

C.I. APPLIED PHYSICS AND BIostatISTICS (6 CFU)

Module PHYSICS APPLIED TO BIOTECHNOLOGIES + Module PRINCIPLES OF MATHEMATICS AND BIostatISTICS

Academic Year 2025/2026 · Prof. Notarstefano

Name & Surname: _____

Date: _____

Student ID: _____

Section	Type	Questions	Pts each	Max pts
Mathematics	True/False	6	0.75	4.5
Physics Theory	True/False	10	0.75	7.5
Mathematics	Multiple Choice	4	1.0	4.0
Physics Theory	Multiple Choice	8	1.0	8.0
Physics Exercises	Multiple Choice	3	3.0	9.0
TOTAL		31		33.0

- **True/False** (0.75 pts each): Circle T or F. Wrong answers are not penalised.
- **Multiple Choice** (1 pt each): Choose one answer. Wrong answers are not penalised.
- **Physics Exercises MC** (3 pts each): Choose the correct numerical result.
- Write clearly. Use a separate sheet for calculations if needed.

SECTION A — TRUE / FALSE

Indicate whether each statement is True or False · 0.75 points each

Questions	Points each	Section total
16	0.75	12.0

A1 · Mathematics (6 questions)

Q1.

The equation $\sqrt{A} = -n$ with $n > 0$ has no real solution.

True False

Q2.

A first-degree (linear) equation over \mathbb{R} always has a unique solution when $a \neq 0$.

True False

Q3.

If $f''(x) \geq 0$ on $[a, b]$, then f is concave on $[a, b]$.

True False

Q4.

A removable discontinuity occurs when the limit exists and is finite, but f is either undefined at the point or the function value does not match the limit.

True False

Q5.

Every stationary point (where $f'(x_0) = 0$) is necessarily a local extremum of f .

True False

Q6.

If $0 < a < 1$, then a^x is strictly increasing.

True False

A2 · Physics Theory (10 questions)

Q7.

According to Torricelli's Theorem, the exit speed of a fluid from an orifice at depth h below the free surface equals the speed an object would reach after falling freely from that same height h .

True False

Q8.

Gauss's Law relates the total electric flux through a closed surface to the total charge enclosed.

True False

Q9.

The magnitude of the normal force on a block resting on a horizontal surface always equals the weight of the block, regardless of any additional vertical forces applied.

True False

Q10.

Pressure in a fluid in static equilibrium depends on the horizontal position within the fluid.

True False

Q11.

Two reversible engines operating between the same two temperatures can have different efficiencies.

True False

Q12.

The net magnetic flux through any closed (Gaussian) surface is always zero because magnetic monopoles do not exist.

True False

Q13.

The specific heat capacity of a gas is the same regardless of whether the process occurs at constant pressure or constant volume.

True False

Q14.

In uniform circular motion the speed is constant, therefore the acceleration is zero.

True False

Q15.

A heat engine must operate on a thermodynamic cycle.

True False

Q16.

Ice is denser than liquid water, which is why it sinks when placed in water.

- True False

SECTION B — MULTIPLE CHOICE

Select the single correct answer · 1 point each

Questions	Points each	Section total
12	1.0	12.0

B1 · Mathematics (4 questions)

Q1.

For a general function f , $|f(x)|$ equals:

- A) $f(x)$ always
 B) $-f(x)$ always
 C) $f(x)$ if $f(x) \geq 0$, and $-f(x)$ if $f(x) < 0$
 D) $\sqrt{f(x)}$

Q2.

Which statement is logically equivalent to $B \subseteq A$?

- A) $\forall x \in A, x \in B$
 B) $\forall x \in B, x \in A$
 C) $\exists x \in B$ such that $x \notin A$
 D) $A \cap B = \emptyset$

Q3.

A linear equation can be written in the form $ax + b = 0$ with $a \neq 0$. Its solution is:

- A) $x = a / b$
 B) $x = -b / a$
 C) $x = b / a$
 D) $x = -ab$

Q4.

The **Uniqueness of the Limit** theorem states that if $\lim_{x \rightarrow x_0} f(x) = l$ and $\lim_{x \rightarrow x_0} f(x) = l'$, then:

- A) $l \neq l'$ is possible when $f(x_0)$ is undefined
 B) $l = l'$
 C) $l \cdot l' = 0$
 D) The conclusion depends on whether x_0 is isolated

B2 · Physics Theory (8 questions)

Q5.

The Bernoulli Effect (Bernoulli's Principle) states that in horizontal flow:

- A) Pressure increases where velocity increases
 B) Pressure decreases where velocity increases
 C) Pressure and velocity are always equal
 D) Pressure is independent of velocity

Q6.

In a thermodynamic cycle (a closed path on a p-V diagram), the net work done by the system satisfies:

- A) $|W| = 0$ always
- B) $W < 0$ always
- C) $|W| = |Q|$ (net work equals net heat exchanged)
- D) $W = \Delta U$ of the cycle

Q7.

Gay-Lussac's Law states that for an ideal gas at constant volume:

- A) $p \cdot V = \text{constant}$
- B) $V / T = \text{constant}$
- C) $p / T = \text{constant}$
- D) $p \cdot T = \text{constant}$

Q8.

Bernoulli's Equation for an ideal fluid in steady flow expresses conservation of:

- A) Momentum along the streamline
- B) Mass flow rate across all sections
- C) Energy per unit volume along a streamline: $P + \frac{1}{2}\rho v^2 + \rho gh = \text{constant}$
- D) Force per unit area at every point

Q9.

According to the Biot-Savart Law, the magnetic field produced by a long straight current-carrying wire is:

- A) Directly proportional to the distance from the wire
- B) Inversely proportional to the distance from the wire
- C) Independent of the current
- D) Directed radially outward from the wire

Q10.

Mechanical energy E_{meC} is defined as:

- A) $E_{meC} = KE - PE$
- B) $E_{meC} = KE + PE$
- C) $E_{meC} = KE \times PE$
- D) $E_{meC} = PE / KE$

Q11.

An electric dipole consists of:

- A) Two positive charges separated by a distance d
- B) Two particles with same charge magnitude but opposite sign, separated by d
- C) A single charge in an external electric field
- D) Two neutral particles separated by a distance d

Q12.

If $W_{cycIe} < 0$, the device is classified as:

- A) A heat engine
- B) A refrigerator
- C) A Carnot engine
- D) An isolated system

SECTION C — PHYSICS EXERCISES

Select the correct numerical result · 3 points each

Questions	Points each	Section total
3	3.0	9.0

Q1.

A skier descends a plane inclined at 30° with kinetic friction $\mu_D = 0.1$ ($g = 9.8 \text{ m/s}^2$, starts from rest). Calculate her **acceleration** and the **velocity reached after 4 s**.

- A) $a = 4.05 \text{ m/s}^2$, $v = 16.2 \text{ m/s}$
- B) $a = 4.90 \text{ m/s}^2$, $v = 16.2 \text{ m/s}$
- C) $a = 3.20 \text{ m/s}^2$, $v = 8.1 \text{ m/s}$
- D) $a = 4.05 \text{ m/s}^2$, $v = 19.6 \text{ m/s}$

Q2.

A rigid sphere ($V=785 \text{ L}$, $\rho_{\text{sphere}}=759 \text{ kg/m}^3$) is anchored to the seabed by a spring stretched by **22.9 cm**. Determine the spring constant k . ($\rho_{\text{seaWater}}=1025 \text{ kg/m}^3$, $g=9.8 \text{ m/s}^2$)

- A) $k \approx 8.1 \times 10^3 \text{ N/m}$
- B) $k \approx 3.2 \times 10^3 \text{ N/m}$
- C) $k \approx 1.0 \times 10^4 \text{ N/m}$
- D) $k \approx 8.1 \times 10^2 \text{ N/m}$

Q3.

One mole of a monatomic ideal gas ($c_v = \frac{3}{2}R$, $c_p = \frac{5}{2}R$): isochoric $A \rightarrow B$ ($p_A=3 \text{ atm} \rightarrow p_B=2 \text{ atm}$, $V=1 \text{ L}$); isothermal $B \rightarrow C$ ($V_C=2 \text{ L}$); isobaric $C \rightarrow D$ ($V_D=3 \text{ L}$). Calculate **Q_{tot}** , **W_{tot}** , **ΔU_{tot}** .

- A) $Q_{\text{tot}} \approx +2.4 \times 10^2 \text{ J}$, $W_{\text{tot}} \approx +2.4 \times 10^2 \text{ J}$, $\Delta U_{\text{tot}} = 0$
- B) $Q_{\text{tot}} = 0$, $W_{\text{tot}} \approx +2.4 \times 10^2 \text{ J}$, $\Delta U_{\text{tot}} \approx -2.4 \times 10^2 \text{ J}$
- C) $Q_{\text{tot}} \approx -2.4 \times 10^2 \text{ J}$, $W_{\text{tot}} \approx -2.4 \times 10^2 \text{ J}$, $\Delta U_{\text{tot}} = 0$
- D) $Q_{\text{tot}} \approx +4.0 \times 10^2 \text{ J}$, $W_{\text{tot}} \approx +2.4 \times 10^2 \text{ J}$, $\Delta U_{\text{tot}} \approx +1.6 \times 10^2 \text{ J}$