EOCS

Egyptian Olympiad in Computational Science

Sample Questions Bank

2026

Computational Fields

Biology • Chemistry • Physics • Mathematics

Contents

1. Computational Biology

1.1. Biology Exam 1

Easy

1.

In Mendelian genetics, if a trait is autosomal dominant, which description correctly identifies an affected individual?

(a) They must be homozygous dominant (AA).

(b) They carry at least one dominant allele.

(c) They must have two recessive alleles.

(d) They cannot pass the trait to offspring.

Answer: b

Solution: An autosomal dominant trait is expressed when at least one dominant allele is present, so affected individuals may be AA or Aa.

2.

What is the narrow space between an axon terminal and the next neuron's membrane called?

(a) Axon hillock

(b) Synaptic cleft

(c) Myelin sheath

(d) Node of Ranvier

Answer: b

Solution: The synaptic cleft is the small extracellular gap across which neurotransmitters diffuse during chemical synaptic transmission.

3.

In a population with allele frequency $p(A) = 0.7$, what is the frequency of the alternative allele a?

(a) 0.7

(b) 0.49

(c) 0.3

(d) 1.7

Answer: c

Solution: For a two-allele locus, allele frequencies sum to one. Therefore $q(a) = 1 - 0.7 = 0.3$.

Moderate

4.

A sensory neuron receives weak and strong stimuli. Both produce action potentials with the same amplitude, but the stronger stimulus feels more intense. What best explains this?

(a) The stronger stimulus increases spike amplitude.

(b) The stronger stimulus increases firing frequency.

(c) The stronger stimulus removes the refractory period.

(d) The stronger stimulus changes the axon diameter immediately.

Answer: b

Solution: Action potentials are all-or-none, so intensity is commonly encoded by firing rate rather than by spike amplitude.

5.

A population has genotype frequencies $AA = 0.25$, $Aa = 0.50$, and $aa = 0.25$. What is $p(A)$, and is this consistent with Hardy–Weinberg equilibrium?

(a) $p = 0.25$; not consistent

(b) $p = 0.50$; consistent

(c) $p = 0.75$; consistent

(d) $p = 0.50$; not consistent

Answer: b

Solution: The allele frequency is $p = 0.25 + 0.50/2 = 0.50$. Expected frequencies are $p^2 = 0.25$, $2pq = 0.50$, and $q^2 = 0.25$, matching the observations.

Difficult

6.

Two species differ at 12% of homologous DNA sites. If substitutions accumulate independently in each lineage at 1.5% per million years, when did they diverge?

(a) 4 million years ago

(b) 8 million years ago

(c) 12 million years ago

(d) 18 million years ago

Answer: a

Solution: The total divergence accumulates across two lineages, so each lineage contributes 6%. At 1.5% per million years, the divergence time is $6/1.5 = 4$ million years.

1.2. Biology Exam 2

Easy

1.

Which molecule is the primary carrier of inherited genetic information in cells?

(a) DNA

(b) ATP

(c) Glucose

(d) Cholesterol

Answer: a

Solution: DNA stores hereditary information in its nucleotide sequence.

2.

What insulating material allows action potentials to travel faster along many axons?

(a) Actin

(b) Myelin

(c) Hemoglobin

(d) Collagen

Answer: b

Solution: Myelin electrically insulates axons and supports rapid saltatory conduction between nodes of Ranvier.

3.

Which evolutionary process is random sampling error that is strongest in small populations?

(a) Genetic drift

(b) Gene flow

(c) Natural selection

(d) Nonrandom mating

Answer: a

Solution: Genetic drift is random fluctuation in allele frequencies, and its effects are strongest when population size is small.

Moderate

4.

The figure shows an ion channel changing from closed to open. Which conclusion is most accurate?

(a) A protein conformational change allows ions to move across the membrane.

(b) The channel destroys all ion gradients immediately.

(c) The channel must always cause an action potential.

(d) The channel prevents any future voltage change.

Answer: a

Solution: Ion channels open through conformational changes, allowing selective ion flow that may depolarize or hyperpolarize the membrane.

5.

A recessive disease allele has frequency $q = 0.2$ under Hardy–Weinberg equilibrium. What fraction of the population is expected to be affected?

(a) 0.2

(b) 0.04

(c) 0.32

(d) 0.8

Answer: b

Solution: Affected individuals are homozygous recessive, so their expected frequency is $q^2 = (0.2)^2 = 0.04$.

Difficult

6.

In a Hardy–Weinberg population, the affected frequency for a recessive disorder is 0.01. What is the expected carrier frequency?

(a) 0.01

(b) 0.09

(c) 0.18

(d) 0.81

Answer: c

Solution: For a recessive disorder, $q^2 = 0.01$, so $q = 0.1$ and $p = 0.9$. The carrier frequency is $2pq = 2(0.9)(0.1) = 0.18$.

2. Computational Chemistry

2.1. Chemistry Exam 1

Easy

1.

A program calculates root-mean-square gas speed, which scales as $\sqrt{T/M}$. If temperature is constant and molar mass becomes four times larger, how does the computed speed scale?

(a) It doubles.

(b) It is cut in half.

(c) It quadruples.

(d) It is quartered.

Answer: b

Solution: Because $v_{rms} = \sqrt{3RT/M}$, speed is inversely proportional to $\sqrt{M}$ at fixed temperature. Increasing M by 4 multiplies speed by $1/\sqrt{4} = 1/2$.

2.

An electroplating simulator uses Faraday's law. With current $I = 2.0$ A for $t = 96.5$ s and $F \approx 96500$ C/mol, how many moles of electrons are transferred?

(a) 0.002 mol

(b) 0.001 mol

(c) 0.200 mol

(d) 2.000 mol

Answer: a

Solution: The electron moles are $n_e = It/F = (2.0)(96.5)/96500 = 193/96500 = 0.002$ mol.

3.

A drug discovery model calculates topological polar surface area by scanning for highly electronegative atoms such as N and O covalently bonded to hydrogen. Which intermolecular force is being mapped?

(a) London dispersion forces

(b) Hydrogen bonding

(c) Covalent network bonding

(d) Ion–dipole interactions

Answer: b

Solution: Hydrogen bonding is associated with H atoms bonded to electronegative atoms such as N or O, which strongly influence polarity and membrane permeability.

Moderate

4.

For a reaction $aA + bB \rightarrow cC$ with initial moles n_A and n_B, which inequality triggers the flag that reactant A is limiting?

(a) $n_A/b < n_B/a$

(b) $n_A a < n_B b$

(c) $n_A/a < n_B/b$

(d) $n_A - a < n_B - b$

Answer: c

Solution: Limiting-reagent comparison uses moles divided by stoichiometric coefficient. Reactant A is limiting when $n_A/a < n_B/b$.

5.

For a non-linear molecule of N atoms, total degrees of freedom are $3N$. After subtracting 3 translational and 3 rotational degrees, how many vibrational degrees of freedom remain?

(a) $3N - 3$

(b) $3N - 5$

(c) $3N$

(d) $3N - 6$

Answer: d

Solution: A non-linear molecule has 3 translational and 3 rotational degrees of freedom. The vibrational degrees of freedom are therefore $3N - 6$.

Difficult

6.

For $2A(g) \rightleftharpoons B(g)$ in a fixed volume, initial A pressure is P_0 and B starts at zero. At equilibrium, A drops by $2x$ and B gains x. Which formula is generated for K_p?

(a) $K_p = \dfrac{x}{(P_0 - 2x)^2}$

(b) $K_p = \dfrac{x}{(P_0 - x)^2}$

(c) $K_p = \dfrac{2x}{(P_0 - 2x)^2}$

(d) $K_p = \dfrac{x^2}{P_0 - 2x}$

Answer: a

Solution: Mass action for $2A(g) \rightleftharpoons B(g)$ is $K_p = P_B/P_A^2$. Substituting $P_B = x$ and $P_A = P_0 - 2x$ gives $K_p = \frac{x}{(P_0-2x)^2}$.

2.2. Chemistry Exam 2

Easy

1.

A Le Chatelier script halves the volume of a gas-phase equilibrium container, increasing pressure. If the product side has fewer gas moles, what happens to product concentration?

(a) It increases.

(b) It decreases.

(c) It remains entirely unchanged.

(d) It instantly drops to zero.

Answer: a

Solution: Increasing pressure shifts equilibrium toward the side with fewer gas moles. If products have fewer moles, the equilibrium shifts toward products, increasing their concentration.

2.

For $A \rightleftharpoons B$, steady-state concentrations are $[A] = 2.0$ M and $[B] = 8.0$ M. What is K_c?

(a) 0.25

(b) 2.0

(c) 16.0

(d) 4.0

Answer: d

Solution: Mass action gives $K_c = [B]/[A] = 8.0/2.0 = 4.0$.

3.

A tool selects the most polar single-bonded diatomic molecule by greatest electronegativity difference. Which option has the highest polarity score?

(a) F_2

(b) ClF

(c) HF

(d) HCl

Answer: c

Solution: Bond polarity increases with electronegativity difference. The H–F bond has the largest difference among the listed choices.

Moderate

4.

A kinetic model observes that doubling $[X]$ increases rate R by a factor of 4. If $R = k[X]^n$, what reaction order n is assigned?

(a) 0

(b) 1

(c) 2

(d) 3

Answer: c

Solution: Doubling concentration changes the rate by 2^n. Since $2^n = 4$, $n = 2$.

5.

A potential-energy surface algorithm finds a stationary point where the first derivative is zero and the point is a minimum in all directions except one, where it is a maximum. What has it located?

(a) A ground-state global minimum

(b) A completely unbound state

(c) A thermodynamic equilibrium

(d) A reaction transition state

Answer: d

Solution: A transition state is a first-order saddle point on a potential-energy surface: minimum-like in all but one direction and maximum-like along the reaction coordinate.

Difficult

6.

A weak acid HA dissociates into H^+ and A^-. Given $\alpha = [A^-]/([HA] + [A^-])$ and $K_a = [H^+][A^-]/[HA]$, which formula computes α using only $[H^+]$ and K_a?

(a) $\alpha = \dfrac{K_a}{K_a + [H^+]}$

(b) $\alpha = \dfrac{[H^+]}{K_a + [H^+]}$

(c) $\alpha = K_a[H^+]$

(d) $\alpha = \dfrac{K_a + [H^+]}{K_a}$

Answer: a

Solution: From $K_a = [H^+][A^-]/[HA]$, rearrange $[HA] = [H^+][A^-]/K_a$. Substitute into α: $\alpha = \frac{[A^-]}{[H^+][A^-]/K_a + [A^-]} = \frac{1}{[H^+]/K_a + 1} = \frac{K_a}{K_a + [H^+]}$.

3. Computational Physics

3.1. Physics Exam 1

Easy

1.

If two masses M and m are separated by distance r, which expression defines the magnitude of the gravitational force between them?

(a) $F = \dfrac{GMm}{r}$

(b) $F = \dfrac{GMm}{r^2}$

(c) $F = \dfrac{G(M+m)}{r^2}$

(d) $F = GMmr$

Answer: b

Solution: Newton's law of universal gravitation gives $F = GMm/r^2$.

2.

Pressure is force distributed over area. Which expression correctly defines pressure P?

(a) $P = FA$

(b) $P = \dfrac{A}{F}$

(c) $P = \dfrac{F}{A}$

(d) $P = F + A$

Answer: c

Solution: Pressure is force per unit area: $P = F/A$.

3.

A wave has frequency f and wavelength λ. Which expression relates wave speed v to these quantities?

(a) $v = f\lambda$

(b) $v = \dfrac{\lambda}{f}$

(c) $v = \dfrac{f}{\lambda}$

(d) $v = f + \lambda$

Answer: a

Solution: Wave speed equals frequency times wavelength: $v = f\lambda$.

Moderate

4.

For a planet of mass m in a circular orbit of radius r around a star of mass M, which expression gives the total mechanical energy E?

(a) $E = +\dfrac{GMm}{2r}$

(b) $E = -\dfrac{GMm}{2r}$

(c) $E = -\dfrac{GMm}{r}$

(d) $E = 0$

Answer: b

Solution: Using $v^2 = GM/r$, $K = GMm/(2r)$ and $U = -GMm/r$. Therefore $E = K + U = -GMm/(2r)$.

5.

For SHM with amplitude A and angular frequency ω, which expression gives maximum acceleration a_{max}?

(a) $a_{max} = \omega A$

(b) $a_{max} = A/\omega^2$

(c) $a_{max} = \omega^2 A$

(d) $a_{max} = \omega^2/A$

Answer: c

Solution: For $x(t) = A\cos(\omega t + \phi)$, $a(t) = -A\omega^2\cos(\omega t + \phi)$. The maximum magnitude is $A\omega^2$.

Difficult

6.

For a gravitationally bound steady-state system, the virial theorem gives $2\langle K\rangle = -\langle U\rangle$. If $E_{total} = \langle K\rangle + \langle U\rangle$, what is $\langle K\rangle/E_{total}$?

(a) 1

(b) -1

(c) 2

(d) -2

Answer: b

Solution: From $\langle U\rangle = -2\langle K\rangle$, $E_{total} = \langle K\rangle - 2\langle K\rangle = -\langle K\rangle$, so $\langle K\rangle/E_{total} = -1$.

3.2. Physics Exam 2

Easy

1.

A moving object of mass m and speed v has kinetic energy. Which expression defines it?

(a) mv

(b) mv^2

(c) $\frac{1}{2}mv^2$

(d) $\frac{1}{2}mv$

Answer: c

Solution: Kinetic energy is $KE = \frac{1}{2}mv^2$.

2.

An isolated system undergoes a collision between two bodies. Which physical quantity must remain conserved?

(a) Temperature

(b) Pressure

(c) Momentum

(d) Density

Answer: c

Solution: In an isolated system, total linear momentum is conserved during any collision.

3.

A material has mass m and volume V. Which expression defines density ρ?

(a) $\rho = \dfrac{V}{m}$

(b) $\rho = mV$

(c) $\rho = \dfrac{m}{V}$

(d) $\rho = m + V$

Answer: c

Solution: Density is mass per unit volume: $\rho = m/V$.

Moderate

4.

A satellite's circular-orbit radius increases from r to $2r$. By what factor does its orbital period T change?

(a) T becomes $\dfrac{1}{2}T$

(b) T becomes $\sqrt{2}T$

(c) T becomes $2T$

(d) T becomes $2\sqrt{2}T$

Answer: d

Solution: Kepler's third law gives $T^2 \propto r^3$, so $T_2/T_1 = (r_2/r_1)^{3/2} = 2^{3/2} = 2\sqrt{2}$.

5.

A block of mass m slides with speed v on a frictionless surface and compresses a spring of force constant k until it stops. Which relation gives maximum compression x?

(a) $\dfrac{1}{2}mv^2 = kx$

(b) $\dfrac{1}{2}mv^2 = \dfrac{1}{2}kx^2$

(c) $mv^2 = kx^2$

(d) $mv = kx$

Answer: b

Solution: At maximum compression, kinetic energy has converted into spring potential energy: $\frac{1}{2}mv^2 = \frac{1}{2}kx^2$.

Difficult

6.

An ambulance source emits frequency f_s while moving away from an observer at speed v_s; the observer chases it from behind at speed v_o. Sound speed is v_{sound}. Which expression gives observed frequency f_o?

(a) $f_o = f_s \dfrac{v_{sound} + v_o}{v_{sound} + v_s}$

(b) $f_o = f_s \dfrac{v_{sound} - v_o}{v_{sound} + v_s}$

(c) $f_o = f_s \dfrac{v_{sound} + v_o}{v_{sound} - v_s}$

(d) $f_o = f_s \dfrac{v_{sound} - v_o}{v_{sound} - v_s}$

Answer: b

Solution: The source moves away, so use $+v_s$ in the denominator. The observer moves away from the oncoming wavefronts, so use $-v_o$ in the numerator. Thus $f_o = f_s \frac{v_{sound} - v_o}{v_{sound} + v_s}$.

4. Computational Mathematics

4.1. Mathematics Exam 1

Easy

1.

Solve for x in the relation $3x + 8 = 23$.

(a) 3

(b) 5

(c) 7

(d) 4

Answer: b

Solution: Subtract 8 to get $3x = 15$, then divide by 3: $x = 5$.

2.

A testing loop follows the arithmetic sequence $4, 7, 10, 13, \ldots$. What is the 10th term?

(a) 28

(b) 31

(c) 34

(d) 37

Answer: b

Solution: The sequence has first term 4 and difference 3. The 10th term is $4 + 9(3) = 31$.

3.

Find the point where $2x - 5y = 10$ intersects the x-axis.

(a) $(0, -2)$

(b) $(5, 0)$

(c) $(-5, 0)$

(d) $(2, 0)$

Answer: b

Solution: On the x-axis, $y = 0$. Then $2x = 10$, so $x = 5$ and the point is $(5, 0)$.

Moderate

4.

Find the sum of the first six terms of $3, 6, 12, 24, \ldots$.

(a) 189

(b) 93

(c) 381

(d) 192

Answer: a

Solution: This geometric series has $a = 3$, ratio 2, and six terms, so $S_6 = 3(2^6 - 1)/(2 - 1) = 189$.

5.

Find the equation of the line perpendicular to $y = 3x - 4$ that passes through $(6, 5)$.

(a) $y = -3x + 23$

(b) $y = \frac{1}{3}x + 3$

(c) $y = -\frac{1}{3}x + 7$

(d) $y = -\frac{1}{3}x + 5$

Answer: c

Solution: A perpendicular line has slope $-1/3$. Using $(6, 5)$ gives $5 = -2 + b$, so $b = 7$ and $y = -\frac{1}{3}x + 7$.

Difficult

6.

For what exact value of k will the system $2x - 3y = 8$ and $4x + ky = 7$ have no solution?

(a) 6

(b) -6

(c) -3

(d) 0

Answer: b

Solution: No solution occurs when the lines are parallel but distinct. Doubling $2x - 3y = 8$ gives $4x - 6y = 16$, so $k = -6$ makes the left sides parallel while constants differ.

4.2. Mathematics Exam 2

Easy

1.

Two 1D coordinates are $A = -3$ and $B = 5$. What is the distance between them?

(a) 2

(b) 4

(c) 8

(d) 10

Answer: c

Solution: Distance on a line is absolute difference: $|5 - (-3)| = 8$.

2.

Solve the inequality $5 - 2x < 11$.

(a) $x < -3$

(b) $x > -3$

(c) $x < 3$

(d) $x > 3$

Answer: b

Solution: Subtract 5: $-2x < 6$. Dividing by -2 reverses the inequality, so $x > -3$.

3.

Calculate the sum of the first five terms $2, 4, 8, 16, 32$.

(a) 60

(b) 62

(c) 64

(d) 30

Answer: b

Solution: The sum is $2 + 4 + 8 + 16 + 32 = 62$.

Moderate

4.

Solve the quadratic inequality $x^2 - 4x - 5 \leq 0$.

(a) $x \leq -1$ or $x \geq 5$

(b) $-1 \leq x \leq 5$

(c) $-5 \leq x \leq 1$

(d) $1 \leq x \leq 5$

Answer: b

Solution: Factor $x^2 - 4x - 5 = (x - 5)(x + 1)$. Since the parabola opens upward, it is nonpositive between the roots: $-1 \leq x \leq 5$.

5.

Find the average rate of change of $f(x) = 3x^2 - 2x$ over $[1, 4]$.

(a) 13

(b) 15

(c) 39

(d) 11

Answer: a

Solution: $f(4) = 48 - 8 = 40$ and $f(1) = 3 - 2 = 1$. Average rate of change is $(40 - 1)/(4 - 1) = 13$.

Difficult

6.

A channel drops packets with probability $p = 0.2$ per attempt. What is the expected number of attempts required to successfully deliver one packet?

(a) 1.25

(b) 1.5

(c) 2.0

(d) 5.0

Answer: a

Solution: The success probability is $1 - p = 0.8$. For a geometric process, expected attempts are $1/0.8 = 1.25$.

5. Computer Science

5.1. Computer Science Exam 1

Easy

1.

Problem Title: Average Temperature Over Time

Description: A sensor records the temperature of a specific point in a simulation every hour. Given N temperature readings, calculate the average temperature.

Input: Line 1 contains an integer N ($1 \leq N \leq 1000$). Line 2 contains N space-separated integers representing the temperature readings T_i ($-50 \leq T_i \leq 100$).

Output: A single floating-point number, the average temperature, rounded to 2 decimal places.

Example:

```
Input:
5
10 12 8 15 10
Output:
11.00
```

Solution:

Listing 1: Python Solution

```python
def calculate_average_python():
    n = int(input())
    temperatures = list(map(int, input().split()))
    total_sum = sum(temperatures)
    average = total_sum / n
    print(f"{average:.2f}")

calculate_average_python()
```

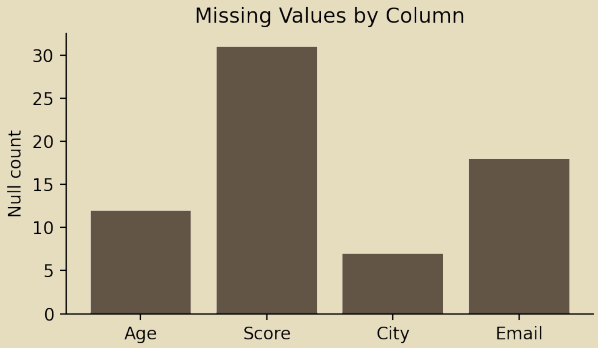
Listing 2: C++ Solution

```cpp
#include <iomanip>
#include <iostream>
#include <vector>

void calculateAverageCpp() {
```

```
    int n;
    std::cin >> n;
    std::vector<int> temperatures(n);
    long long total_sum = 0;

    for (int i = 0; i < n; ++i) {
        std::cin >> temperatures[i];
        total_sum += temperatures[i];
    }

    double average = static_cast<double>(total_sum) / n;
    std::cout << std::fixed << std::setprecision(2) << average << std::
        endl;
}

int main() {
    calculateAverageCpp();
    return 0;
}
```

Moderate

2.



Which Pandas command should you run first to quantify the tallest bar?

(a) `df.dropna()`

(b) `df.isnull().sum()`

(c) `df.replace()`

(d) `df.fillna(0)`

Answer: b

Solution: The command `df.isnull().sum()` counts missing values column by column, which lets you identify the column corresponding to the tallest bar.

3.

Which call clones a NumPy array so changes to the copy never affect the original?

(a) `b = a`

(b) `b = a.view()`

(c) `b = a.copy()`

(d) `b = np.asarray(a)`

Answer: c

Solution: The method `a.copy()` creates an independent array with its own data buffer, unlike assignment or a view.

Difficult

4.

Average-case lookup time for a Python `dict` is:

(a) $\Theta(\log n)$

(b) $\Theta(n)$

(c) $\Theta(n \log n)$

(d) $\Theta(1)$

Answer: d

Solution: Python dictionaries are hash tables, so successful key lookup is constant time on average.