

2023 年度日本政府(文部科学省)奨学金留学生選考試験

QUALIFYING EXAMINATION FOR APPLICANTS FOR THE JAPANESE
GOVERNMENT (MEXT) SCHOLARSHIP 2023

学科試験 問題

EXAMINATION QUESTIONS

(学部留学生)

UNDERGRADUATE STUDENTS

物 理

PHYSICS

注意 ☆試験時間は **60 分**。

PLEASE NOTE: THE TEST PERIOD IS **60 MINUTES**.

(2023)

Physics

Nationality		No.	
Name	(Please print full name, underlining family name)		
Marks			

Before you start, fill in the necessary details (nationality, examination number, name etc.) in the box at the top of this examination sheet and on the answer sheet.

For each question, select the correct answer and write the corresponding letter in the space provided on the answer sheet.

1. Answer the following questions.

(1) Figure 1-1 shows the velocity v (m/s) of an object moving along the x -axis as a function of time t (s). The object departed from the origin ($x = 0$) at $t = 0$ s. Find the position x (m) of the object at $t = 8.0$ s.

- (a) 0 m (b) 1 m (c) 2 m
(d) 4 m (e) 6 m (f) 8 m

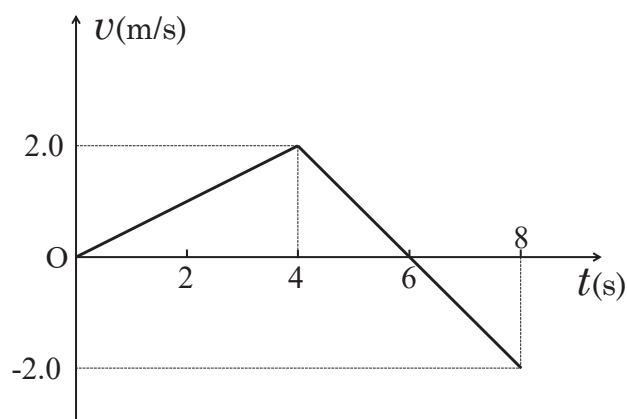


Fig. 1-1

- (2) As shown in Fig. 1-2, a ball collided with the floor at a speed of 2.0 m/s at an angle of 60° , and bounced off at an angle of 30° . Find the coefficient of restitution between the ball and the floor. The velocity component in the parallel direction to the floor does not change before and after the collision.

- | | | |
|----------|----------|----------|
| (a) 0 | (b) 0.25 | (c) 0.33 |
| (d) 0.66 | (e) 0.75 | (f) 0.8 |

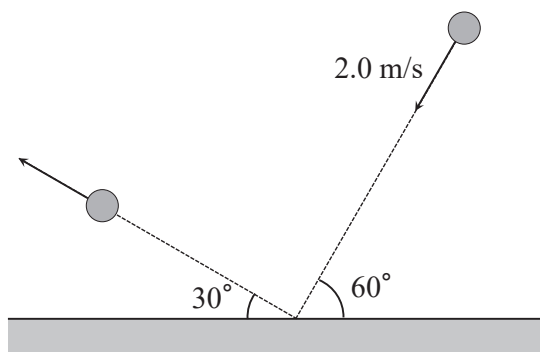


Fig. 1-2

- (3) As shown in Fig. 1-3, there is an equilateral triangle ABC with side l , and point P is the midpoint between points A and B. Two particles of equal charge q (>0) are fixed at points A and B, respectively. Find the amount of work required to move the positive charge of Q from point C to point P. Coulomb's constant is denoted as $k(= \frac{1}{4\pi\epsilon_0})$, where ϵ_0 is the permittivity of a vacuum.

- | | | |
|-----------------------|------------------------|------------------------|
| (a) $\frac{kqQ}{l}$ | (b) $\frac{2kqQ}{l}$ | (c) $\frac{3kqQ}{l}$ |
| (d) $\frac{kqQ}{l^2}$ | (e) $\frac{2kqQ}{l^2}$ | (f) $\frac{3kqQ}{l^2}$ |

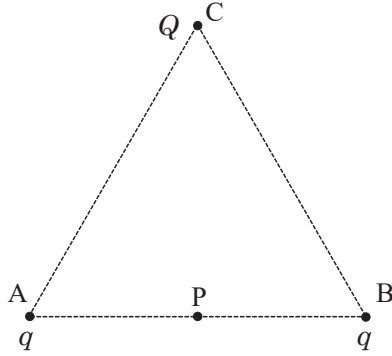


Fig. 1-3

- (4) As shown in Fig. 1-4, a cylindrical container filled with an ideal gas is divided into two parts, A and B, by a frictionless piston. Initially, the gas in A and B had a pressure of p_0 and a temperature of T_0 . The length from the both ends of the container to the piston was L . Then, the temperature of the gas in B is increased and fixed at T ($> T_0$), while that of the gas in A is kept at T_0 . How far does the piston move, and to which direction?

- | | |
|--|--|
| (a) $\frac{T - T_0}{T + T_0}L$, A $\rightarrow$ B | (b) $\frac{T + T_0}{T - T_0}L$, A $\rightarrow$ B |
| (c) $\frac{2T_0}{T + T_0}L$, A $\rightarrow$ B | (d) $\frac{T - T_0}{T + T_0}L$, A $\leftarrow$ B |
| (e) $\frac{T + T_0}{T - T_0}L$, A $\leftarrow$ B | (f) $\frac{2T_0}{T + T_0}L$, A $\leftarrow$ B |

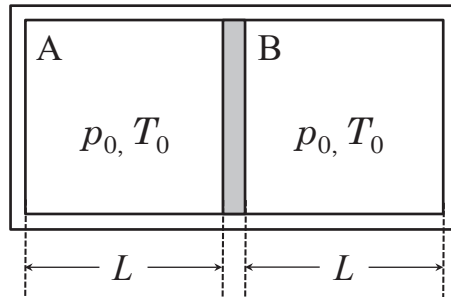


Fig. 1-4

(5) Parallel light rays cross interfaces from medium 1 into medium 2 and then into medium 3 as shown in Fig. 1-5. What can we say about the relative sizes of the refractive indices of these media n_1, n_2 and n_3 ?

- (a) $n_1 > n_2 > n_3$ (b) $n_3 > n_2 > n_1$ (c) $n_2 > n_3 > n_1$
(d) $n_1 > n_3 > n_2$ (e) $n_2 > n_1 > n_3$ (f) $n_3 > n_1 > n_2$

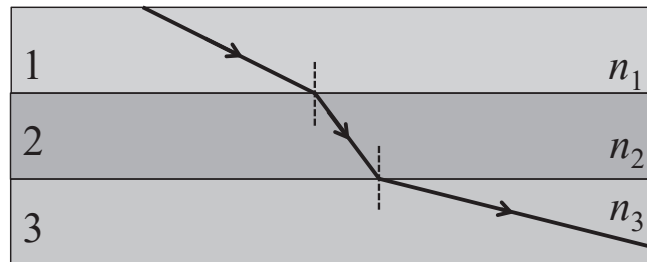


Fig. 1-5

2. Consider a circuit shown in Fig. 2, consisting of three same capacitors C_1 , C_2 , and C_3 of capacitance C , a battery of voltage V , and switches S_1 and S_2 . Capacitors C_2 and C_3 are grounded as shown in the figure. At the beginning, S_1 and S_2 were open, and all the capacitors were uncharged. Answer the following questions.

(1) First, only S_1 was closed, and then, C_1 and C_2 were fully charged. Find the charge on C_2 .

- | | | |
|---------------------|---------------------|---------------------|
| (a) CV | (b) $2CV$ | (c) $3CV$ |
| (d) $\frac{1}{4}CV$ | (e) $\frac{1}{2}CV$ | (f) $\frac{1}{3}CV$ |

(2) Find the total energy stored in C_1 and C_2 after the operation in (1).

- | | | |
|-----------------------|-----------------------|-----------------------|
| (a) CV^2 | (b) $2CV^2$ | (c) $3CV^2$ |
| (d) $\frac{1}{4}CV^2$ | (e) $\frac{1}{2}CV^2$ | (f) $\frac{1}{3}CV^2$ |

(3) Next, S_1 was opened, and then S_2 was closed. Find the charge on C_2 after this operation.

- | | | |
|---------------------|---------------------|---------------------|
| (a) CV | (b) $2CV$ | (c) $3CV$ |
| (d) $\frac{1}{4}CV$ | (e) $\frac{1}{2}CV$ | (f) $\frac{1}{3}CV$ |

(4) Find the electric potentials V_A and V_B at points A and B, respectively, with reference to the ground after the operation in (3)

- | | |
|--|--|
| (a) $V_A = \frac{1}{2}V, V_B = V$ | (b) $V_A = V, V_B = \frac{1}{2}V$ |
| (c) $V_A = \frac{1}{2}V, V_B = \frac{3}{2}V$ | (d) $V_A = \frac{3}{2}V, V_B = \frac{1}{2}V$ |
| (e) $V_A = \frac{1}{4}V, V_B = \frac{3}{4}V$ | (f) $V_A = \frac{3}{4}V, V_B = \frac{1}{4}V$ |

(5) Next, S_2 was opened, and then S_1 was closed. After that, C_1 and C_2 were fully charged. Find the charge on C_2 .

(a) $\frac{1}{8}CV$

(b) $\frac{3}{8}CV$

(c) $\frac{5}{8}CV$

(d) $\frac{1}{4}CV$

(e) $\frac{3}{4}CV$

(f) $\frac{5}{4}CV$

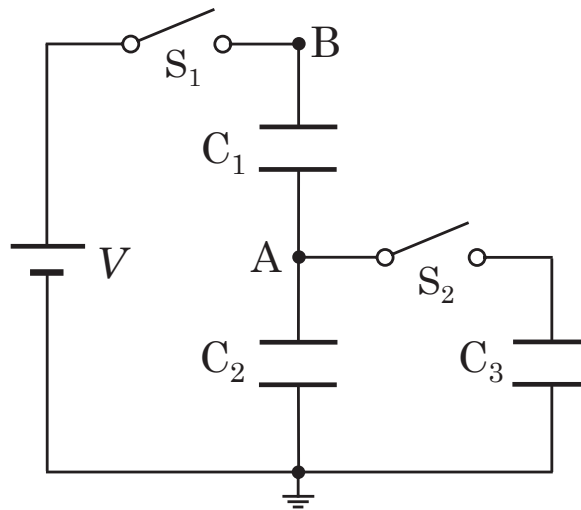


Fig. 2

3. An artificial satellite with mass m is circulating the Earth as shown in Fig. 3. The satellite rotates around the Earth in the direction of the Earth's rotation. The satellite's height above the Earth is h . The shape of the Earth is assumed to be a perfect sphere with radius R . The mass of the Earth is M and the Earth's rotation period is T . The gravitational constant is denoted by G . Answer the following questions.

(1) Find the angular velocity of the Earth's rotation.

- (a) $\frac{1}{T}$ (b) $\frac{4\pi^2}{T^2}$ (c) $\frac{R}{T}$
 (d) $\frac{2\pi}{T}$ (e) $\frac{2\pi R}{T}$ (f) $\frac{4\pi R^2}{T}$

(2) Find the speed of the satellite.

- (a) $\frac{GM}{R}$ (b) $\sqrt{\frac{GM}{R+h}}$ (c) $\sqrt{\frac{GMm}{R+h}}$
 (d) $\sqrt{\frac{GMm}{R}}$ (e) $\sqrt{\frac{GM}{R}}$ (f) $\frac{GM}{h}$

(3) Find the period of the satellite's orbit, T_s .

- (a) $2\pi(R+h)\sqrt{\frac{R+h}{GMm}}$ (b) $2\pi\sqrt{\frac{R+h}{GM}}$ (c) $2\pi\sqrt{\frac{R+h}{GMm}}$
 (d) $2\pi R\sqrt{\frac{R}{GMm}}$ (e) $2\pi R\sqrt{\frac{R}{GM}}$ (f) $2\pi(R+h)\sqrt{\frac{R+h}{GM}}$

(4) Find the formula for h when $T_s = T$.

- (a) $\left(\frac{GMT^2}{4\pi^2}\right)^{\frac{1}{2}} - R$ (b) $\left(\frac{GMT^2}{4\pi^2}\right)^{\frac{1}{3}}$ (c) $\left(\frac{GmMT^2}{4\pi^2}\right)^{\frac{1}{2}}$
 (d) $\left(\frac{GmMT^2}{4\pi^2}\right)^{\frac{1}{3}}$ (e) $\left(\frac{GMT^2}{4\pi^2}\right)^{\frac{1}{3}} - R$ (f) $\left(\frac{GmMT^2}{4\pi^2}\right)^{\frac{1}{3}} - R$

(5) Find the speed of the satellite when $T_s = T$.

- (a) $\left(\frac{2\pi GM}{T}\right)^{\frac{1}{3}}$ (b) $\left(\frac{2\pi GmM}{T}\right)^{\frac{1}{3}}$ (c) $\left(\frac{2\pi GM}{T}\right)^{\frac{1}{2}}$
 (d) $\left(\frac{2\pi GmM}{T}\right)^{\frac{1}{2}}$ (e) $\frac{2\pi GmM}{T}$ (f) $\frac{2\pi GM}{T}$

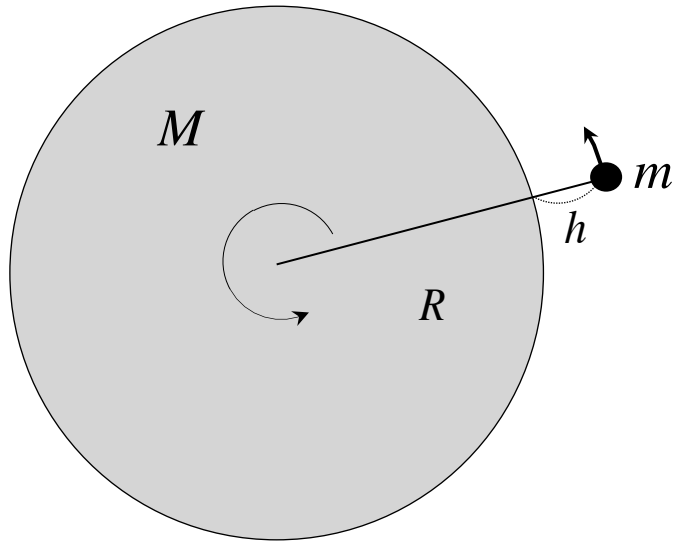


Fig. 3

4. Consider two volume expansion processes of an ideal gas: One is isothermal and the other is adiabatic. The changes of the gas pressure, P , as a function of the gas volume, V , are shown in Fig. 4-1 for both processes. The curve AB is for the isothermal process and the curve AC is for the adiabatic process. At point A the pressure is P_A and the volume is V_1 . At point B and C the volume is V_2 . Answer the following questions.

- (1) Find the pressure at B.

(a) $\frac{P_A V_2}{V_1 + V_2}$ (b) $\frac{P_A V_1}{V_1 + V_2}$ (c) $\frac{P_A (V_1 + V_2)}{V_2}$
 (d) $\frac{P_A (V_1 + V_2)}{V_1}$ (e) $\frac{P_A V_2}{V_1}$ (f) $\frac{P_A V_1}{V_2}$

- (2) In which process does the internal energy remain the same?

(a) AB (b) AC

- (3) The work done by the gas in process AB is denoted by W_{AB} and the work done by the gas in process AC is denoted by W_{AC} . Find the correct equation or the correct set of equations for them.

(a) $W_{AB} > W_{AC}$ (b) $W_{AC} > W_{AB}$ (c) $W_{AB} = W_{AC}$
 (d) $W_{AB} = 0, W_{AC} > 0$ (e) $W_{AC} = 0, W_{AB} > 0$ (f) $W_{AC} = \frac{3}{2}W_{AB}$

Figure 4-2 shows the change of the gas volume, V , as a function of the temperature, T . Some of the curves or the line shown in Fig. 4-2 correspond to the processes AB and AC in Fig. 4-1.

- (4) Find the curve or line corresponding to process AB.

(a) X_2X_1 (b) X_2Y_1 (c) X_2Z_1
 (d) Y_2X_1 (e) Z_2X_1

- (5) Find the curve or line corresponding to process AC.

(a) X_2X_1 (b) X_2Y_1 (c) X_2Z_1
 (d) Y_2X_1 (e) Z_2X_1

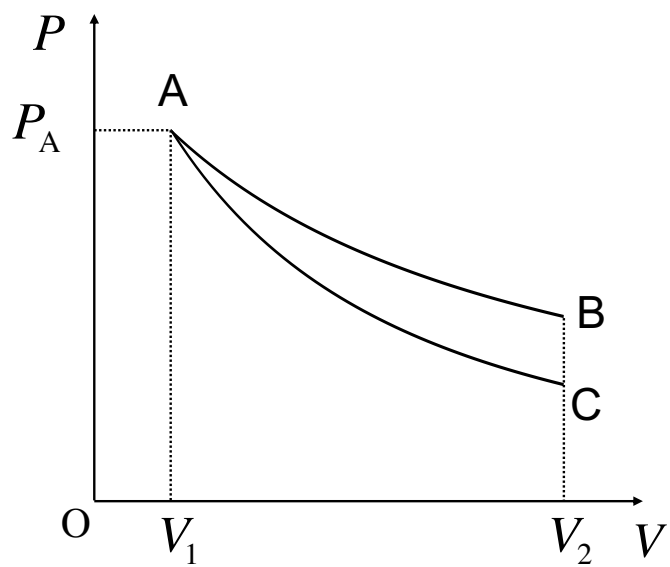


Fig. 4-1

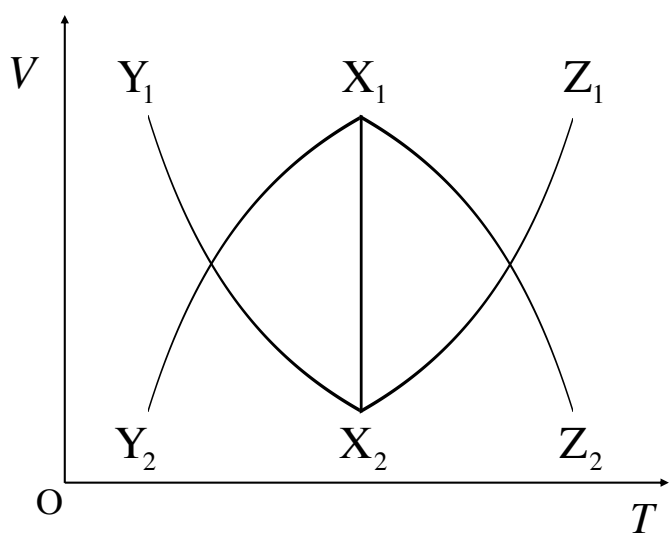


Fig. 4-2

5. In vacuum, laser light with wavelength λ passes through two slits, S_1 and S_2 , and reaches the screen as shown in Fig. 5. Two slits, S_1 and S_2 , are separated by d . The distance between the slits and the screen is R , and R is much larger than d . The position of the point P on the screen is denoted by x , which is measured from the center of the screen, O. L_1 and L_2 are the distances of S_1P and S_2P , respectively. Answer the following questions.

- (1) Using the approximation formula, $(1 + a)^p \simeq 1 + pa$, in which $|a| \ll 1$, find the expression of $L_2 - L_1$.

(a) $\frac{dx}{R}$

(b) $\frac{Rx}{d}$

(c) $\frac{Rd}{x}$

(d) $\frac{(x + d)^2}{R}$

(e) $\frac{(x - d)^2}{R}$

(f) $\frac{dx^2}{R^2}$

- (2) On the screen bright interference fringes are observed. Find the formula for the spacing between fringes.

(a) d

(b) $2d$

(c) λ

(d) $\frac{d\lambda}{R}$

(e) $\frac{R\lambda}{d}$

(f) $\frac{d^2}{R}$

We then do the same experiment in a medium with refractive index $n(> 1)$.

- (3) Find the formula for the spacing between bright interference fringes on the screen.

(a) $\frac{d\lambda}{nR}$

(b) $\frac{nd^2}{R}$

(c) $\frac{R\lambda}{nd}$

(d) nd

(e) $\frac{2d}{n}$

(f) $n\lambda$

- (4) Find the wavelength λ when $d = 1.0 \times 10^{-4}$ m, $n = 1.2$, $R = 2.4$ m, and the spacing between fringes is 1.0×10^{-2} m.

(a) $\lambda = 5.0 \times 10^{-6}$ m (b) $\lambda = 5.0 \times 10^{-7}$ m (c) $\lambda = 5.0 \times 10^{-8}$ m

(d) $\lambda = 2.4 \times 10^{-6}$ m (e) $\lambda = 2.4 \times 10^{-7}$ m (f) $\lambda = 2.4 \times 10^{-8}$ m

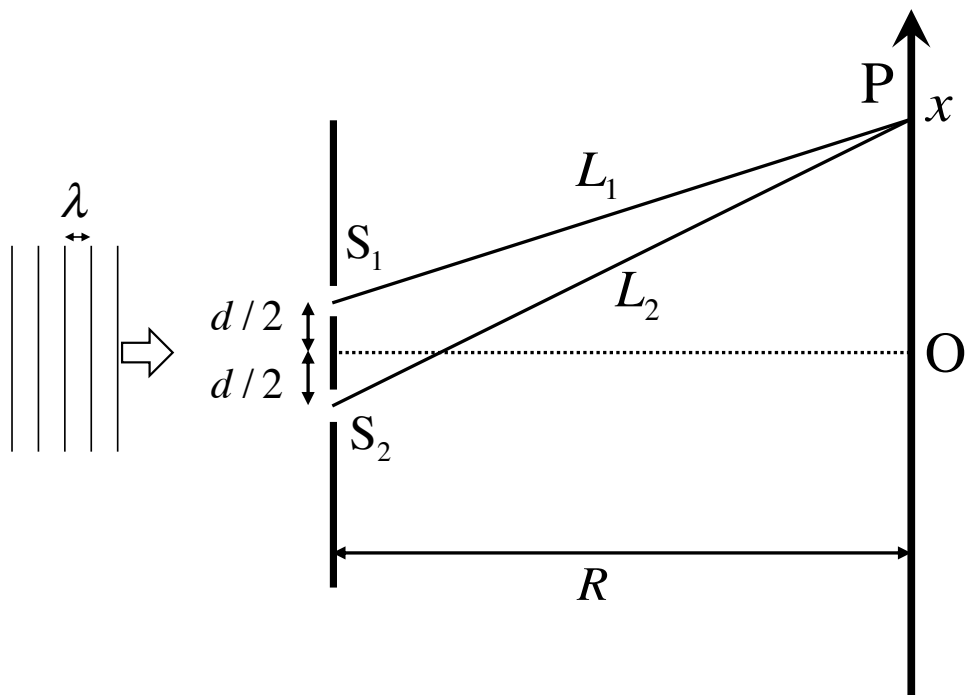


Fig. 5