GATE Biomedical Engineering

Sample Paper – 8

Duration: 128 Minutes | **Maximum Marks: 72**

Instructions

- This paper contains **46 questions** covering the core **Biomedical Engineering** subject of the GATE paper conducted by the IITs and IISc (General Aptitude and Engineering Mathematics are provided as separate papers).
- **Q1–Q20 carry 1 mark each** and **Q21–Q46 carry 2 marks each**, for a total of **72 marks**.
- Each question carries **negative marking of one-third of its allotted marks**: a wrong 1-mark question costs **0.33** and a wrong 2-mark question costs **0.67**. Unattempted questions carry no penalty.
- Every question here is a single-correct **MCQ**. The real GATE paper also has Multiple Select (MSQ) and Numerical Answer Type (NAT) questions, and **those carry no negative marking**.
- Attempt this paper in one timed sitting of about **128 minutes**, the share this core subject earns at GATE's overall pace of 180 minutes for 65 questions. Use standard physiological values (resting membrane potential ≈ -70 mV, speed of sound in soft tissue ≈ 1540 m/s) unless stated otherwise.

Human Anatomy and Physiology

Q1. In the human eye, the light-sensitive inner layer that contains the photoreceptor cells (rods and cones) and on which a sharp image must be formed is the: **[1 mark]**

(A) retina

(B) cornea

(C) sclera

(D) iris

Q2. The photoreceptor cells of the retina that are responsible for colour vision and function best in bright light (photopic vision) are the: **[1 mark]**

(A) rods

(B) bipolar cells

(C) ganglion cells

(D) cones

Q3. In the human ear, the spiral, fluid-filled structure of the inner ear that houses the sensory hair cells and converts sound vibrations into nerve impulses is the: **[1 mark]**

(A) tympanic membrane (eardrum)

(B) pinna

(C) cochlea

(D) eustachian tube

Q4. The three ossicles of the middle ear transmit and amplify vibrations from the eardrum to the oval window. Their correct order along this pathway, from the eardrum inward, is: **[1 mark]**

(A) malleus, incus, stapes

(B) stapes, incus, malleus

(C) incus, malleus, stapes

(D) malleus, stapes, incus

Q5. A person can see near objects clearly but cannot focus on distant objects, because parallel rays converge in front of the retina. This refractive defect (myopia) is corrected with a: **[1 mark]**

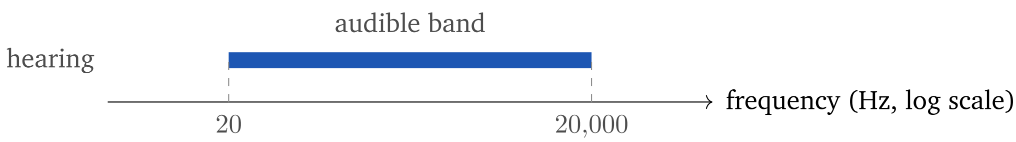
(A) convex (converging) lens

(B) cylindrical lens

(C) concave (diverging) lens

(D) plane mirror

Q6. The shaded band below marks the range of frequencies that a healthy young human ear can perceive as sound. The approximate audible frequency range is: **[1 mark]**



(A) 2 Hz to 2 kHz

(B) 200 Hz to 200 kHz

(C) 20 Hz to 200 Hz

(D) 20 Hz to 20 kHz

Electric Circuits, Signals and Systems

Q7. Thevenin's theorem states that any linear two-terminal resistive network, however complex, can be replaced at its terminals by: **[1 mark]**

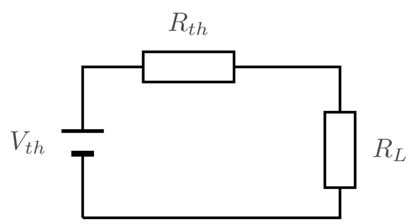
(A) a single current source in parallel with a resistance

(B) a single resistance only

(C) a single voltage source in series with a single resistance

(D) an ideal voltage source with no series element

Q8. The circuit shown is the Thevenin equivalent of a source network (V_{th} in series with R_{th}) connected to a variable load resistance R_L. By the maximum power transfer theorem, the power delivered to R_L is greatest when R_L equals: **[1 mark]**



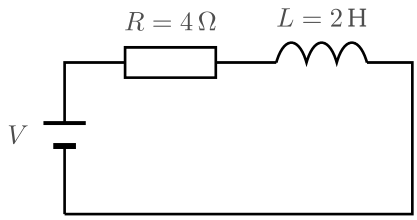
(A) zero

(B) infinity

(C) the Thevenin source resistance R_{th}

(D) twice the source resistance $2R_{th}$

Q9. For the series RL circuit shown, $R = 4\,\Omega$ and $L = 2$ H. The time constant of the circuit, $\tau = L/R$, is: **[1 mark]**



(A) 8 s

(B) 0.5 s

(C) 2 s

(D) 4 s

Q10. The Norton equivalent of a linear two-terminal network consists of: **[1 mark]**

(A) a voltage source in series with a resistance

(B) a voltage source in parallel with a resistance

(C) a current source in series with a resistance

(D) a current source in parallel with a resistance

Q11. The superposition theorem, used to find the response due to several independent sources, is applicable only to networks that are: **[1 mark]**

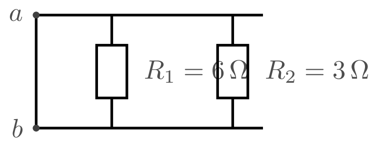
(A) purely resistive

(B) linear

(C) nonlinear

(D) driven by a single source

Q12. The two resistors shown, $R_1 = 6\ \Omega$ and $R_2 = 3\ \Omega$, are connected in parallel across the terminals. The equivalent resistance seen at the terminals is: **[1 mark]**



(A) $2\ \Omega$

(B) $9\ \Omega$

(C) $4.5\ \Omega$

(D) $18\ \Omega$

Q13. A continuous-time linear time-invariant (LTI) system has impulse response $h(t)$. For an arbitrary input $x(t)$, the output $y(t)$ is obtained as: **[1 mark]**

(A) the convolution of $x(t)$ with $h(t)$

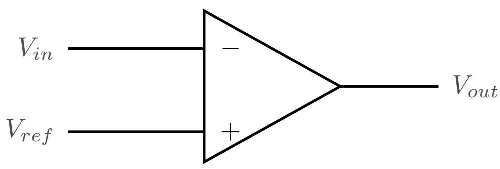
(B) the product $x(t)\,h(t)$

(C) the sum $x(t) + h(t)$

(D) the ratio $x(t)/h(t)$

Analog and Digital Electronics

Q14. The op-amp stage shown is operated open-loop (no feedback path). Its output saturates to $+V_{sat}$ or $-V_{sat}$ depending on whether V_{in} is above or below V_{ref}. This circuit functions as a: **[1 mark]**



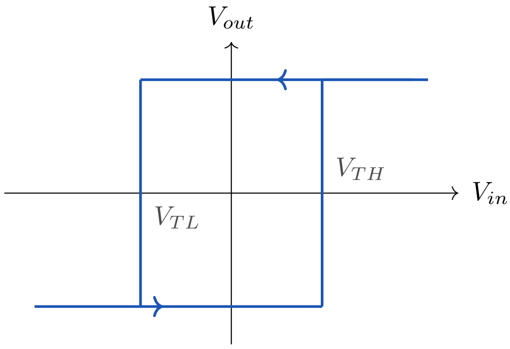
(A) integrator

(B) comparator

(C) summing amplifier

(D) voltage follower

Q15. The input–output transfer characteristic shown has two distinct switching thresholds, V_{TL} and V_{TH}, and the output follows a hysteresis loop. This behaviour is that of a: **[1 mark]**



(A) linear amplifier

(B) Schmitt trigger (comparator with hysteresis)

(C) ideal integrator

(D) low-pass filter

Q16. When a slowly varying but noisy signal crosses a threshold, a plain comparator may chatter (switch back and forth many times). The chief advantage of a Schmitt trigger in this situation is that it: **[1 mark]**

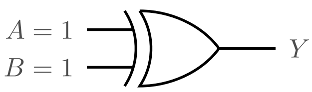
(A) increases the open-loop gain

(B) removes any DC offset from the signal

(C) prevents multiple false transitions on a noisy input by providing hysteresis

(D) lowers the required supply voltage

Q17. For the two-input exclusive-OR (XOR) gate shown, both inputs are held HIGH, i.e. $A = 1$ and $B = 1$. The logic level at the output Y is: **[1 mark]**



(A) 1

(B) high impedance

(C) undefined

(D) 0

Q18. A digital-to-analog converter (DAC) is specified to produce 1024 distinct output levels. The number of input bits it requires is: **[1 mark]**

(A) 8

(B) 10

(C) 12

(D) 1024

Q19. A non-inverting Schmitt trigger uses output saturation levels of ± 10 V with a feedback network $R_1 = 1$ kΩ and $R_2 = 10$ kΩ, giving thresholds $V_{TH,TL} = \pm \frac{R_1}{R_2} V_{sat}$. The total hysteresis width (the difference between the upper and lower thresholds) is: **[1 mark]**

(A) 10 V

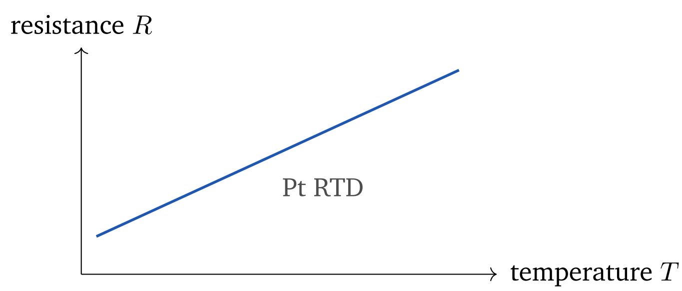
(B) 0.5 V

(C) 20 V

(D) 2 V

Sensors, Bioinstrumentation and Measurements

Q20. The resistance–temperature characteristic sketched below is that of a platinum resistance temperature detector (RTD) used in patient-temperature monitoring. From the curve, the RTD is best described as a device whose resistance: **[1 mark]**



(A) decreases exponentially with temperature

(B) increases nearly linearly with temperature (positive temperature coefficient)

(C) is essentially independent of temperature

(D) decreases linearly with temperature

Q21. A platinum RTD of the Pt100 type has a resistance $R_0 = 100\ \Omega$ at 0 °C and a temperature coefficient $\alpha = 0.00385$ °C^{-1}. Using $R = R_0(1 + \alpha T)$, its resistance at $T = 100$ °C is: **[2 marks]**

(A) $138.5\ \Omega$

(B) $100\ \Omega$

(C) $385\ \Omega$

(D) $3.85\ \Omega$

Q22. An electromagnetic blood flowmeter is clamped around a vessel and measures the average flow velocity of the (conducting) blood. Its operating principle is: **[2 marks]**

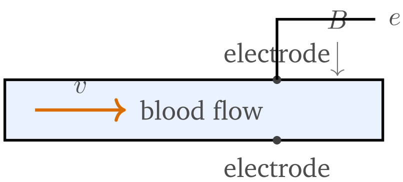
(A) the Doppler shift of a transmitted ultrasound beam

(B) Faraday's law of electromagnetic induction (an EMF is induced across the moving conductor)

(C) the thermal cooling of a heated element by the flowing fluid

(D) the differential pressure developed across an orifice plate

Q23. In an electromagnetic flowmeter the induced EMF is $e = B\,L\,v$, where B is the flux density, L the vessel (electrode) spacing and v the flow velocity. For $B = 0.1$ T, $L = 0.02$ m and $v = 0.5$ m/s, the induced EMF is: **[2 marks]**



(A) 10 mV

(B) 0.1 mV

(C) 1 mV

(D) 100 mV

Q24. A continuous-wave ultrasonic Doppler flowmeter is used to estimate blood-flow velocity non-invasively. It determines the velocity by measuring: **[2 marks]**

(A) the attenuation of the beam in tissue

(B) the frequency shift between the transmitted and the reflected ultrasound

(C) the acoustic impedance of the blood

(D) the absolute transit time of a single pulse

Q25. A thermocouple used for temperature measurement has a Seebeck coefficient of $41\ \mu\text{V}/^\circ\text{C}$. When the temperature difference between its hot and cold junctions is $50\ ^\circ\text{C}$, the EMF it generates is: **[2 marks]**

(A) 0.82 mV

(B) 2.05 mV

(C) 20.5 mV

(D) 0.41 mV

Biomedical Signal Processing

Q26. A diagnostic-quality ECG signal has significant frequency content up to about 150 Hz. To digitise it without aliasing, the minimum (Nyquist) sampling frequency required is: **[2 marks]**

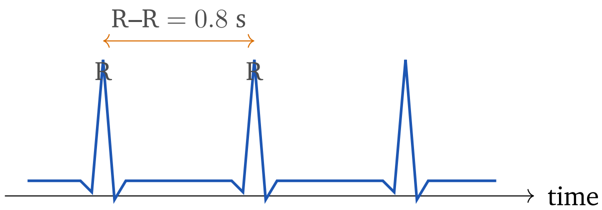
(A) 150 Hz

(B) 75 Hz

(C) 300 Hz

(D) 1500 Hz

Q27. The ECG trace shown has successive R peaks separated by an R–R interval of 0.8 s. The instantaneous heart rate computed from this interval is: **[2 marks]**



(A) 75 bpm

(B) 80 bpm

(C) 48 bpm

(D) 125 bpm

Q28. In an automated ECG arrhythmia-detection system, a sustained resting heart rate below 60 beats per minute is classified as: **[2 marks]**

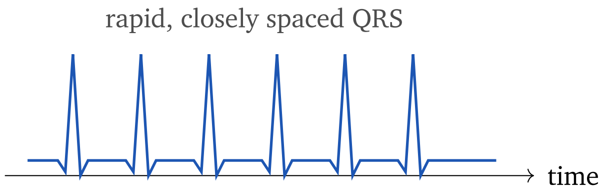
(A) tachycardia

(B) atrial fibrillation

(C) bradycardia

(D) normal sinus rhythm

Q29. The ECG rhythm strip shown has closely spaced QRS complexes of normal shape, giving an R–R interval consistent with about 150 beats per minute. An arrhythmia-detection algorithm should classify this rhythm as: **[2 marks]**



(A) tachycardia

(B) bradycardia

(C) asystole (no beats)

(D) normal rhythm at 72 bpm

Q30. The most widely used classical real-time algorithm for detecting the QRS complex (R-peak) in an ECG, based on band-pass filtering followed by differentiation, squaring and moving-window integration, is the: **[2 marks]**

(A) discrete Fourier transform method

(B) Goertzel algorithm

(C) Levinson–Durbin recursion

(D) Pan–Tompkins algorithm

Medical Imaging Systems

Q31. A low-contrast medical image is enhanced by an operation that redistributes its pixel intensities so that they span the full available range more uniformly. This standard contrast-enhancement technique is: **[2 marks]**

(A) histogram equalization

(B) simple binary thresholding

(C) convolution with a unit impulse

(D) down-sampling

Q32. A recorded medical image is corrupted by salt-and-pepper (impulse) noise. A median filter is generally preferred over a mean (averaging) filter for this task because it: **[2 marks]**

(A) increases the overall image brightness

(B) blurs the edges more strongly

(C) amplifies the high-frequency content

(D) removes isolated impulse noise while preserving edges

Q33. A digital medical image is stored using 8 bits per pixel. The number of distinct gray levels each pixel can represent is: **[2 marks]**

(A) 8

(B) 64

(C) 512

(D) 256

Q34. Which one of the following imaging modalities uses no ionizing radiation and forms its image from the magnetic relaxation of hydrogen protons in tissue? **[2 marks]**

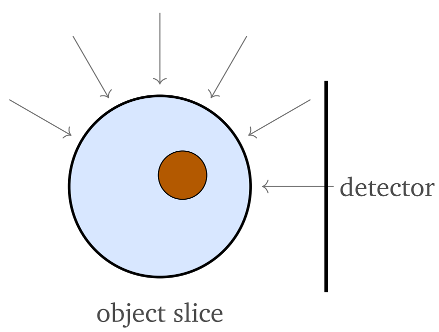
(A) X-ray computed tomography (CT)

(B) magnetic resonance imaging (MRI)

(C) positron emission tomography (PET)

(D) planar X-ray radiography

Q35. In X-ray computed tomography, a set of one-dimensional projections is acquired at many angles around the patient, as shown. The cross-sectional image is reconstructed from these projections chiefly by: **[2 marks]**



(A) histogram equalization of a single view

(B) a direct inverse Fourier transform of one projection

(C) simple intensity thresholding

(D) filtered back-projection

Biomechanics and Biomaterials

Q36. Which material, an alloy of mercury with silver and tin, has long been used for direct dental restorations (fillings) because of its ease of placement, strength and low cost? **[2 marks]**

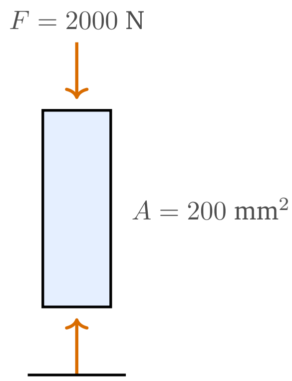
(A) austenitic stainless steel

(B) commercially pure titanium

(C) dental amalgam

(D) cobalt–chromium alloy

Q37. The orthopaedic implant stem shown has a uniform cross-sectional area $A = 200\ \text{mm}^2$ and carries a purely axial compressive load $F = 2000$ N. The average normal (axial) stress in the stem is: **[2 marks]**



(A) 100 MPa

(B) 1 MPa

(C) 20 MPa

(D) 10 MPa

Q38. Titanium-alloy hip stems can cause "stress shielding", in which the surrounding bone is unloaded and gradually resorbs. This occurs chiefly because the Young's modulus of the titanium alloy (about 110 GPa) is: **[2 marks]**

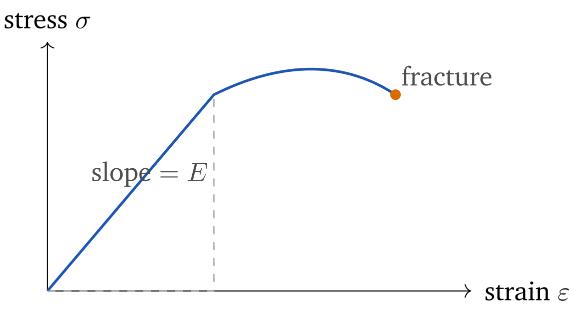
(A) exactly equal to that of cortical bone

(B) much higher than that of cortical bone (about 18 GPa)

(C) much lower than that of cortical bone

(D) effectively zero

Q39. The stress–strain curve of a biomaterial specimen is shown. Within the initial straight (linear-elastic) portion, the Young's modulus E of the material is obtained from the: **[2 marks]**



(A) area under the whole curve

(B) slope of the linear (elastic) region

(C) horizontal (strain-axis) intercept

(D) peak stress at fracture

Q40. Which bioceramic, chemically similar to the mineral phase of natural bone, is widely applied as a coating on orthopaedic and dental implants to promote bone bonding (osseointegration)? **[2 marks]**

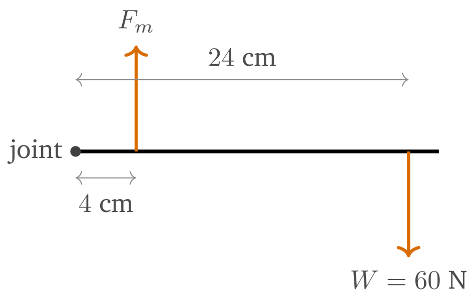
(A) hydroxyapatite

(B) soda-lime glass

(C) poly(methyl methacrylate) (PMMA)

(D) silicone rubber

Q41. The limb shown is modelled as a rigid lever pivoted at the joint. A muscle force F_m acts vertically upward at 4 cm from the joint, balancing a load $W = 60$ N acting downward at 24 cm from the joint. Taking moments about the joint for static equilibrium, the muscle force F_m is: **[2 marks]**



(A) 60 N

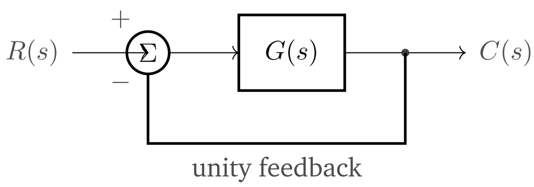
(B) 240 N

(C) 360 N

(D) 1440 N

Control Systems and Medical Instrumentation

Q42. For the unity negative-feedback control system shown, the forward-path transfer function is $G(s)$ and the feedback path is unity. The overall closed-loop transfer function $C(s)/R(s)$ is: [2 marks]



(A) $\dfrac{G(s)}{1+G(s)}$

(B) $\dfrac{G(s)}{1-G(s)}$

(C) $1+G(s)$

(D) $G(s)$

Q43. A cardiac pacemaker is programmed to pace the heart at a fixed rate of 60 pulses per minute. The time interval between two successive pacing pulses is: [2 marks]

(A) 1 s

(B) 0.5 s

(C) 2 s

(D) 60 s

Q44. A defibrillator stores its energy in a capacitor $C = 100\ \mu$F charged to $V = 3000$ V, and then discharges it through the patient. The energy stored, $E = \frac{1}{2}CV^2$, is: **[2 marks]**

(A) 150 J

(B) 300 J

(C) 450 J

(D) 900 J

Q45. A pacemaker that continuously senses the heart's own electrical activity and delivers a stimulating pulse only when a natural beat fails to appear within a set interval is called a: **[2 marks]**

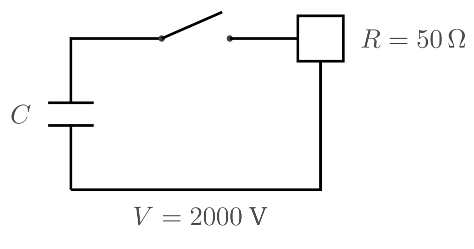
(A) demand (synchronous) pacemaker

(B) fixed-rate (asynchronous) pacemaker

(C) external defibrillator

(D) Holter monitor

Q46. The defibrillator discharge circuit shown delivers its charge through a patient of resistance $R = 50\ \Omega$ from a capacitor initially charged to $V = 2000$ V. The peak (initial) discharge current, $I = V/R$, is: **[2 marks]**



(A) 100 A

(B) 10 A

(C) 4 A

(D) 40 A

Detailed Solutions

Q1.

Solution

Concept – optical layers of the eye: The eye works like a camera: the front elements focus light, and one inner layer detects it.

Step 1 – identify the light-detecting layer: The retina lines the back inner surface of the eyeball and carries the rod and cone photoreceptors.

Step 2 – relate to image formation: The cornea and lens bend the incoming light so that a sharp inverted image is formed exactly on the retina.

Step 3 – confirm the sensory role: The photoreceptors of the retina transduce the light into nerve impulses that travel to the brain along the optic nerve.

Why the other options are wrong:

- B, cornea: is the transparent front window that refracts light but does not detect it.
- C, sclera: is the tough white outer coat and is not light sensitive.
- D, iris: is the coloured diaphragm that only controls the pupil size.

Final Answer: retina $\Rightarrow \boxed{\text{A}}$

$\boxed{\text{Answer: (A)}}$ Go Back to Q1

Q2.

Solution

Concept – two kinds of photoreceptor: The retina has two receptor types with complementary jobs.

Step 1 – recall rod function: Rods are highly sensitive, work in dim light (scotopic vision) and give only shades of grey.

Step 2 – recall cone function: Cones need brighter light (photopic vision) and come in three types tuned to different wavelengths, giving colour vision.

Step 3 – match to the question: Colour vision in bright light is the job of the cones.

Why the other options are wrong:

- A, rods: handle low-light vision and cannot distinguish colour.
- B and C, bipolar and ganglion cells: are relay and output neurons, not pho-

toreceptors.

Final Answer: cones $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q2

Q3.

Solution

Concept – the inner-ear transducer: Hearing needs a structure that turns mechanical vibration into neural signals.

Step 1 – trace the sound path: Sound passes the eardrum, is amplified by the ossicles, and reaches the fluid of the inner ear.

Step 2 – locate the sensory organ: The cochlea is the coiled, fluid-filled inner-ear structure that contains the organ of Corti with its hair cells.

Step 3 – state the transduction: Movement of the cochlear fluid bends the hair cells, which generate the nerve impulses of hearing.

Why the other options are wrong:

- A, tympanic membrane: only vibrates in response to sound; it does not transduce to nerve signals.
- B, pinna: is the outer ear that merely collects sound.
- D, eustachian tube: only equalises middle-ear pressure.

Final Answer: cochlea $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q3

Q4.

Solution

Concept – the middle-ear ossicular chain: Three tiny bones couple the eardrum to the inner ear and amplify the vibration.

Step 1 – name the bones: From outside inward they are the malleus (hammer), the incus (anvil) and the stapes (stirrup).

Step 2 – follow the vibration path: The eardrum drives the malleus, the malleus drives the incus, and the incus drives the stapes.

Step 3 – reach the inner ear: The footplate of the stapes pushes on the oval window, passing the vibration into the cochlear fluid.

Why the other options are wrong:

- B, C and D: all list the three bones in the wrong sequence; only malleus $\rightarrow$ incus $\rightarrow$ stapes follows the true path.

Final Answer: malleus, incus, stapes $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q4

Q5.

Solution

Concept – correcting a refractive error: The corrective lens must move the image back onto the retina.

Step 1 – describe the defect: In myopia (short sight) the eye is too converging, so distant parallel rays focus in front of the retina.

Step 2 – decide the correction needed: The rays must be made slightly divergent before entering the eye so they focus a little further back, on the retina.

Step 3 – pick the lens: A concave (diverging) lens spreads the incoming rays and shifts the focus onto the retina.

Why the other options are wrong:

- A, convex lens: adds convergence and corrects hypermetropia, not myopia.
- B, cylindrical lens: corrects astigmatism.
- D, plane mirror: does not focus light at all.

Final Answer: concave (diverging) lens $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q5

Q6.

Solution

Concept – range of human hearing: The audible band is bounded below and above in frequency.

Step 1 – read the lower limit: A healthy young ear begins to hear at about 20 Hz; below this is infrasound.

Step 2 – read the upper limit: The upper limit is about $20{,}000$ Hz (20 kHz); above this is ultrasound.

Step 3 – state the band: The audible range is therefore about 20 Hz to 20 kHz, as shaded on the plot.

Why the other options are wrong:

- A, 2 Hz to 2 kHz: both limits are far too low.
- B, 200 Hz to 200 kHz: the upper limit is in the ultrasound region.
- C, 20 Hz to 200 Hz: covers only the low bass, not the full range.

Final Answer: 20 Hz to 20 kHz $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q6

Q7.

Solution

Concept – Thevenin's theorem: It provides the simplest possible model of a linear source network at a chosen pair of terminals.

Step 1 – state the theorem: Any linear two-terminal network can be replaced by one voltage source V_{th} in series with one resistance R_{th}.

Step 2 – identify the two parameters: V_{th} is the open-circuit voltage at the terminals, and R_{th} is the resistance looking back with all independent sources deactivated.

Step 3 – match to the options: The description "a single voltage source in series with a single resistance" is exactly the Thevenin form.

Why the other options are wrong:

- A, current source in parallel with a resistance: is the Norton equivalent, not Thevenin.
- B, a resistance only: discards the source voltage.
- D, an ideal source alone: ignores the internal (Thevenin) resistance.

Final Answer: voltage source in series with a resistance $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q7

Q8.

Solution

Concept – maximum power transfer theorem: For a fixed source, there is an optimum load that draws the most power.

Step 1 – write the load power: With source V_{th} and internal resistance R_{th}, the load current is $I = \dfrac{V_{th}}{R_{th} + R_L}$ and the load power is $P = I^2 R_L = \dfrac{V_{th}^2 R_L}{(R_{th} + R_L)^2}$.

Step 2 – maximise with respect to R_L: Setting $\dfrac{dP}{dR_L} = 0$ leads to the condition $R_L = R_{th}$.

Step 3 – interpret: Maximum power is transferred when the load is matched to the Thevenin source resistance.

Why the other options are wrong:

- A, zero: gives large current but zero load power ($P = I^2 R_L = 0$).
- B, infinity: gives zero current and again zero power.
- D, $2R_{th}$: does not satisfy the matching condition and delivers less power.

Final Answer: $R_L = R_{th} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q8

Q9.

Solution

Concept – time constant of a series RL circuit: $\tau = \dfrac{L}{R}$.

Step 1 – list the data: $L = 2$ H, $R = 4\ \Omega$.

Step 2 – substitute: $\tau = \dfrac{2}{4}$

Step 3 – simplify: $\tau = 0.5$ s

Step 4 – interpret: The current rises to about 63.2% of its final value in one time constant, i.e. in 0.5 s.

Why the other options are wrong:

- A, 8 s: comes from multiplying $L \times R$ instead of dividing.
- C, 2 s: takes L alone, ignoring R.
- D, 4 s: takes R alone, ignoring L.

Final Answer: $\tau = 0.5$ s $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q9

Q10.

Solution

Concept – Norton's theorem: It is the current-source dual of Thevenin's theorem.

Step 1 – state the theorem: Any linear two-terminal network can be replaced by one current source I_N in parallel with one resistance R_N.

Step 2 – identify the parameters: I_N is the short-circuit current at the terminals and $R_N = R_{th}$ is the same resistance as in the Thevenin model.

Step 3 – match to the options: The Norton form is a current source in parallel with a resistance.

Why the other options are wrong:

- A, voltage source in series with a resistance: is the Thevenin equivalent.
- B, voltage source in parallel: is not a standard equivalent.
- C, current source in series: an ideal current source in series adds nothing meaningful and is not the Norton form.

Final Answer: current source in parallel with a resistance $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q10

Q11.

Solution

Concept – scope of the superposition theorem: Superposition relies on the response being a linear function of each source.

Step 1 – state the requirement: The theorem lets you add the responses due to each independent source acting alone, which is valid only if the network obeys linearity (homogeneity and additivity).

Step 2 – apply the condition: Resistors, ideal inductors and capacitors are linear elements, so superposition holds whether or not reactive elements are present.

Step 3 – rule out non-linearity: If any element is non-linear (for example a diode in conduction), the responses cannot simply be added, and superposition fails.

Why the other options are wrong:

- A, purely resistive only: too narrow; linear reactive circuits also qualify.

- C, nonlinear: is exactly the case where superposition does not apply.
- D, single source: superposition is trivial (and least useful) there; it is meant for multiple sources.

Final Answer: linear networks $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q11

Q12.

Solution

Concept – resistors in parallel: $R_{eq} = \dfrac{R_1 R_2}{R_1 + R_2}$.

Step 1 – list the data: $R_1 = 6\ \Omega$, $R_2 = 3\ \Omega$.

Step 2 – form the product: $R_1 R_2 = 6 \times 3 = 18$

Step 3 – form the sum: $R_1 + R_2 = 6 + 3 = 9$

Step 4 – divide: $R_{eq} = \dfrac{18}{9}$

$R_{eq} = 2\ \Omega$

Why the other options are wrong:

- B, $9\ \Omega$: is the series sum, not the parallel value.
- C, $4.5\ \Omega$: is the simple average of the two, which is not the parallel formula.
- D, $18\ \Omega$: is just the product $R_1 R_2$ without dividing by the sum.

Final Answer: $R_{eq} = 2\ \Omega \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q12

Q13.

Solution

Concept – input–output relation of an LTI system: For a linear time-invariant system the output is the convolution of the input with the impulse response.

Step 1 – recall the definition of $h(t)$: $h(t)$ is the output when the input is a unit impulse $\delta(t)$.

Step 2 – decompose a general input: Any input $x(t)$ can be viewed as a continuum of scaled, shifted impulses.

Step 3 – superpose the responses: By linearity and time invariance, the total output is $y(t) = \int_{-\infty}^{\infty} x(\tau)\, h(t-\tau)\, d\tau = x(t) * h(t)$, the convolution integral.

Why the other options are wrong:

- B, product: multiplication in time is not how an LTI system combines input and impulse response.
- C, sum: simply adding the signals has no physical basis here.
- D, ratio: division of the two signals is meaningless as a system response.

Final Answer: $y(t) = x(t) * h(t) \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q13

Q14.

Solution

Concept – op-amp with no feedback: An op-amp has enormous open-loop gain, so even a tiny input difference drives the output to a rail.

Step 1 – note the absence of feedback: There is no resistor from the output back to an input, so the amplifier runs open-loop.

Step 2 – analyse the output behaviour: If $V_{in} > V_{ref}$ the difference at the inputs pushes the output to one saturation rail; if $V_{in} < V_{ref}$ it swings to the other rail.

Step 3 – name the circuit: A device that outputs a two-state (high/low) signal indicating which input is larger is a comparator.

Why the other options are wrong:

- A, integrator: needs a capacitor in the feedback path.
- C, summing amplifier: needs multiple input resistors and a feedback resistor.
- D, voltage follower: needs direct output-to-input feedback and stays linear.

Final Answer: comparator $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q14

Q15.

Solution

Concept – hysteresis in a switching circuit: Two separate thresholds for rising and falling input is the signature of hysteresis.

Step 1 – read the characteristic: As V_{in} increases, the output flips only when it reaches the upper threshold V_{TH}; as V_{in} decreases, it flips back only at the lower threshold V_{TL}.

Step 2 – recognise the loop: Because $V_{TH} \neq V_{TL}$, the transfer curve traces a loop rather than a single line.

Step 3 – name the circuit: A comparator that has this deliberate gap between its two thresholds is a Schmitt trigger.

Why the other options are wrong:

- A, linear amplifier: has a single-valued straight-line characteristic, not a loop.
- C, integrator: produces a ramp output, not a two-level one.
- D, low-pass filter: attenuates high frequencies and has no switching thresholds.

Final Answer: Schmitt trigger $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q15

Q16.

Solution

Concept – why hysteresis helps with noise: Noise near a single threshold causes repeated unwanted crossings.

Step 1 – describe the problem with a plain comparator: When a noisy signal hovers near the single threshold, small noise excursions push it back and forth, so the output chatters between states.

Step 2 – apply the Schmitt trigger: Its two separated thresholds mean that once the output switches, the input must move by the full hysteresis gap before it can switch back.

Step 3 – state the benefit: If the noise amplitude is smaller than the hysteresis gap, these false multiple transitions are suppressed and the output stays clean.

Why the other options are wrong:

- A, gain: hysteresis does not change the open-loop gain.
- B, DC offset: a Schmitt trigger does not remove offsets.
- D, supply voltage: it has no effect on the required supply.

Final Answer: it prevents false multiple transitions through hysteresis $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q16

Q17.

Solution

Concept – XOR truth table: An exclusive-OR gate outputs 1 only when its inputs differ.

Step 1 – write the XOR rule: $Y = A \oplus B$, which is 1 when exactly one input is 1 and 0 when the inputs are equal.

Step 2 – apply the given inputs: Here $A = 1$ and $B = 1$, so the inputs are equal.

Step 3 – read the output: Since both inputs are the same, $Y = 1 \oplus 1 = 0$.

Why the other options are wrong:

- A, 1: would require the inputs to differ.
- B, high impedance: applies to tri-state buffers, not a logic gate driven to a valid level.
- C, undefined: the XOR output is well defined for valid inputs.

Final Answer: $Y = 0 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q17

Q18.

Solution

Concept – bits and levels in a converter: An n-bit converter has 2^n distinct levels.

Step 1 – write the relation: Number of levels $= 2^n$, where n is the number of bits.

Step 2 – set it equal to the given count: $2^n = 1024$

Step 3 – solve for n: $1024 = 2^{10}$, so $n = 10$.

Why the other options are wrong:

- A, 8: gives $2^8 = 256$ levels.

- C, 12: gives $2^{12} = 4096$ levels.
- D, 1024: confuses the number of levels with the number of bits.

Final Answer: $n = 10$ bits $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q18

Q19.

Solution

Concept – thresholds of a non-inverting Schmitt trigger: $V_{TH} = +\frac{R_1}{R_2}V_{sat}$ and $V_{TL} = -\frac{R_1}{R_2}V_{sat}$.

Step 1 – list the data: $V_{sat} = 10$ V, $R_1 = 1$ kΩ, $R_2 = 10$ kΩ.

Step 2 – form the feedback ratio: $\frac{R_1}{R_2} = \frac{1}{10} = 0.1$

Step 3 – find each threshold: $V_{TH} = 0.1 \times 10 = +1$ V

$V_{TL} = -0.1 \times 10 = -1$ V

Step 4 – compute the hysteresis width: $V_{TH} - V_{TL} = 1 - (-1) = 2$ V

Why the other options are wrong:

- A, 10 V: is the saturation voltage, not the threshold gap.
- B, 0.5 V: ignores the factor of two between the two thresholds.
- C, 20 V: is the full rail-to-rail output swing $2V_{sat}$, not the input hysteresis.

Final Answer: hysteresis $= 2$ V $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q19

Q20.

Solution

Concept – RTD characteristic: A resistance temperature detector uses a metal whose resistance rises with temperature.

Step 1 – read the curve: The plotted resistance climbs steadily and almost as a straight line as temperature increases.

Step 2 – identify the coefficient sign: A rising resistance means a positive temperature coefficient of resistance.

Step 3 – link to platinum: Platinum is chosen precisely because its resistance increases nearly linearly with temperature over a wide range, which makes calibration easy.

Why the other options are wrong:

- A, decreases exponentially: describes an NTC thermistor, not an RTD.
- C, independent of temperature: would make the device useless as a thermometer.
- D, decreases linearly: has the wrong sign of slope.

Final Answer: resistance increases nearly linearly (positive temperature coefficient) $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q20

Q21.

Solution

Concept – linear RTD equation: $R = R_0(1 + \alpha T)$.

Step 1 – list the data: $R_0 = 100\ \Omega$, $\alpha = 0.00385\ ^\circ\text{C}^{-1}$, $T = 100\ ^\circ\text{C}$.

Step 2 – form the product αT: $\alpha T = 0.00385 \times 100 = 0.385$

Step 3 – add one: $1 + \alpha T = 1 + 0.385 = 1.385$

Step 4 – multiply by R_0: $R = 100 \times 1.385$

$R = 138.5\ \Omega$

Why the other options are wrong:

- B, $100\ \Omega$: is the value at $0\ ^\circ\text{C}$, ignoring the temperature rise.
- C, $385\ \Omega$: misplaces a factor and is far too large.
- D, $3.85\ \Omega$: is only the change term without adding R_0 correctly.

Final Answer: $R = 138.5\ \Omega \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q21

Q22.

Solution

Concept – electromagnetic flowmeter: A conductor (blood) moving through a magnetic field develops an EMF.

Step 1 – set up the physics: The meter applies a magnetic field across the vessel. Flowing blood is a moving electrical conductor.

Step 2 – apply Faraday's law: By electromagnetic induction, an EMF is generated across electrodes placed perpendicular to both the flow and the field: $e = B\,L\,v$.

Step 3 – link EMF to velocity: Since B and L are fixed, the measured EMF is directly proportional to the flow velocity v.

Why the other options are wrong:

- A, Doppler shift: is the principle of an ultrasonic flowmeter, not the electromagnetic one.
- C, thermal cooling: describes a hot-wire/thermal flowmeter.
- D, differential pressure: describes an orifice or venturi meter.

Final Answer: Faraday's law of electromagnetic induction $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q22

Q23.

Solution

Concept – induced EMF in an electromagnetic flowmeter: $e = B\,L\,v$.

Step 1 – list the data: $B = 0.1$ T, $L = 0.02$ m, $v = 0.5$ m/s.

Step 2 – multiply the first two factors: $B\,L = 0.1 \times 0.02 = 0.002$

Step 3 – multiply by the velocity: $e = 0.002 \times 0.5 = 0.001$ V

Step 4 – convert to millivolts: $e = 0.001$ V $= 1$ mV

Why the other options are wrong:

- A, 10 mV: is ten times too large (a decimal-place slip).
- B, 0.1 mV: is ten times too small.
- D, 100 mV: is a hundred times too large.

Final Answer: $e = 1$ mV $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q23

Q24.

Solution

Concept – ultrasonic Doppler flowmeter: A reflected ultrasound wave changes frequency when it bounces off moving blood cells.

Step 1 – describe the measurement: A transducer transmits ultrasound; red blood cells moving with the flow reflect it back.

Step 2 – identify the Doppler effect: Because the reflectors are moving, the received frequency differs from the transmitted frequency by the Doppler shift Δf.

Step 3 – relate to velocity: The shift is proportional to the flow velocity, so measuring Δf gives the blood velocity.

Why the other options are wrong:

- A, attenuation: is not how a Doppler meter extracts velocity.
- C, acoustic impedance: relates to reflection strength, not to velocity.
- D, absolute transit time: is the principle of a transit-time flowmeter, a different method.

Final Answer: the frequency shift of the reflected ultrasound $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q24

Q25.

Solution

Concept – thermocouple EMF: The Seebeck EMF is the Seebeck coefficient times the junction temperature difference, $e = S\,\Delta T$.

Step 1 – list the data: $S = 41\ \mu$V/°C, $\Delta T = 50$ °C.

Step 2 – multiply: $e = 41 \times 50\ \mu$V

$e = 2050\ \mu$V

Step 3 – convert to millivolts: $e = 2050\ \mu\text{V} = 2.05$ mV

Why the other options are wrong:

- A, 0.82 mV: uses $\Delta T = 20$ °C by mistake.
- C, 20.5 mV: is ten times too large (a decimal slip).
- D, 0.41 mV: corresponds to only a 10 °C difference.

Final Answer: $e = 2.05$ mV $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q25

Q26.

Solution

Concept – Nyquist sampling criterion: To avoid aliasing, the sampling rate must be at least twice the highest signal frequency, $f_s \geq 2f_{max}$.

Step 1 – identify the highest frequency: The diagnostic ECG has content up to $f_{max} = 150$ Hz.

Step 2 – apply the Nyquist rule: $f_{s,min} = 2 \times f_{max}$

Step 3 – substitute: $f_{s,min} = 2 \times 150$

$f_{s,min} = 300$ Hz

Why the other options are wrong:

- A, 150 Hz: equals f_{max} and would alias the signal.
- B, 75 Hz: is only half of f_{max}, far below Nyquist.
- D, 1500 Hz: is valid but is not the *minimum* required rate.

Final Answer: $f_{s,min} = 300$ Hz $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q26

Q27.

Solution

Concept – heart rate from the R–R interval: $\text{HR (bpm)} = \dfrac{60}{\text{R–R interval in seconds}}$.

Step 1 – read the interval: The R–R interval marked on the trace is 0.8 s.

Step 2 – substitute: $\text{HR} = \dfrac{60}{0.8}$

Step 3 – divide: $\text{HR} = 75$ bpm

Step 4 – interpret: A rate of 75 bpm lies in the normal resting range (60–100 bpm).

Why the other options are wrong:

- B, 80 bpm: would need an interval of 0.75 s.
- C, 48 bpm: would need an interval of 1.25 s.
- D, 125 bpm: would need an interval of about 0.48 s.

Final Answer: HR $= 75$ bpm $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q27

Q28.

Solution

Concept – classifying heart rate: Rhythm labels depend on the resting rate.

Step 1 – recall the normal range: A normal resting adult heart rate is 60–100 bpm.

Step 2 – apply the threshold: A sustained rate below 60 bpm falls under the medical term "brady-" (slow).

Step 3 – name the condition: A slow heart rate below 60 bpm is bradycardia.

Why the other options are wrong:

- A, tachycardia: is a fast rate, above 100 bpm.
- B, atrial fibrillation: is an irregular chaotic rhythm, not defined simply by a slow rate.
- D, normal sinus rhythm: is 60–100 bpm, which excludes rates below 60.

Final Answer: bradycardia $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q28

Q29.

Solution

Concept – classifying a fast rhythm: The rate follows from the R–R spacing; the QRS shape tells whether it is normal conduction.

Step 1 – read the rate: Closely spaced beats giving about 150 bpm are well above the normal upper limit of 100 bpm.

Step 2 – check the QRS: The QRS complexes are of normal shape, so the beats are being conducted normally, just too fast.

Step 3 – assign the label: A regular rhythm faster than 100 bpm is tachycardia.

Why the other options are wrong:

- B, bradycardia: is a slow rate below 60 bpm, the opposite of what is shown.
- C, asystole: means no beats at all (a flat line).
- D, normal at 72 bpm: contradicts the measured 150 bpm.

Final Answer: tachycardia $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q29

Q30.

Solution

Concept – classical QRS-detection algorithm: Real-time R-peak detection uses a chain of simple signal-processing stages.

Step 1 – recall the processing chain: Band-pass filter to isolate the QRS energy, then differentiate to emphasise the steep slopes, then square to make everything positive and boost large slopes, then a moving-window integrator to obtain waveform-feature information.

Step 2 – name the method: This specific sequence is the Pan–Tompkins algorithm, the standard real-time QRS detector.

Step 3 – confirm its use: It is widely implemented in heart-rate monitors and arrhythmia detectors for its robustness and low computation.

Why the other options are wrong:

- A, DFT: gives a spectrum but does not directly locate R-peaks in time.
- B, Goertzel: detects a single fixed tone, not QRS complexes.
- C, Levinson–Durbin: solves for linear-prediction coefficients, not R-peak timing.

Final Answer: Pan–Tompkins algorithm $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q30

Q31.

Solution

Concept – contrast enhancement by redistributing intensities: Spreading the pixel values over the full range improves contrast.

Step 1 – describe the problem: A low-contrast image has its pixel intensities bunched into a narrow band of the available range.

Step 2 – apply the remedy: Histogram equalization remaps the intensities using the cumulative distribution so that the output histogram is spread more uniformly across the full range.

Step 3 – state the effect: This stretches the contrast and makes previously faint structures more visible.

Why the other options are wrong:

- B, thresholding: converts the image to two levels and discards grey detail.
- C, convolution with a unit impulse: leaves the image unchanged.
- D, down-sampling: reduces resolution and does not enhance contrast.

Final Answer: histogram equalization $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q31

Q32.

Solution

Concept – median filtering of impulse noise: The median is robust to extreme outlier pixel values.

Step 1 – describe salt-and-pepper noise: It consists of scattered pixels set to the extreme black or white values.

Step 2 – see why the median works: The median of a neighbourhood ignores these few extreme outliers, replacing a noisy pixel with a representative local value.

Step 3 – note the edge preservation: Because the median picks an actual local value rather than averaging, sharp edges are kept while the impulses are removed.

Why the other options are wrong:

- A, increases brightness: the median filter does not systematically brighten the image.
- B, blurs edges more: that is the drawback of the mean filter, not the median.
- C, amplifies high frequencies: median filtering is a smoothing operation, not a sharpening one.

Final Answer: it removes impulse noise while preserving edges $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q32

Q33.

Solution

Concept – gray levels for a given bit depth: Number of gray levels $= 2^b$, where b is bits per pixel.

Step 1 – list the data: $b = 8$ bits per pixel.

Step 2 – substitute: Levels $= 2^8$

Step 3 – evaluate: $2^8 = 256$

Why the other options are wrong:

- A, 8: confuses bit depth with the number of levels.
- B, 64: is 2^6, i.e. only 6 bits.
- C, 512: is 2^9, i.e. 9 bits.

Final Answer: 256 gray levels $\Rightarrow \boxed{\text{D}}$

$\boxed{\text{Answer: (D)}}$ Go Back to Q33

Q34.

Solution

Concept – which modality avoids ionizing radiation: Different modalities rely on different physics; only some use ionizing radiation.

Step 1 – classify by radiation: CT, planar X-ray and PET all involve ionizing radiation (X-rays or gamma rays).

Step 2 – identify the exception: MRI uses a strong static magnetic field and radio-frequency pulses; it involves no ionizing radiation.

Step 3 – confirm the signal source: MRI forms its image from the nuclear magnetic relaxation of hydrogen protons in tissue water and fat.

Why the other options are wrong:

- A, CT: uses ionizing X-rays.
- C, PET: uses gamma rays from a radioactive tracer.
- D, planar X-ray: uses ionizing X-rays.

Final Answer: magnetic resonance imaging (MRI) $\Rightarrow \boxed{\text{B}}$

$\boxed{\text{Answer: (B)}}$ Go Back to Q34

Q35.

Solution

Concept – CT image reconstruction: A slice must be rebuilt from many one-dimensional projections.

Step 1 – describe the data: The scanner records line-integral projections of the slice at many angles around the patient.

Step 2 – recall the reconstruction method: Simple back-projection alone gives a blurred image, so each projection is first filtered (ramp filter) and then back-projected.

Step 3 – name the standard technique: This is filtered back-projection, the classical analytic CT reconstruction algorithm.

Why the other options are wrong:

- A, histogram equalization: is a contrast operation, not a reconstruction.
- B, inverse Fourier of one projection: a single view is insufficient; the full angular set is required.
- C, thresholding: is a segmentation step, not reconstruction.

Final Answer: filtered back-projection $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q35

Q36.

Solution

Concept – traditional dental restorative material: Direct fillings need a workable, strong, durable material.

Step 1 – recall the composition: Dental amalgam is formed by mixing liquid mercury with a powdered silver–tin alloy, which then hardens in the cavity.

Step 2 – note its advantages: It is easy to place, strong in compression, wear resistant and inexpensive, which made it the classic filling material.

Step 3 – match to the question: The mercury–silver–tin alloy used for fillings is dental amalgam.

Why the other options are wrong:

- A, stainless steel: is used for instruments and temporary crowns, not as a plastic filling.
- B, titanium: is used for implants, not direct fillings.

- D, cobalt–chromium: is used for cast partial-denture frameworks, not amalgam fillings.

Final Answer: dental amalgam $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q36

Q37.

Solution

Concept – axial (normal) stress: $\sigma = \dfrac{F}{A}$.

Step 1 – list the data in base units: $F = 2000$ N, $A = 200\ \text{mm}^2 = 200 \times 10^{-6}\ \text{m}^2 = 2 \times 10^{-4}\ \text{m}^2$.

Step 2 – substitute: $\sigma = \dfrac{2000}{2 \times 10^{-4}}$

Step 3 – divide the coefficients: $\dfrac{2000}{2} = 1000$

Step 4 – handle the power of ten: $\dfrac{1}{10^{-4}} = 10^4$, so $\sigma = 1000 \times 10^4 = 10^7$ Pa

Step 5 – convert to megapascals: $\sigma = 10^7$ Pa $= 10$ MPa

Why the other options are wrong:

- A, 100 MPa: is ten times too large (an area-unit slip).
- B, 1 MPa: is ten times too small.
- C, 20 MPa: would need double the load or half the area.

Final Answer: $\sigma = 10$ MPa $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q37

Q38.

Solution

Concept – stress shielding and modulus mismatch: Load sharing between an implant and bone depends on their relative stiffness.

Step 1 – compare the moduli: Titanium alloy has $E \approx 110$ GPa, while cortical bone has $E \approx 18$ GPa.

Step 2 – reason about load sharing: Two parallel load paths share load in proportion to their stiffness, so the much stiffer titanium carries most of the load.

Step 3 – explain the bone response: The surrounding bone is then under-loaded;

by Wolff's law, unloaded bone gradually resorbs. This is stress shielding.

Why the other options are wrong:

- A, equal to bone: if the moduli matched there would be no shielding.
- C, much lower: is factually wrong; titanium is stiffer than bone.
- D, zero: titanium has a large, non-zero modulus.

Final Answer: much higher than that of cortical bone $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q38

Q39.

Solution

Concept – Young's modulus from the stress–strain curve: In the elastic region, stress is proportional to strain, $\sigma = E\,\varepsilon$.

Step 1 – identify the elastic region: It is the initial straight portion of the curve from the origin.

Step 2 – relate modulus to the graph: Rearranging, $E = \dfrac{\sigma}{\varepsilon}$, which is precisely the slope (rise over run) of that straight line.

Step 3 – read it from the figure: The dashed triangle shows the slope of the linear region, and that slope equals E.

Why the other options are wrong:

- A, area under the curve: represents toughness (energy absorbed), not the modulus.
- C, strain-axis intercept: relates to residual/plastic strain, not stiffness.
- D, peak stress: is the ultimate strength, not the modulus.

Final Answer: slope of the linear (elastic) region $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q39

Q40.

Solution

Concept – bioactive implant coating: A coating that bonds to bone must resemble bone mineral.

Step 1 – recall bone's mineral phase: Natural bone mineral is a calcium phosphate, essentially hydroxyapatite.

Step 2 – match the coating: Coating a metal implant with hydroxyapatite gives a bioactive surface that bone cells recognise and bond to.

Step 3 – state the benefit: This promotes osseointegration, improving the fixation of orthopaedic and dental implants.

Why the other options are wrong:

- B, soda-lime glass: is a common window glass, not a bioactive bone-bonding coating.
- C, PMMA: is a bone cement/spacer, not a bioceramic that mimics bone mineral.
- D, silicone rubber: is a soft, bioinert elastomer used for other purposes.

Final Answer: hydroxyapatite $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q40

Q41.

Solution

Concept – moment (torque) balance about a pivot: For static equilibrium the clockwise and anticlockwise moments about the joint are equal.

Step 1 – list the data: Muscle force F_m acts at $d_m = 4$ cm; load $W = 60$ N acts at $d_W = 24$ cm.

Step 2 – write the moment balance: $F_m \times d_m = W \times d_W$

Step 3 – substitute the values: $F_m \times 4 = 60 \times 24$

Step 4 – evaluate the right side: $60 \times 24 = 1440$

Step 5 – solve for F_m: $F_m = \dfrac{1440}{4} = 360$ N

Why the other options are wrong:

- A, 60 N: ignores the lever-arm ratio entirely.
- B, 240 N: uses a wrong arm ratio.
- D, 1440 N: forgets to divide by the muscle arm of 4 cm.

Final Answer: $F_m = 360$ N $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q41

Q42.

Solution

Concept – closed-loop transfer function with unity feedback: For negative feedback, $\dfrac{C}{R} = \dfrac{G}{1+GH}$.

Step 1 – write the summing-junction equation: The error is $E(s) = R(s) - H(s)\,C(s)$; with unity feedback $H(s) = 1$, so $E(s) = R(s) - C(s)$.

Step 2 – write the forward-path equation: $C(s) = G(s)\,E(s) = G(s)\big(R(s) - C(s)\big)$

Step 3 – expand: $C(s) = G(s)R(s) - G(s)C(s)$

Step 4 – collect $C(s)$ terms: $C(s) + G(s)C(s) = G(s)R(s)$

$C(s)\big(1 + G(s)\big) = G(s)R(s)$

Step 5 – solve for the ratio: $\dfrac{C(s)}{R(s)} = \dfrac{G(s)}{1+G(s)}$

Why the other options are wrong:

- B, $\dfrac{G}{1-G}$: is the positive-feedback result.
- C, $1+G$: is only the denominator term, not the full ratio.
- D, G: is the open-loop gain, ignoring feedback.

Final Answer: $\dfrac{C}{R} = \dfrac{G}{1+G} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q42

Q43.

Solution

Concept – period from pacing rate: Interval (s) $= \dfrac{60}{\text{rate in pulses per minute}}$.

Step 1 – list the data: Rate $= 60$ pulses per minute.

Step 2 – substitute: $T = \dfrac{60}{60}$

Step 3 – evaluate: $T = 1$ s

Step 4 – interpret: At 60 ppm the pacemaker issues exactly one pulse every second.

Why the other options are wrong:

- B, 0.5 s: corresponds to 120 ppm.
- C, 2 s: corresponds to 30 ppm.

- D, 60 s: confuses the per-minute rate with the interval.

Final Answer: $T = 1\text{ s} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q43

Q44.

Solution

Concept – energy stored in a capacitor: $E = \frac{1}{2}CV^2$.

Step 1 – list the data in base units: $C = 100\ \mu\text{F} = 100 \times 10^{-6}$ F, $V = 3000$ V.

Step 2 – square the voltage: $V^2 = (3000)^2 = 9 \times 10^6\ \text{V}^2$

Step 3 – multiply by the capacitance: $CV^2 = 100 \times 10^{-6} \times 9 \times 10^6$

Step 4 – combine coefficients and powers of ten: $100 \times 9 = 900$ and $10^{-6} \times 10^6 = 10^0 = 1$, so $CV^2 = 900$

Step 5 – apply the factor one-half: $E = \frac{1}{2} \times 900 = 450$ J

Why the other options are wrong:

- A, 150 J: uses a wrong numerical factor.
- B, 300 J: drops the one-half incorrectly.
- D, 900 J: forgets the factor of one-half.

Final Answer: $E = 450\text{ J} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q44

Q45.

Solution

Concept – demand versus fixed-rate pacing: Modern pacemakers usually sense the heart before deciding to stimulate.

Step 1 – describe sensing: A demand pacemaker continuously monitors the intrinsic cardiac electrical activity.

Step 2 – describe the response: If a natural beat occurs within the set escape interval, the pacemaker inhibits its output; only if the beat is missing does it deliver a stimulus.

Step 3 – name the mode: This sense-and-inhibit behaviour defines the demand (synchronous) pacemaker.

Why the other options are wrong:

- B, fixed-rate (asynchronous) pacemaker: paces at a constant rate regardless of the heart's own beats.
- C, external defibrillator: delivers a high-energy shock to stop fibrillation, not routine pacing.
- D, Holter monitor: only records the ECG; it does not pace.

Final Answer: demand (synchronous) pacemaker $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q45

Q46.

Solution

Concept – peak discharge current: At the instant of discharge the capacitor voltage appears across the patient, so $I = \dfrac{V}{R}$.

Step 1 – list the data: $V = 2000$ V, $R = 50\ \Omega$.

Step 2 – substitute: $I = \dfrac{2000}{50}$

Step 3 – divide: $I = 40$ A

Step 4 – interpret: This large initial current is what depolarises the myocardium during defibrillation, then decays as the capacitor discharges.

Why the other options are wrong:

- A, 100 A: would require $R = 20\ \Omega$.
- B, 10 A: would require $R = 200\ \Omega$.
- C, 4 A: is ten times too small (a decimal slip).

Final Answer: $I = 40$ A $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q46

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	D	3	C	4	A	5	C
6	D	7	C	8	C	9	B	10	D
11	B	12	A	13	A	14	B	15	B
16	C	17	D	18	B	19	D	20	B
21	A	22	B	23	C	24	B	25	B
26	C	27	A	28	C	29	A	30	D
31	A	32	D	33	D	34	B	35	D
36	C	37	D	38	B	39	B	40	A
41	C	42	A	43	A	44	C	45	A
46	D								