Written Examination
Graduate School of Marine Science and Technology

Course of Marine Resources and Environment

Basic Subjects for Marine Resources and Environment

February 3, 2026

The envelope contains the question and answer sheets of the following five subjects.

Select three subjects from the five ones and answer them.

Write your examinee's number and name only on the sheets of the selected subjects.

If you have written your examinee's number and name on the sheets of more than three subjects, only the sheets of the first three subjects in the following order will be scored.

1. Mathematics
2. Physics
3. Chemistry
4. Biology
5. Earth Science

Written Examination
Graduate School of Marine Science and Technology

Course of Marine Resources and Environment

Basic Subject Mathematics

February 3, 2026

※Write answers in English on answer sheet and continue overleaf if necessary.

Problem: Consider a 2×2 matrix

$$A = \begin{pmatrix} 0 & 1 \\ 2 & -1 \end{pmatrix}.$$

Answer the following questions.

(1) Let k be a real number, and I be a 2×2 identity matrix. Find all real numbers k that satisfy $|kI - A| = 0$, where $|kI - A|$ is the determinant of $kI - A$.

(2) Let k_1, k_2 be the values of k found in (1) with $k_1 < k_2$. For each $j = 1, 2$, find one vector p_j that satisfies the condition $Ap_j = k_j p_j$. Here

$$p_j \neq \begin{pmatrix} 0 \\ 0 \end{pmatrix}.$$

(3) Define vectors p_1, p_2 by

$$p_1 = \begin{pmatrix} p_{11} \\ p_{21} \end{pmatrix}, \qquad p_2 = \begin{pmatrix} p_{12} \\ p_{22} \end{pmatrix},$$

and a 2×2 matrix P by

$$P = \begin{pmatrix} p_{11} & p_{12} \\ p_{21} & p_{22} \end{pmatrix}.$$

Compute P^{-1} and $D = P^{-1}AP$.

(4) For a nonnegative integer n, compute A^n.

Answer Sheet

Graduate School of Marine Science and Technology

February 3, 2026

Course	Course of Marine Resources and Environment	Applicant's number	
Name of Basic Subject	Mathematics	Name	

※Write answers in English on this page and continue overleaf if necessary.

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Written Examination
Graduate School of Marine Science and Technology

Course of Marine Resources and Environment

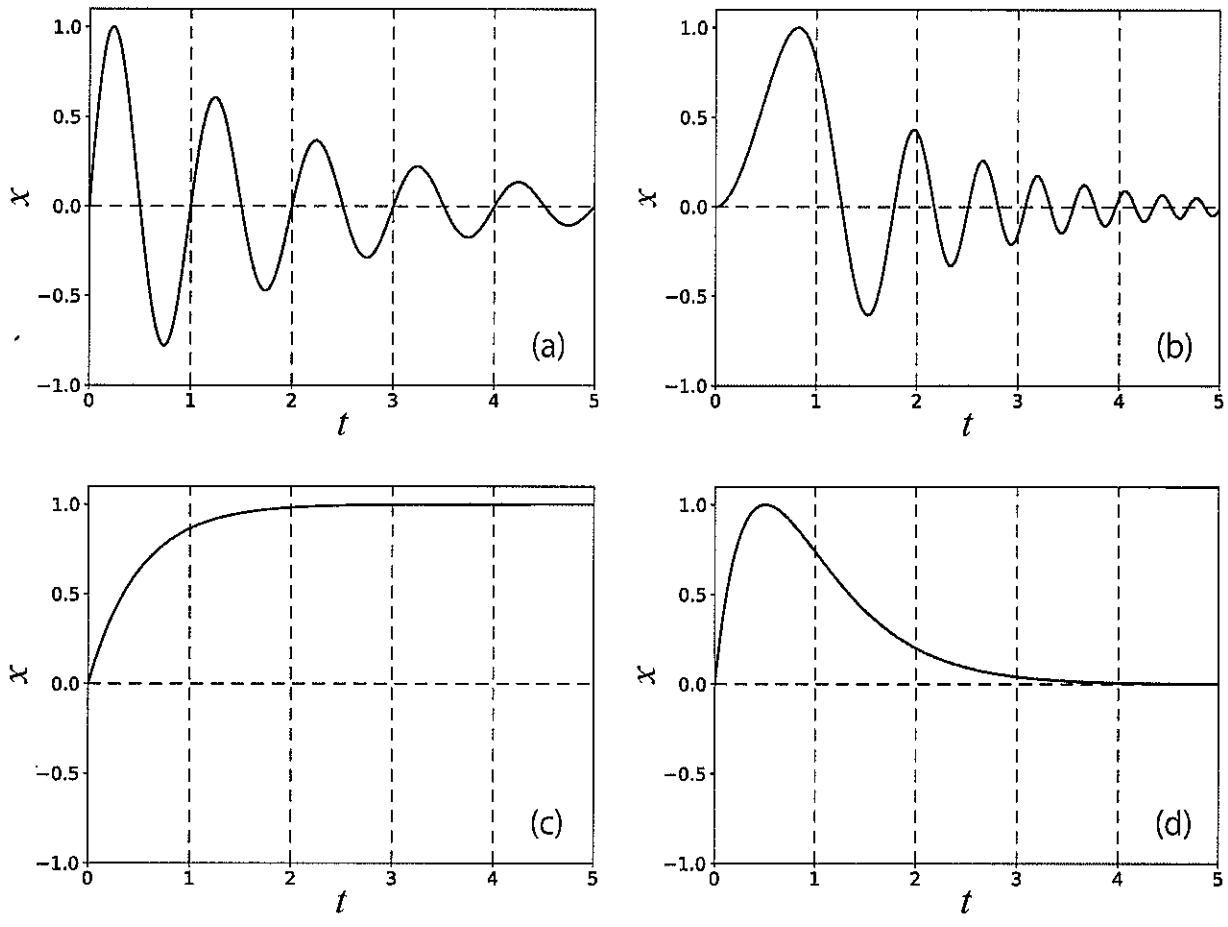
Basic Subject Physics

February 3, 2026

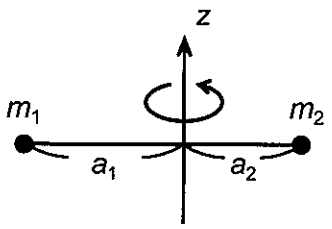
※Write answers in English on answer sheet.

1. A light spring with a spring constant k is placed on a smooth horizontal surface. The spring has one end fixed to a wall, and the other end attached to a mass m. Take the x-axis pointing to the direction in which the spring extends, with the origin at the position of the mass when the spring is at its natural length. Let the displacement of the mass at time t be denoted by x(t), its velocity by $\dot{x}(t)$, and its acceleration by $\ddot{x}(t)$.

(1) Write the equation of motion for the mass.
(2) Find the general solution to the equation obtained in (1).
(3) From the general solution obtained in (2), find the solution that satisfies the following initial conditions: $x(0) = 0$ and $\dot{x}(0) = v_0$.
(4) Consider a case where a resistance force proportional to the velocity acts on the mass. Under the initial conditions in (3), select two appropriate graphs from the options (a) through (d) below, showing the time evolution of the displacement of the mass. Note that the horizontal and vertical axes of each graph are appropriately normalized.



2. As shown in the figure below, there is a rigid body consisting of a light, thin rod with a small sphere 1 of mass m_1 attached to one end and another small sphere 2 of mass m_2 attached to the other end. The rigid body is set perpendicular to the z-axis, with the distances from the z-axis to spheres 1 and 2 are a_1 and a_2, respectively. Assume that the rigid body can rotate smoothly around the z-axis.



(1) Find the moment of inertia of this rigid body about the z-axis.

(2) A force of constant magnitude F is applied to sphere 1 in the tangential direction of rotation. The force acts counterclockwise when viewed from the positive to the negative side of the z-axis. Find the magnitude of the torque about the z-axis exerted on the rigid body by this force. Furthermore, find the magnitude of the angular acceleration of the rigid body.

Next, consider generating the force equivalent to that in (2) using an induced electric field. Sphere 1 carries a positive electric charge q. A sufficiently long solenoid with a radius b (where $b < a_1, a_2$) and n turns per unit length is placed such that its central axis coincides with the z-axis. Assume that the rigid body can rotate freely around the z-axis, as shown in the figure above. A current αt (where α is a positive constant), which increases with time t, flows through the solenoid in a counterclockwise direction when viewed from the positive z-axis. Let μ_0 be the permeability of vacuum.

(3) Find the magnitude and direction of the magnetic flux density inside the solenoid.

(4) Find the magnitude and direction of the induced electric field at the position of sphere 1.

(5) Find the magnitude and direction of the force exerted on sphere 1 by the induced electric field obtained in (4).

Answer Sheet

Graduate School of Marine Science and Technology

February 3, 2026

Course	**Course of Marine Resources and Environment**	Applicant's number	
Name of Basic Subject	**Physics**	Name	

※Write answers in English on this page

1.

(1)
(2)
(3)
(4)

2.

(1)
(2) Torque
Angular acceleration
(3)
(4)
(5)

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Written Examination
Graduate School of Marine Science and Technology

Course of Marine Resources and Environment

Basic Subject Chemistry

February 3, 2026

※Write answers in English on answer sheet and continue overleaf if necessary.

Question 1: Answer about dipole moment.

(1) Draw the structural formulas of NH_3, CO_2, HCl, and H_2O molecules, and indicate the dipole moment of each bond with a small arrow (→) and the dipole moment of the entire molecule with a large arrow (➡). If the dipole moment is zero, write "none."

(2) Explain what a dipole moment is using all of the following terms.
[bond, distance, electronegativity]

Question 2: Explain the principles and uses of chromatography below.

(1) Reverse-phase chromatography
(2) Size-exclusion chromatography
(3) Thin-layer chromatography

Question 3: Draw the structural formula corresponding to the IUPAC name below.

(1) 3-ethylpentanamide (2) 3,4-dimethylhexanoic acid
(3) *N*-methylpentylamine (4) 3-methylbutanal (5) 2-methyl-3-hexanone
(6) 2-methylcyclohexanol (7) ethyl methyl ether
(8) 2-methyl-2-octene (9) *p*-nitrotoluene (10) 4-tert-butyl-2-methylheptane

Question 4: Explain the following stereoisomers drawing structure formula of the examples.

(1) enantiomers (optical isomers)

(2) diastereomers

Answer Sheet

Graduate School of Marine Science and Technology

February 3, 2026

Course	Course of Marine Resources and Environment	Applicant's number	
Name of Basic Subject	Chemistry	Name	

※Write answers in English on this page and continue overleaf if necessary.

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Written Examination
Graduate School of Marine Science and Technology

Course of Marine Resources and Environment

Basic Subject Biology

February 3, 2026

※Write answers in English on answer sheet and continue overleaf if necessary.

1. Answer the following questions based on the text below.

To assess the level of water pollution, it is effective to use biological responses as indicators in addition to physicochemical measurements, such as a) COD and BOD. Organisms respond sensitively to changes in environmental conditions, including pollutants, temperature, and dissolved oxygen concentration, and these effects are reflected in their life history traits, behavior, and distribution patterns.

For example, mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) tend to occur under specific environmental conditions. Therefore, b) the total number of species belonging to these three orders, known as the EPT index, is widely used as an indicator of river water quality. This approach, which evaluates environmental conditions based on biological responses, is referred to as the use of c) biological indicators.

Q1: Regarding the underlined part a), explain what each of COD and BOD represents as an indicator of water quality. In addition, if measurements in a certain water body show that COD values are higher than BOD values, explain the characteristics of the water body that can be inferred from this result.

Q2: Regarding the underlined part b), the EPT index of a river was calculated as 12 at Site A, 21 at Site B, and 3 at Site C. Based on these values, explain the relative pollution status of each site, referring to the ecological characteristics of EPT taxa.

Q3: Regarding the underlined part c), list two advantages and two disadvantages of using biological indicators for environmental assessment, and explain each briefly.

2. Answer Questions 1–5 on food webs and food chains.

Q 1: Answer the words that fit in blanks 1 to 3.

Among the classifications of consumers, a (1) consumes animals, a (2) consumes plants, and an (3) consumes both.

Q 2: What is the term for the indirect effect within a food web that occurs when the impact of predation extends to lower trophic levels, such as when predators reduce the abundance of their prey and thereby increase the abundance of the prey's food resources (usually plants)?

Q 3: Choose the appropriate words for blanks 1 to 4 from the options below.

In a community consisting of three trophic levels, if predators regulate the abundance of grazers, the grazers can be said to be under (1). Conversely, predators are said to be under (2), which represents the standard predator–prey interaction. Furthermore, plants are released from (3) due to the effect of predators acting on grazers, and instead come under (4).

Options

A: bottom-up control

B: top-down control

Q 4: Choose the appropriate words for blanks 1 to 3 from the options below.

In marine ecosystems, the biomass of top predators is determined by energy loss during energy transfer and by the number of links connecting trophic levels. This number is generally influenced by the body size of primary producers.

In environments such as the open ocean, where the dominant phytoplankton are (1), food chains tend to be (2).

In such environments, (3), play an important role as the first linkers.

Options

A: small

B: large

C: short

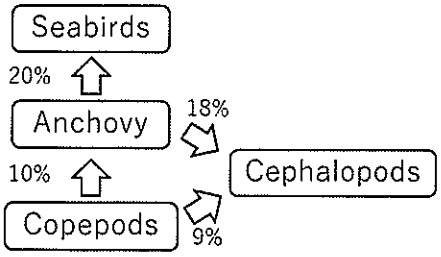
D: long

E: copepods and krill

F: dinoflagellates and ciliates

G: micronekton

Q 5: In the diagram below representing a food chain, the numbers indicate the efficiency of energy transfer (%) between trophic levels. Write your calculations in the answer box.



(1) If seabirds feed only on anchovies, and anchovies feed only on copepods, how many grams of copepods are required for seabirds to gain 100 g in body mass?

(2) In addition, if cephalopods feed on copepods and anchovies at a weight ratio of 3:1 and gain 100 g in body mass, how many grams of copepods are required directly and indirectly?

Answer Sheet

Graduate School of Marine Science and Technology

February 3, 2026

Course	Course of Marine Resources and Environment	Applicant's number	
Name of Basic Subject	Biology	Name	

※Write answers in English on this page and continue overleaf if necessary.

1.

Q1.

COD:

BOD:

Characteristics of the water body:

Q2.

Q3.

Advantages:

Disadvantages:

2.

Q1.

（1.　　）　（2.　　）　（3.　　）

Q2.

（　　）

Q3.

（1.　　）（2.　　）（3.　　）（4.　　）

Q4.

（1.　　）　（2.　　）　（3.　　）

Q5.

（1）

（2）

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Written Examination
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Course of Marine Resources and Environment

Basic Subject　Earth Science

February 3, 2026

※Write answers in English on answer sheet and continue overleaf if necessary.

Q 1. The chart below is a simplified geologic time scale. Answer questions (1) to (3) below.

(1) Fill in the blanks "A" – "F" in the chart.

(2) Which Series/Epoch does the Chibanian belong to?

(3) Absolute dates have been established for the boundaries of each period, such as 66,600 years ago (66.00 Ma) for the Cretaceous-Paleogene boundary and 250 million years ago (251.902 Ma) for the Permian-Triassic boundary. Explain in 150 words or less the methods used to determine such absolute dates using the following keywords.

(Keywords: isotopes, decay, half-life, igneous rock)

Eonothem / Eon	Erathem / Era	Series / Epoch	Series / Epoch
Phanerozoic	Cenozoic	Quaternary	E
			Pleistocene
		B	Pliocene
			Miocene
		Paleogene	F
			Eocene
			Paleocene
	A	Cretaceous	
		Jurassic	
		Triassic	
	Paleozoic	Permian	
		C	
		Devonian	
		Silurian	
		D	
		Cambrian	
Proterozoic			
Archean			

Geological Time Scale

Q2. Answer question (1) to (5) by reading the following description.

Earth's interior consists of four layers: the crust, mantle, outer core, and inner core. The crust is generally divided into oceanic and continental crust, which exhibit different thicknesses, rock types, and densities. The upper continental crust is composed of [A], and the oceanic crust is composed of [B], respectively. The structure of Earth's interior is estimated by seismic wave velocity, and $_1$the velocity changes at the boundary between the crust and the mantle. The core is composed of an iron-nickel alloy, and $_2$the outer and inner cores are estimated to be liquid and solid phases, respectively.

Rocks composed of crust are disintegrated and decomposed by the reaction with water and atmospheric air on Earth's surface: this is called chemical weathering. For example, $_3$kaolinite ($Al_2Si_2O_5(OH)_4$) is formed from anorthite ($CaAl_2Si_2O_8$) by reacting with water and carbon dioxide in atmospheric air. On the other hand, the weathering process that causes the disintegration of rocks without chemical change is called [C]. Weathering is a fundamental process in shaping landscapes and transporting materials on Earth's surface.

(1) Choose one rock name for each of [A] and [B] from the list below.

[basalt, peridotite, limestone, mudstone, granite, tuff, serpentine]

(2) About the underline part 1, answer a name of the boundary between the crust and the mantle. And provide a reason to change seismic wave velocity at the boundary.

(3) About the underline part 2, choose the characteristic of seismic waves observed in the inner core from (a)–(d) below.

(a) : P waves pass through, but S waves do not.
(b) : P waves do not pass through, but S waves do.
(c) : Both P waves and S waves pass through.
(d) : Neither P waves nor S waves pass through.

(4) Fill in the word for [C] .

(5) About the underline part 3, answer the chemical reaction formula.

Answer Sheet

Graduate School of Marine Science and Technology

February 3, 2026

Course	Marine Resources and Environment	Applicant's number	
Name of Basic Subject	Earth Science	Name	

※Write answers in English on this page and continue overleaf if necessary.

Q1.

(1)

A		D	
B		E	
C		F	

(2)

(3)

(150 words)

Answer Sheet

Graduate School of Marine Science and Technology

February 3, 2026

Course	Marine Resources and Environment	Applicant's number	
Name of Basic Subject	Earth Science	Name	

※Write answers in English on this page and continue overleaf if necessary.

Q2.

(1)

A		B	

(2)

Name: _____

Reason

(3)

(4)

C	

(5)

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