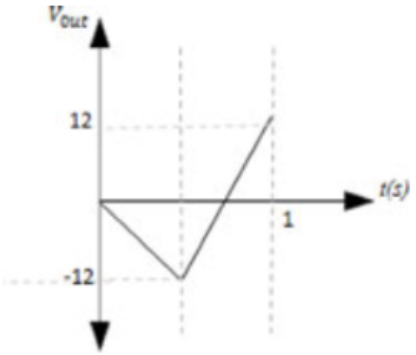


Fig. 38

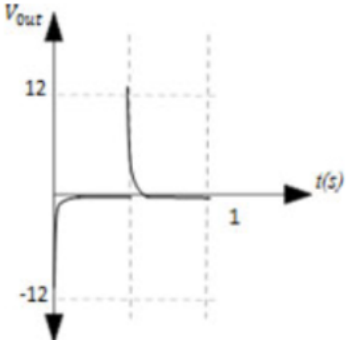
(GATE BM 2020)



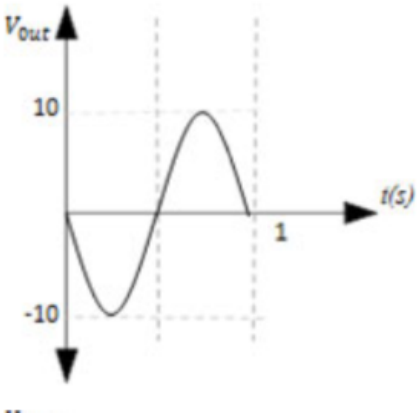
(a)



(b)



(d)



(c)

39) During a non-invasive measurement of blood pressure, mean arterial pressure was observed to be 100 mm Hg. If systolic pressure is 150 mm Hg, the diastolic pressure would be

(GATE BM 2020)

a) 110 mm Hg b) 75 mm Hg c) 70 mm Hg d) 50 mm Hg

40) Two loads are connected to AC supply mains as depicted in the figure. One load draws 10 kW whereas the other load of 10 kVA is operated at 0.6 pf lagging. To achieve an overall power factor of 0.9544 lagging, the nearest kVAr rating of the capacitor bank needed to be connected across the supply mains is equal to

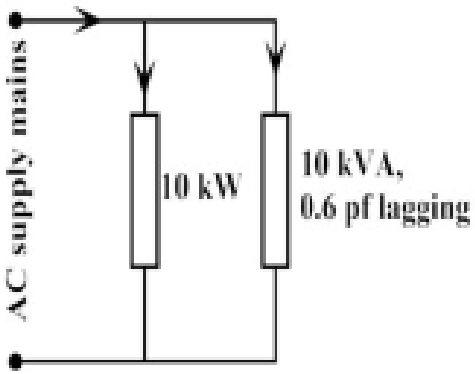


Fig. 40

(GATE BM 2020)

a) 3 b) 5 c) 7 d) 9

41) The nearest value of power dissipated in the 3 Ω resistance in the circuit is

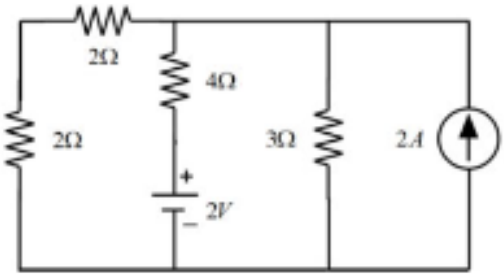


Fig. 41

(GATE BM 2020)

a) 3 W b) 25/3 W c) 12 W d) 25/12 W

42) A second order low pass filter is being constructed by cascading two first order low pass filters with the following transfer functions

$$H_1(j\omega) = \frac{1}{1 + j\frac{\omega}{\omega_1}}, \quad H_2(j\omega) = \frac{1}{1 + j\frac{\omega}{\omega_2}}$$

where ω_1 and ω_2 are the respective 3dB cut-off frequencies.
The undamped natural frequency ω_n of the resulting second order low pass filter is

(GATE BM 2020)

a) $\omega_n = \sqrt{\omega_1 \omega_2}$
b) $\omega_n = \omega_1 + \omega_2$
c) $\omega_n = \dfrac{\omega_1 \omega_2}{\omega_1 + \omega_2}$
d) $\omega_n = \sqrt{\omega_1^2 + \omega_2^2}$

43) Match the bridge type with the application given below:

Name of the bridge	Application
P. Maxwell bridge	K. Measurement of Low resistance
Q. Kelvin double bridge	L. Measurement of medium Q-coil inductance
R. Hay bridge	M. Measurement of capacitance
S. Schering bridge	N. Measurement of High Q-coil inductance

TABLE 43

(GATE BM 2020)

a) P-L, Q-K, R-N, S-M
b) P-N, Q-K, R-L, S-M
c) P-N, Q-L, R-M, S-K
d) P-L, Q-M, R-N, S-K

44) For a non-unity feedback system with

$$G(s) = \frac{12}{s(s+2)} \quad \text{and} \quad H(s) = \frac{2}{s(s+3)},$$

the magnitude of steady-state error to a unit step-input is

(GATE BM 2020)

a) 0.50 b) 0.45 c) 0.25 d) 0.20

45) Match the Boolean expression with its minimal realization:

Boolean expression	Minimal realization
P. $XYZ + \overline{X}YZ + XY\overline{Z}$	K. $X(Y+Z)$
Q. $XYZ + X\overline{Y}Z + XY\overline{Z}$	L. $X(Y+Z)$
R. $XY\overline{Z} + X\overline{Y}Z + \overline{X}YZ$	M. YZ
S. $XYZ + XY\overline{Z} + X\overline{Y}Z + \overline{X}YZ$	N. $Y(X+Z)$

TABLE 45

(GATE BM 2020)

a) P-K, Q-L, R-N, S-M
b) P-L, Q-K, R-N, S-M
c) P-L, Q-K, R-M, S-K
d) P-N, Q-K, R-L, S-M

46) The glomerulus filtration process of kidney is modeled as a flat membrane with pores of radius 1 nm and length of pore 60 nm. The viscosity of the fluid is 0.002 Pa.s. The aggregate area of the pores makes 5% of total surface area of the membrane. The average pressure over the blood side of the membrane is 8000 Pa and on the ultrafiltrate side is 6200 Pa. The total available area of membrane is 1.5 m^2. The nearest value of resulting filtration rate in cm^3/min is

(GATE BM 2020)

a) 0.14
b) 1.40
c) 8.43
d) 34.7

47) During resting state, the voltage outside the cell membrane compared to that inside the membrane is _____. Under such conditions, the intracellular and extracellular regions have _____ and _____ concentrations, respectively.

(GATE BM 2020)

a) More positive, more Potassium [K^+], more Sodium [Na^+]
b) More negative, more Potassium [K^+], more Sodium [Na^+]
c) More negative, more Sodium [Na^+], more Potassium [K^+]
d) More positive, more Sodium [Na^+], more Potassium [K^+]

48) The tensile strength of a degradable suture used for a surgical procedure in the human body shows 60% decrease exponentially for 10 days. The tensile strength shows 80% after 10 days and 20 days, respectively. The closest approximation (in days) for the tensile strength to decay to 20% of its original value would be

(GATE BM 2020)

a) 26
b) 33
c) 43
d) 52

49) A 60 kg person is standing on one foot on a force plate. The ground reaction force is found to act 60 mm anterior to the ankle joint. The knee joint is 60 mm from the Trochanter Knee Ankle (TKA) line. If the weight of the foot is 18.5 kg, the closest value of *magnitude* of moment acting on the ankle joint is

(GATE BM 2020)

a) 23 Nm
b) 248 Nm
c) 223 Nm
d) 466 Nm

50) The temperature of bone cement is increased from 37°C to 87°C during the femoral hip arthroplasty. The cement thickness is noted to be 20 mm. The stress developed due to exothermic reaction of bone cement during the polymerization process and shrinkage of the bone cement, respectively, are

Assume that:

- bone, cement, and implant are modeled as a set of concentric cylinders

- no direct adhesion takes place between bone and cement
- temperature is uniform

Coefficient of thermal expansion of bone cement = $90 \times 10^{-6}/^{\circ}\text{C}$
Young's modulus of bone cement = 3.5 GPa

(GATE BM 2020)

a) 15.75 MPa, 90 μm
b) 15.75 MPa, 110 μm
c) 6.85 MPa, 110 μm
d) 6.85 MPa, 90 μm

51) An object is imaged in a 1 Tesla MRI scanner and induced voltage is found to be equal to V_0. The expression for the magnitude of the received voltage in RF coil is given by

$$|V| = 2\pi\gamma M_0(\sin\alpha)f$$

When the patient is shifted to a 3 Tesla MRI scanner that uses the same RF coil and the slice thickness is halved, the magnitude of the induced voltage was found to be equal to V_2. The ratio V_2/V_1 is

(GATE BM 2020)

a) 1.5 b) 3.0 c) 4.5 d) 6.0

52) A 3 MHz ultrasound transducer transmits a 3-cycle long pulse into a soft tissue at normal incidence to fat and liver interface. The axial resolution (mm) and the amplitude reflection coefficient at fat-liver interface, respectively, are

$$c_{\text{tissue}} = 1500\,\text{m/s}, \quad c_{\text{fat}} = 1450\,\text{m/s}, \quad c_{\text{liver}} = 1570\,\text{m/s}$$

$$\rho_{\text{fat}} = 920\,\text{kg/m}^3, \quad \rho_{\text{liver}} = 1060\,\text{kg/m}^3$$

(GATE BM 2020)

a) 0.75, 0.22
b) 0.75, 0.12
c) 0.5, 0.22
d) 0.5, 0.11

53) The forward biased current of a silicon (Si) diode is being calculated from the exponential model of the V-I characteristics. If the diode current $I_D = 1$ mA at a voltage drop $V_D = 0.7$ V, the nearest value of I_D when $V_D = 0.8$ V is

$$I = I_S \exp\left(\frac{V_D}{V_T}\right)$$

Assume thermal voltage $V_T = 25.3$ mV for Si diode.

(GATE BM 2020)

a) 0.133 mA
b) 2 mA
c) 7.5 mA
d) 22 mA

54) A continuous random variable x has a probability density function given by

$$f(x) = ce^{-|x|}, \qquad -\infty < x < \infty$$

where c is a real constant. The variance of x is _____ (correct up to one decimal place).

(GATE BM 2020)

55) The magnitude of the gradient of the function $f(x, y) = x^2 + y^2$ at the point (1,1) is _____ (correct up to two decimal places).

(GATE BM 2020)

56) The value of the following double integral is _____ (correct up to three decimal places).

$$\iint_R xy\,dx\,dy$$

where R is the first quadrant of the circle with center at the origin and radius of one unit.

(GATE BM 2020)

57) A gynaecologist recorded the blood pressure (BP) of patients as shown in the Table below. Using Regression process, the diastolic BP of a 38 year old patient (mm Hg) is _____ (rounded off to two decimal places).

Age (years)	23	24	25	26	28	29	31	35	40
BP (diastolic) mm Hg	65	60	62	70	70	73	75	83	90

Fig. 57

(GATE BM 2020)

58) A person in standing position first flexes the hip by 50° from the initial Trochanter knee ankle (TKA) line and then flexes knee by 20°. The distance of ankle joint from the initial TKA line is _____ (rounded off to nearest integer).
(i) The distance between hip joint and knee joint is 400 mm
(ii) The distance between knee joint and ankle joint is 300 mm

(GATE BM 2020)

59) A chest radiograph of 36 cm × 48 cm is digitized. If we want to preserve details in the image to a spatial resolution of 6 cycles/mm, the approximate image data size in MB

for an 8 bit quantization is _____ (rounded off to two decimal places).

(GATE BM 2020)

60) The X-ray radiography scenario is shown in the figure. If the number of incident photons (N_i) is equal to 2×10^6 at 50 keV, the number of photons (N_d) that exit the tissue is _____ $\times 10^6$ (rounded off to two decimal places).

(use linear attenuation coefficient for soft tissue and blood at 50 keV as 0.4 cm^{-1} and 0.2 cm^{-1}, respectively).

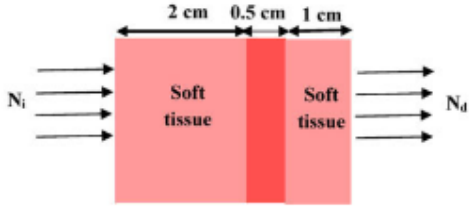


Fig. 60

(GATE BM 2020)

61) The wavelength of an electron accelerated to a potential of 1 V is _____ nm (rounded off to two decimal places).
Mass of electron = 9.11×10^{-31} kg
Planck's constant, $h = 6.63 \times 10^{-34}$ Js
Charge of electron = 1.6×10^{-19} C

(GATE BM 2020)

62) In a permanent magnetic moving coil (PMMC) instrument having following specifications, the angular deflection of the pointer for a coil current of 100 μA will be _____ degrees (rounded off to one decimal place).

Magnetic flux density = 1.5 Tesla
Torsional spring constant = 2×10^{-6} Nm/deg
Cross sectional area of the coil = 2.5 cm^2
Number of turns of the coil = 500

(GATE BM 2020)

63) Arterial blood extracted from a healthy adult showed an oxygen partial pressure value of 40 mm Hg. The total oxygen content in the arterial blood measured in %V/V is _____ (rounded off to one decimal place).

Given:

Solubility of oxygen in blood = 0.003 ml/mm Hg/dL

Hemoglobin oxygen saturation = 95%

Oxygen carrying capacity of Hb = 1.34 ml/g

Arterial blood hemoglobin concentration = 15 g/dL

(GATE BM 2020)

64) In the process of measuring blood flow from an artery using C-clamp magnetic flow probe, the voltage recorded across diametrically opposite sites of the artery is 3.75 nV. The blood flow rate through the artery is _____ cm^3/s (rounded off to two decimal places).

The inner diameter of the C-clamp = 0.5 cm,

The magnetic flux density = 1.5×10^{-5} Wb/m^2.

65) A cell is injected with a current

$$i(t) = u(t)$$

to produce a change in the intracellular membrane voltage

$$v(t).$$

The cell-membrane is modeled as a linear system with impulse response

$$h(t) = Ae^{-\frac{t}{\tau}}u(t).$$

The cell membrane voltage output at 5 ms is _____ mV.

Use $A = -34$ V/s; $\tau = 3$ ms.

(GATE BM 2020)

END OF QUESTION PAPER