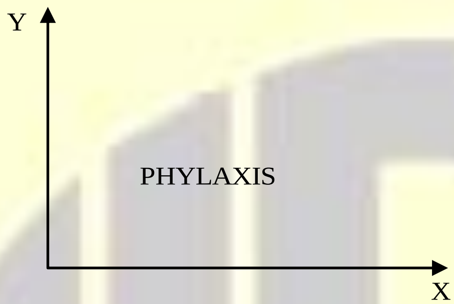
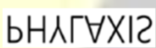
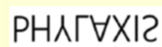
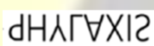
GENERAL APTITUDE

Q. No. 1 - 5 Carry One Mark Each

1. The mirror image of the above text about the x-axis is



(A)  (B) 

(C)  (D)  .

Answer: (A)

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2. Four persons P, Q, R and S are to be seated in a row, R should not be seated at the second position from the left end of the row. The number of distinct seating arrangement possible is:

(A) 6 (B) 18 (C) 9 (D) 24

Answer: (B)

---

3. $\oplus$ and $\odot$ are two operators on numbers p and q such that

$p \odot q = p - q$, and $p \oplus q = p \times q$

Then, $\left(9 \odot \left(6 \oplus 7\right)\right) \odot \left(7 \oplus \left(6 \odot 5\right)\right) =$

(A) –33 (B) –40 (C) 40 (D) –26

Answer: (B)

---

4. **(i)** Arun and Aparna are here.

(ii) Arun and Aparna is here.

(iii) Arun's families is here.

(iv) Arun's family is here.

Which of the above sentences are grammatically CORRECT?

(A) (ii) and (iv) (B) (i) and (ii) (C) (i) and (iv) (D) (iii) and (iv)

Answer: (B)

---

5. Two identical cube shaped dice each with faces numbered 1 to 6 rolled simultaneously. The probability that an even number is rolled out on each dice is:

(A) $\frac{1}{12}$ (B) $\frac{1}{8}$ (C) $\frac{1}{36}$ (D) $\frac{1}{4}$

Answer: (D)

Q. No. 6-10 Carry Two Marks Each

6. In an equivalent triangle PQR, side PQ is divided into four equal parts, side QR is divided into six equal parts and side PR is divided into eight equal parts. The length of each subdivided part in cm is an integer.

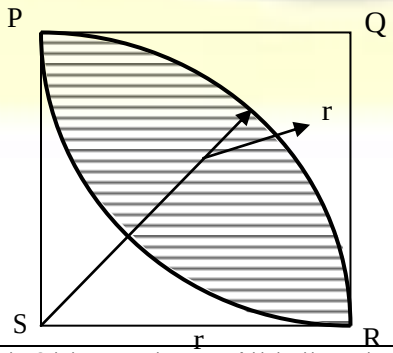
The minimum area of the triangle PQR possible, in cm^2, is

(A) $144\sqrt{3}$ (B) $48\sqrt{3}$ (C) 18 (D) 24

Answer: (A)

---

7. In the figure shown above, PQRS is a square. The shaded portion is formed by the intersection of sectors of circles with radius equal to the side of the square and centers at S and Q.



The probability that any point picked randomly within the square falls in the shaded area is _____.

(A) $\frac{\pi}{4}$ (B) $4-\frac{\pi}{2}$ (C) $\frac{1}{2}$ (D) $\frac{\pi}{2}-1$

Answer: (D)

---

8. **1.** Some football players play cricket.

2. All cricket players play hockey.

Among the options given below, the statement that logically follows from the two statements 1 and 2 above, is

(A) All hockey players play football (B) No football player plays hockey

(C) All football players play hockey (D) Some football players play hockey

Answer: (D)

---

9. On a planar field, you travelled 3 units East from a point O. Next you travelled 4 units South to arrive at point P. Then you travelled from P in the North-East direction such that you arrive at a point that is 6 units East of point O. Next, you travelled in the North-West direction, so that you arrive at point Q that is 8 units North of point P. The distance of point Q to point O, in the same units, should be _____

(A) 3 (B) 6 (C) 4 (D) 5

Answer: (B)

---

10. The author said, "Musicians rehearse before their concerts. Actors rehearse their roles before the opening of a new play. On the other hand, I find it strange that many public speakers think they can just walk on to the stage and start speaking. In my opinion, it is no less important for public speakers to rehearse their talks". Based on the above passage, which one of the following is TRUE?

(A) The author is of the opinion that rehearsing is important for musicians, actors and public speakers

(B) The author is of the opinion that rehearsing is more important only for musicians than public speakers

(C) The author is of the opinion that rehearsal is more important for actors than musicians

(D) The author is of the opinion that rehearsing is less important for public speakers than for musicians and actors

Answer: (A)

BIOMEDICAL ENGINEERING

Q. No. 1–25 Carry One Mark Each

1. For $f_x(x)=\frac{1}{\pi}\left(\frac{q}{e^{x}+e^{-x}}\right)$ to be a valid probability distribution function of a random variable X, the value of q is _____.

(A) 2 (B) π (C) 4 (D) $-\pi$

Answer: (A)

---

2. Given a scalar function $V(x,y)=\frac{1}{2}\left(x^2+y^2\right)$, the directional derivative of V in the direction of the vector field $3yi-3xj$ at the point (1, 1) is _____.

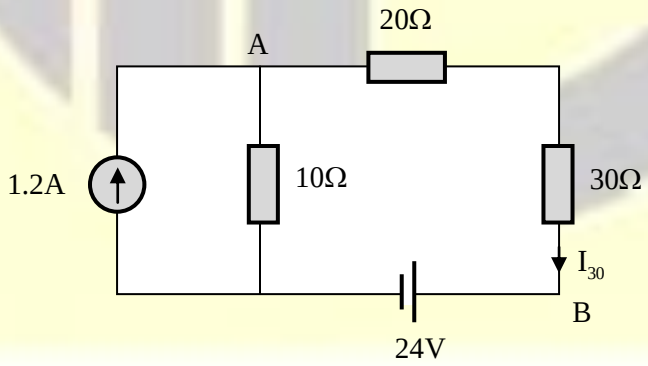
(Note: i and j are the unit vectors along the x and y directions, respectively).

(A) $\sqrt{18}$ (B) 0 (C) $\frac{1}{\sqrt{18}}$ (D) $\frac{3}{2}$

Answer: (C)

---

3. Three resistive loads are connected to ideal voltage and current sources as shown in the circuit below. The voltage V_{AB} across the terminals A and B is equal to _____V.



(A) +10 (B) –10 (C) –6 (D) +6

Answer: (B)

4. An ideal inductor with an inductance value of 1/3 H is connected to a 50 Hz sinusoidal AC voltage source. The energy stored in the inductor is 6J. The value of the maximum power delivered to the inductor is _____W.

(A) 1200π (B) 600π (C) 1200 (D) 0

Answer: (A)

---

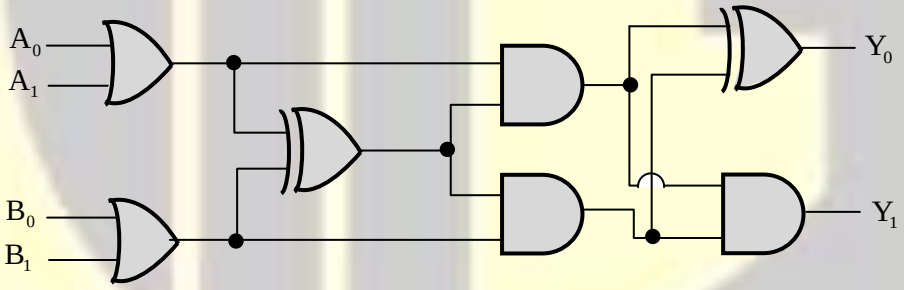
5. Let $X(j\omega)$ denote the Fourier transform of x(t). If $X(j\omega)=10e^{-j\pi f}\left(\frac{\sin(\pi f)}{\pi f}\right)$, then $\frac{1}{2\pi}\int_{-\infty}^{\infty}X(j\omega)d\omega=$ _____. (where $\omega=2\pi f$)

(A) 10π (B) 100 (C) 10 (D) 20π

Answer: (C)

---

6. In the circuit shown below, Y is a 2-bit (Y_1Y_0) output of the combinational logic. What is the maximum value of Y for any given digital inputs, A_1A_0 and B_1B_0 ?

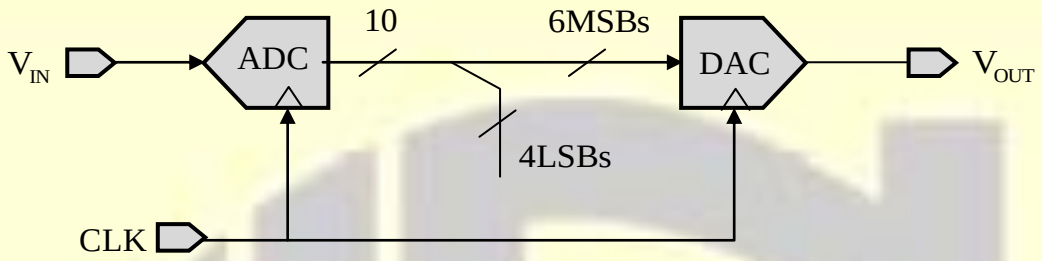


(A) 01 (B) 10 (C) 00 (D) 11

Answer: (A)

---

7. In the block diagram shown below, an analog signal, $V_{IN} = \sin\left(2\pi 10^6 t\right)$ is quantized by a 10-bit Nyquist ADC. Later, 4 LSBs are dropped and 6 MSBs are converted to an analog signal $\left(V_{OUT}\right)$ while using a 6-bit DAC. Assume uniform distribution for quantization noise. The peak SQNR at the output of DAC is _____ dB.



(A) 61.96 (B) 25.84 (C) 49.92 (D) 37.88

Answer: (D)

---

8. For a linear stable second order system, if the unit step response is such that the peak time is twice the rise time, then the system is _____.

(A) underdamped (B) undamped (C) overdamped (D) critically damped

Answer: (B)

---

9. Which of the following displacement sensors is known to have a high sensitivity and a relatively larger measurement range?

(A) Strain gauge (B) Capacitive sensor

(C) LVDT (D) Piezoelectric sensor

Answer: (C)

---

10. Which of the following temperature sensors is used in contact-type digital thermometers for measuring body temperature?

(A) Thermocouple (B) Thermistor

(C) Resistance temperature detector (D) Infrared LED-photodetector pair

Answer: (B)

11. The pH of blood in a healthy human is precisely in the range of _____.

(A) 7.10-8.10 (B) 6.95-7.05 (C) 7.15-7.20 (D) 7.35-7.45

Answer: (D)

---

12. Which of the following is a cranial bone in the human body?

(A) Occipital (B) Mandible (C) Coccyx (D) Sternum

Answer: (A)

---

13. Which of the following glands produces the Thyroid Simulating Hormone (TSH)?

(A) Thyroid (B) Parathyroid (C) Pituitary (D) Pineal

Answer: (C)

---

14. Which of the following causes Myocardial Infraction (MI)?

(A) Obstruction in one of the arteries supplying blood to the heart

(B) Obstruction in one of the arteries supplying blood to the brain

(C) Obstruction in one of the veins draining blood from the heart

(D) Obstruction in one of the veins draining blood from the brain

Answer: (A)

---

15. If we consider blood as a suspension of RBCs in a Newtonian fluid, the shear forces experienced by the RBCs during blood flow would

(A) Randomize the orientation of blood cells

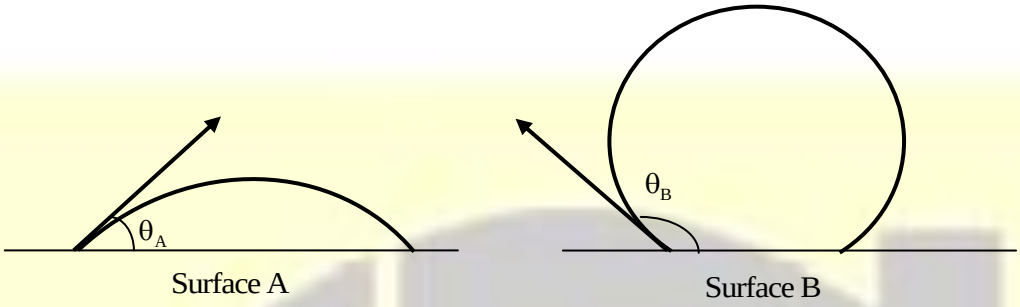
(B) Align RBCs along their long axes with streamlines

(C) Align RBCs along their short axes with streamlines

(D) Create an equal distribution of RBCs aligned in their long and short axes

Answer: (B)

16. As shown in the figure, the water contact angles of surfaces A and B are θ_A and θ_B, respectively. Based on the figure, which of the following statements given below is TRUE?



(A) Surface A is hydrophilic and surface B is hydrophobic

(B) Surface A is hydrophobic and surface B is hydrophilic

(C) Both surfaces are hydrophilic

(D) Both surfaces are hydrophobic

Answer: (A)

---

17. Which of the following is a bone resorbing cell?

(A) Osteoblasts (B) Osteoclasts (C) Osteocytes (D) Osteocalcin

Answer: (B)

---

18. Which of the following statements are CORRECT in the context of planar X-ray imaging?

(A) Using fast X-ray screen improves spatial resolution

(B) Using fast X-ray screen worsens spatial resolution

(C) Decreasing tube current decreases signal to noise ratio

(D) Decreasing tube current increases signal to noise ratio

Answer: (B, C)

19. While comparing parallel fiber and pinnate muscles of a given volume, which of the following statements are TRUE?

(A) Pinnate muscles provide more muscle force

(B) Parallel fiber muscles provide more muscle force

(C) Pinnate muscles facilitate better muscle shortening

(D) Parallel fiber muscles facilitate better muscle shortening

Answer: (A, D)

---

20. Which of the following may cause failure of bone implants?

(A) Stress shielding-reduction of bone density due to removal of a typical stress from bone by an implant

(B) Aseptic loosening-loss of bond between bone and implant in the absence of an infection

(C) Fretting fatigue-progressive deterioration of material by small scale rubbing

(D) Osseointegration-formation of a direct interface between an implant and a bone, without intervening soft tissues

Answer: (A, B, C)

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21. The minimum value, f_{min}, of the function given below is _____ (rounded off to the nearest integer)

$$f(x_1, x_2, x_3) = \frac{1}{2}\left(x_1^2 + x_2^2 + x_3^2\right) - 2\left(x_2 + x_2 + x_3\right)$$

Answer: (–6)

---

22. A continuous time transfer function $H(s) = \frac{1 + s/10^6}{s}$ is converted to a discrete time transfer function H(z) using a bilinear transform at 100 MHz sampling rate. The pole of H(z) is located at z = _____.

Answer: (1)

---

23. Consider a type 2, unity feedback system. The intersection of the initial -40 dB/sec segment, of its Bode plot, with the zero dB line occurs at a frequency of 2 rad/s. The acceleration error constant of the system K_a is _____.

Answer: (4)

24. The radioactivity of a radionuclide with decay constant of $3.22\times10^{-5}s^{-1}$ is 6mCi at 10:30 AM. The radioactivity of the radionuclide at 4:30PM on the same day will be _____mCi. (rounded off to two decimal places).

Answer: (2.99)

---

25. A polymeric scaffold has been developed for cartilage tissue engineering. To understand the biodegradability of the material, this polymeric scaffold with a dry weight of 20 mg is kept in a lysozyme solution for 7 days. At the end of 7 days, the scaffold is freeze-dried, and the dry weight is measured to be 18 mg. The degradation of the polymeric scaffold after 7 days is _____%.

Answer: (10)

Q. No. 26–55 Carry Two Marks Each

26. The Trace and Determinant of a 2 × 2 nonsingular matrix A are 12 and 32, respectively. The eigen values of A^{-1} are _____ and _____.

(A) 0.6, 0.8 (B) 0.25, 0.125 (C) 6,16 (D) 1/12, 1/32

Answer: (B)

---

27. A unit step input is applied to a system with impulse response $H(s)=\frac{1-s/\omega_z}{1+s/\omega_p}$ at t = 0. The output of the system y(t) at $t=0^+$ is _____.

(A) 1 (B) $-\omega_z/\omega_p$ (C) $-\omega_p/\omega_z$ (D) 0

Answer: (C)

---

28. Consider the following first order partial differential equation, also known as the transport equation

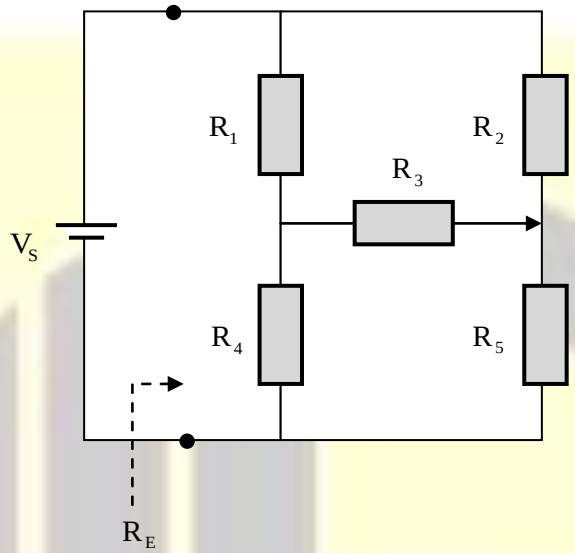
$$\frac{\partial y(x,t)}{\partial t}+5\frac{\partial y(x,t)}{\partial x}=0$$

with initial conditions given by $y(x,0)=\sin x, -\infty<x<\infty$. The value of $y(x,t)$ at $x=\pi$ and $t=\frac{\pi}{6}$ is _____.

(A) 1 (B) 2 (C) 0 (D) 0.5

Answer: (D)

29. In the circuit shown below, $V_s = 100V, R_1 = 30\Omega, R_2 = 60\Omega, R_3 = 90\Omega, R_4 = 45\Omega$ and $R_5 = 30\Omega$. The current flowing through resistor R_3 is _____A. (rounded off to two decimal places).



(A) +0.30 (B) +0.21 (C) –0.21 (D) –0.30

Answer: (B)

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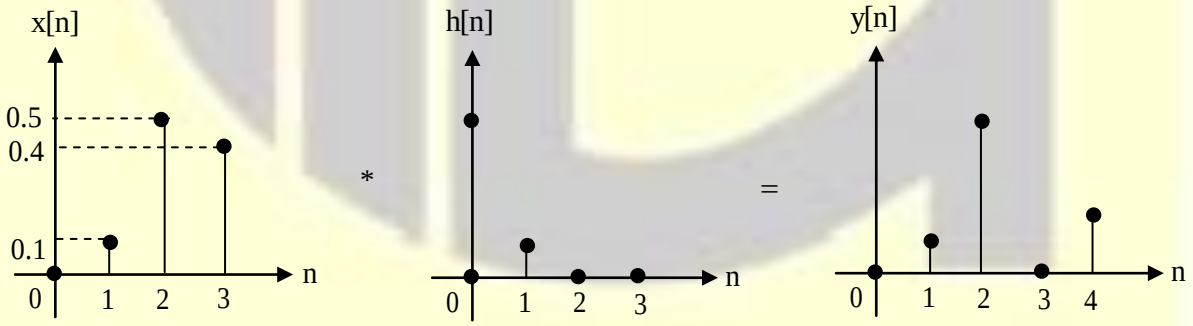
30. x[n] is convolved with h[n] to give y[n]. If y[2] = 1 and y[3] = 0, h[0] = _____. (Graph are not uniformly scaled)



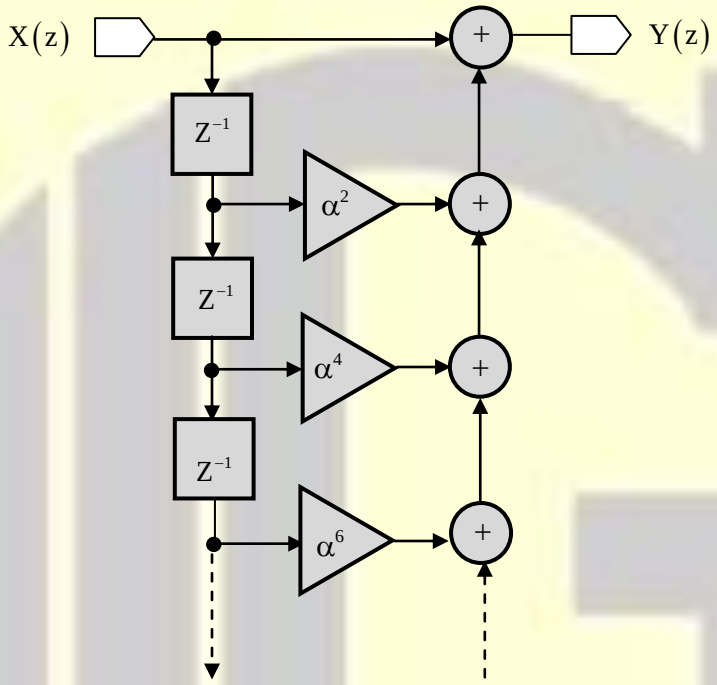
(A) 1.85 (B) –2.50 (C) –1.90 (D) 2.38

Answer: (D)

31. In the block diagram shown below, an infinite tap FIR filter with transfer function $H(z)=Y(z)/X(z)$ is realized. If

$$H(z)=\frac{1}{1-0.5z^{-1}}$$

The value of α is _____.



(A) 2 (B) $\frac{1}{\sqrt{2}}$ (C) 1/2 (D) $\sqrt{2}$

Answer: (B)

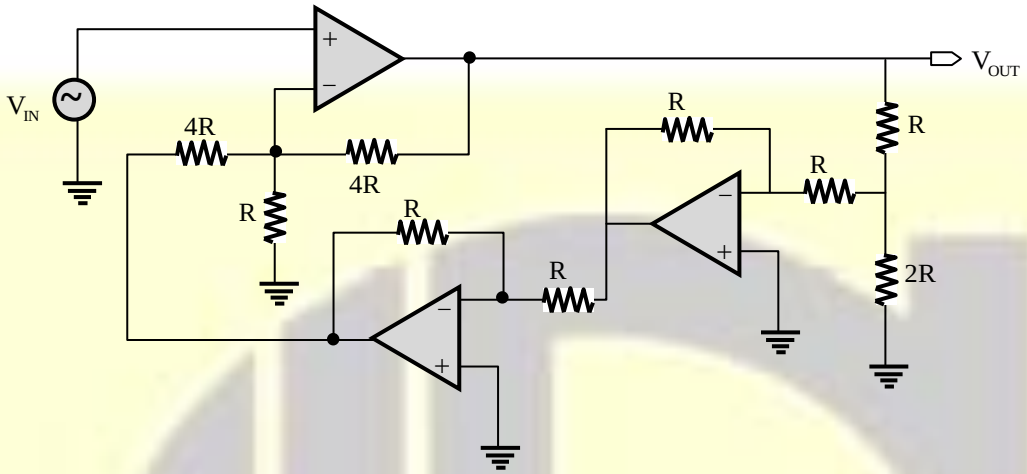
---

32. An analog signal is sampled at 100 MHz to generate 1024 samples. Only these samples are used to evaluate 1024-point FFT. The separation between adjacent frequency points (ΔF) in FFT is _____kHz.

(A) 102.16 (B) 97.66 (C) 100.00 (D) 95.63

Answer: (B)

33. In the circuit diagram shown below, all OPAMPs are ideal with infinite gain and bandwidth. V_{OUT}/V_{IN} for this circuit is _____.

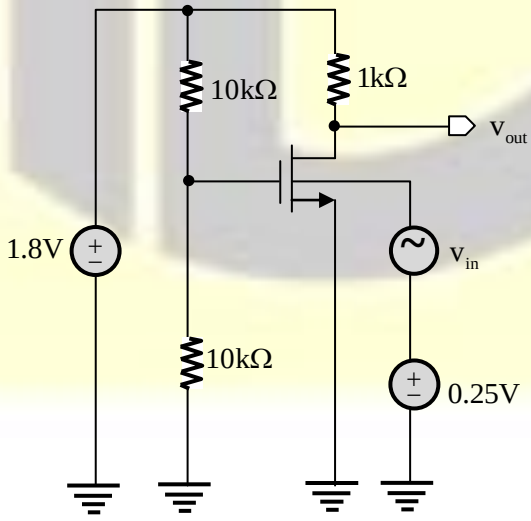


(A) 5.00 (B) 5.33 (C) 4.80 (D) 6.00

Answer: (C)

---

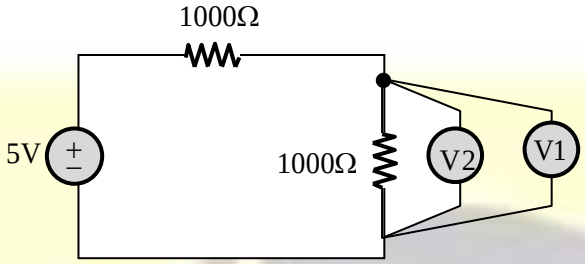
34. In the circuit diagram shown below, NMOS is in saturation region, $\mu_n C_{ox} = 200\,\mu A/V^2$, width $W = 40\,\mu m$, length L = 1 μm, the threshold voltage is 0.4V, and the ratio of body-effect transconductance (g_{mb}) to transconductance (g_m) is 0.1. A small input voltage v_{in} is applied at the bulk-terminal to produce a small change in the output voltage v_{out}. The dc gain for $\frac{v_{out}}{v_{in}}$ is _____ (Neglect channel-length modulation for NMOS and all intrinsic capacitors).



(A) –0.4 (B) –4.0 (C) –4.4 (D) –3.6

Answer: (A)

35. As shown in the circuit below, a constant voltage source is connected to two ideal resistors.



The voltage drop across a resistor is measured using two different voltmeters V1 and V2 at five different time instances and the following values are recorded from V1 and V2.

Time instances	1	2	3	4	5
Reading on V1 (V)	2.479	2.483	2.495	2.508	2.511
Reading on V2 (V)	2.465	2.468	2.470	2.472	2.475

Which of the following is TRUE?

(A) V1 is less accurate, V2 is more precise
(B) V1 is more accurate, V2 is more precise
(C) V1 is less accurate, V2 is less precise
(D) V1 is more accurate, V2 is less precise

Answer: (B)

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36. The closed-loop characteristic equation of a system is given by

$s^4 + 2s^3 + 8s^2 + 8s + 16 = 0$

The frequency of oscillation of this closed-loop system at steady state is _____ rad/s.

(A) 1 (B) 2 (C) 4 (D) 8

Answer: (B)

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37. Match the following in the context of biomaterial characterization:

Surface characterization technique	Surface property
P. Scanning electron microscopy	**K.** Elemental composition
Q. Fourier-transform Infrared spectroscopy	**L.** Roughness
R. X-ray photoelectron spectroscopy	M. Functional groups
S. Atomic force microscopy	**N.** Topography

(A) P-L, Q-N, R-K, S-M
(B) P-N, Q-M, R-K, S-L
(C) P-N, Q-K, R-L, S-M
(D) P-M, Q-K, R-N, S-L

Answer: (B)

38. In comparisons to ECG amplifiers, the surface-EMG amplifiers have

(A) A comparable gain and smaller bandwidth

(B) A comparable gain and larger bandwidth

(C) At least 20 dB higher gain and a larger bandwidth

(D) At least 20 dB lower gain and a smaller bandwidth

Answer: (B)

---

39. Match the following organs with their functions:

Organ	Function
P. Stomach	**K.** Secretion of insulin and glucagon
Q. Liver	**L.** Storage of bile
R. Pancreas	**M.** Synthesis and secretion of bile
S. Gallbladder	**N.** Secretion of gastrin

(A) P-M, Q-N, R-K, S-L (B) P-N, Q-M, R-K, S-L

(C) P-N, Q-K, R-L, S-M (D) P-M, Q-K, R-N, S-L

Answer: (B)

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40. An RF pulse is applied to acquire an axial MR image at the isocenter of 1.5T MRI scanner with slide thickness of 2.5 mm. Assuming a gradient field strength of 2 Gauss/cm is applied, and Gyromagnetic ratio of protons is 42.58 MHz/T, the RF pulse bandwidth required for slice selection is _____ kHz.

(A) 1.06 (B) 2.13 (C) 6.66 (D) 13.31

Answer: (B)

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41. A longitudinal pressure wave travelling inside a muscle tissue is incident at an angle of 60° at the interface between the muscle and kidney. Let the wave impedance be $Z_{muscle} = 1.70 \times 10^5 \text{ g cm}^{-2}\text{s}^{-1}$, $Z_{kidney} = 1.62 \times 10^5 \text{ g cm}^{-2}\text{s}^{-1}$ and wave velocities in muscle and kidney tissues be 1590 and 1560 m/s respectively. The transducer center frequency is 1.5 MHz. The pressure wave propagation angle in the kidney tissue and intensity transmission coefficient at the tissue interface are _____ degree (rounded off to the nearest integer) and _____ (rounded off to two decimal places), respectively.

(A) 58, 0.24 (B) 30, 0.68 (C) 58, 0.94 (D) 30, 0.99

Answer: (C)

42. A novel biomaterial was tested for its tensile properties. The experiment was conducted using a cylindrical sample of this material, which was 10 cm long with 1 cm diameter. When a tensile force of 50kN was applied, this cylindrical sample elongated by 4 mm. Based on the experimental results described above and the tensile moduli of different tissues given in the table below, this biomaterial would be a suitable replacement for _____.

Tissue	Tensile modulus
Bone	5–20 GPa
Tendon	0.5–1 GPa
Ligament	20–400 MPa
Articular cartilage	3–10 MPa

(A) Bone (B) Tendon (C) Ligament (D) Articular cartilage

Answer: (A)

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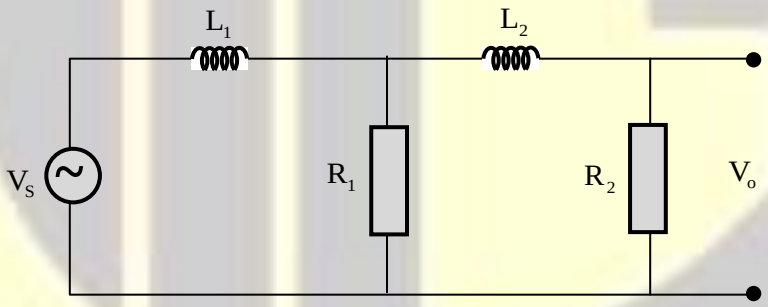
43. In the circuit shown below, $R_1 = 2\Omega, R_2 = 1\Omega, L_1 = 2H$ and $L_2 = 0.5H$. Which of the following describe(s) the characteristics of the circuit?



(A) Second order high pass filter (B) Second order low pass filter

(C) Underdamped system (D) Overdamped system

Answer: (B, D)

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44. An inexperienced clinician was measuring the cardiac output of a healthy human by thermodilution technique. A 2.0 mL of cold saline solution of volume (V_i) at 7°C was injected at the entrance of the

right atrium. The change in blood temperature $\left(\int_0^{t1}\Delta T_b dt\right)$ at the pulmonary artery was measured to be –20 Kelvin-second. The cardiac output F was calculated using the following formula

$$F=\frac{Q}{\rho_b c_b\int_0^{t1}\Delta T_b dt}$$

Where Q is the heat content of injectate in Joules, given by $V_i\Delta T_i\rho_i c_i$ and ΔT_i is the temperature difference between the injectate and blood. It was assumed that the density of blood $\left(\rho_b \text{ in } kg/m^3\right)$ and the specific heat capacity of blood $\left(c_b \text{in } J/(kg.K)\right)$ were respectively equal to that of the injectate ρ_i and c_i.

The clinician realized that there was an error in the measurement of F.

Which of the following is TRUE?

(A) Cardiac output is too low because the cold saline volume was too small

(B) Cardiac output is too low because $\int_0^{t1}\Delta T_b dt$ is too large

(C) Cardiac output is too high because the cold saline volume was too large

(D) Cardiac output is too high because $\int_0^{t1}\Delta T_b dt$ is too small

Answer: (A, B)

---

45. Which of the following statements about smooth muscles are TRUE?

(A) Smooth muscles are found in the walls of hollow organs

(B) Smooth muscles are controlled by the autonomic nervous system

(C) Smooth muscles are made up of non-striated cells

(D) Smooth muscles are made up of striated cells

Answer: (A, B, C)

---

46. Consider a unity feedback system with closed loop transfer function

$$\frac{C(s)}{R(s)}=\frac{s+90}{s^2+10s+90}$$

The steady state error with respect to a unit ramp input is _____. (rounded off to one decimal place).

Answer: (0.1)

47. The diameter of a renal artery lumen in humans is 5 mm. If the mean velocity of the blood flowing in the renal artery is 40 cm/s, the density of blood (ρ) is 1060 kg/m^3, and the viscosity of blood (μ) is 3 cP, the Reynolds number for the blood flowing in the renal artery is _____(rounded off to the nearest integer).

Answer: (7.05)

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48. A drug manufacturer believes that there is a 95% chance that the drug controller will approve a new drug the company plans to distribute if the results of the current testing show that the drug causes no side effects. The manufacturer believes there is a 0.20 probability that the drug will be approved even if the test shows side effects. A physician working for the drug manufacturer believes there is a 0.20 probability that tests will show side effects. If the drug is approved by the drug controller, the probability that the drug causes side effects is _____ (rounded off to three decimal places).

Answer: (0.116)

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49. In a measurement process, groups A and B recorded 10 and 15 values, respectively. The arithmetic means and standard deviations of group A are $\mu_A = 35, \sigma_A = 0.4$ and group B are $\mu_B = 38, \sigma_B = 0.6$, respectively. The standard deviations for the combined set of group A and group B measurements is _____. (rounded off to two decimal places).

Answer: (1.56)

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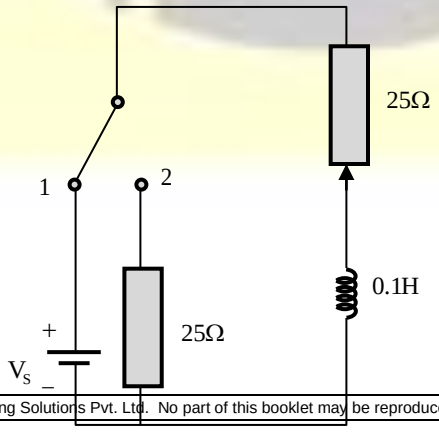
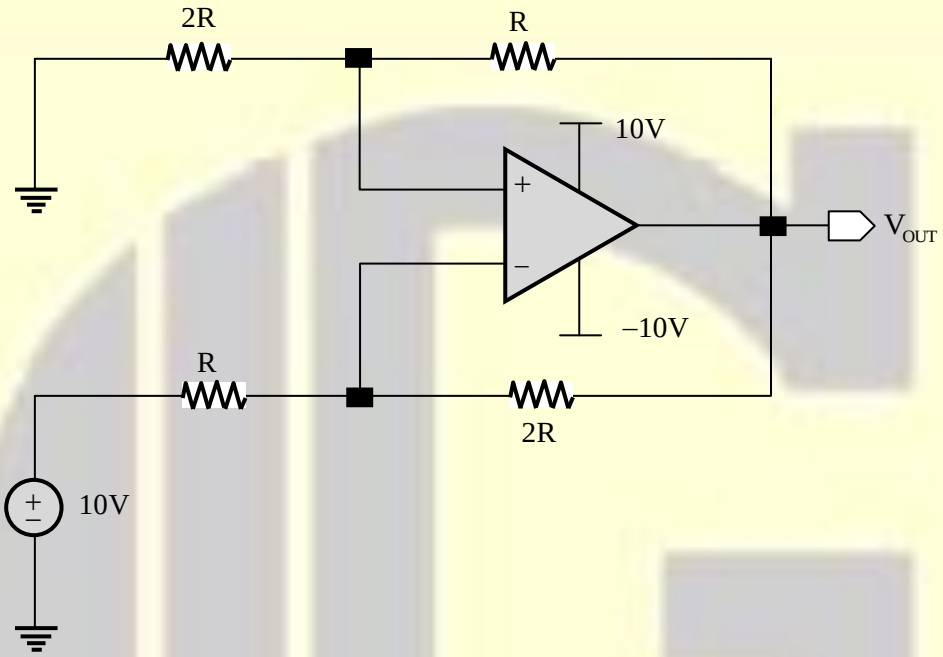
50. In the circuit given below, $V_s = 50V$. Let the circuit reach steady state for the SPDT switch at position 1. Once the circuit is switched to position 2, the energy dissipated in the resistors is _____J. (rounded off to one decimal place).



Answer: (0.2)

51. In the circuit shown below, the output voltage V_{OUT} is _____V.



Answer: (–10)

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52. A pacemaker was implanted in a cardiac patient. It has a battery of 2.4 A.h (Ampere. hour). It is designed to deliver a rectangular pulse of amplifier 1.5V for 1 ms ON time for every one second. The electrode – heart resistance is 150Ω. Assuming the current drained from the battery is negligible, the lifetime of the pacemaker is _____ years. (rounded off to be nearest integer).

Answer: (27.5)

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53. A radiographic system is using X-ray tube operating at 80 kVp. In order to filter the low energy X-rays, an aluminum (Al) filter of 2.5 mm thickness is used. The Al filter is replaced with a copper (Cu) filter to have the same energy filtered. The mass attenuation coefficient of A1 and Cu at 80 kVp are 0.02015 m^2/kg and 0.07519 m^2/kg, respectively. The densities of A1 and Cu are 2699 kg/m^3 and 8960 kg/m^3 respectively. The thickness of the new Cu filter is _____ mm. (rounded off to two decimal places)

Answer: (0.2)

54. In a radioactive isotope, N nuclei are needed to produce radioactivity level of 2 mCi. Assuming decay constant of $3.22\times10^{-5}s^{-1}$ and atomic weight of 98 g/mol and Avogadro's number $=6.02\times10^{23}mol^{-1}$, the mass of N radionuclide is _____ pictograms. (rounded off to the nearest integer).

Answer: (374)

55. A PZT crystal of thickness 1 mm and wave velocity 4000 m/s is emitting a longitudinal pressure wave, which is incident on a blood vessel at an angle of 30°. The Doppler shift in the ultrasound wave for a blood flow of 10 cm/s and wave velocity in the soft tissue of 1540 m/s is _____Hz.

Answer: (225)