

2025 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 2025

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.

(2025)

Physics

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

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) A small ball is thrown vertically upward from the ground with speed v_0 . The acceleration of gravity is denoted by g . Find the speed of the ball when it passes a point at a height h from the ground.

(a) $\sqrt{v_0^2 - 2gh}$

(b) $\sqrt{v_0^2 + 2gh}$

(c) $\sqrt{2gh}$

(d) $\sqrt{v_0^2 - gh}$

(e) $\sqrt{v_0^2 + gh}$

(f) v_0

- (2) As shown in Fig. 1-1, one end of a string of length l is fixed at point O and a small ball of mass m is attached to the other end. The small ball is moving in a uniform circular motion in the horizontal plane. The angle between the string and the vertical direction is θ , and the acceleration of gravity is denoted by g . Find the magnitude of the tension F of the string pulling the small ball and the period T of the circular motion.

$$\begin{aligned}
 & \text{(a)} \quad F = \frac{mg}{\cos \theta}, \quad T = \pi \sqrt{\frac{l}{g}} & \text{(b)} \quad F = mg \cos \theta, \quad T = \pi \sqrt{\frac{l \cos \theta}{g}} \\
 & \text{(c)} \quad F = mg \cos \theta, \quad T = 2\pi \sqrt{\frac{l \sin \theta}{g}} & \text{(d)} \quad F = \frac{mg}{\cos \theta}, \quad T = 2\pi \sqrt{\frac{l \cos \theta}{g}} \\
 & \text{(e)} \quad F = \frac{mg}{\sin \theta}, \quad T = 2\pi \sqrt{\frac{l \sin \theta}{g}} & \text{(f)} \quad F = \frac{mg}{\sin \theta}, \quad T = 2\pi \sqrt{\frac{l}{g}}
 \end{aligned}$$

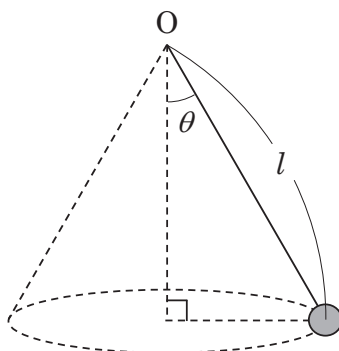


Fig. 1-1

- (3) As shown in Fig. 1-2, in a uniform magnetic field with a flux density of 3.0 T, a conducting wire with a length of 0.10 m is placed at 60° to the magnetic field and a current of 2.0 A is applied. Find the magnitude of the magnetic force on the wire.

- (a) 0.22 N (b) 0.32 N (c) 0.42 N
 (d) 0.52 N (e) 0.62 N (f) 0.72 N

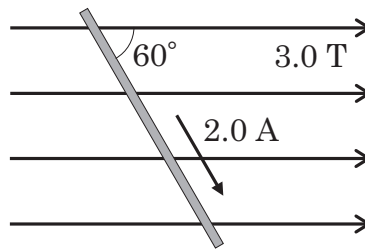


Fig. 1-2

- (4) An infinitely long straight conducting wire has a uniformly distributed charge of ρ per unit length. Find the magnitude of the electric field at a distance r from the wire. The proportionality constant of Coulomb's law is denoted by k . Note that k and the dielectric constant of vacuum ϵ_0 are related by $k = \frac{1}{4\pi\epsilon_0}$.

- (a) $k\rho r$ (b) $\frac{k\rho}{r}$ (c) $\frac{k\rho}{r^2}$
 (d) $2k\rho r$ (e) $\frac{2k\rho}{r}$ (f) $\frac{2k\rho}{r^2}$

- (5) As shown in Fig. 1-3, there is a point light source P at a depth h in a liquid of refractive index n . The refractive index of air is 1. We want to float an opaque disk with the center at point O directly above the point light source on the liquid so that no light leaks into the air. Find the minimum radius r of the disk.

- (a) $\frac{h}{n}$ (b) $\frac{h}{\sqrt{n^2 - 1}}$ (c) $\sqrt{n^2 - 1}h$
- (d) nh (e) $\frac{h}{\sqrt{n^2 + 1}}$ (f) $\sqrt{n^2 + 1}h$

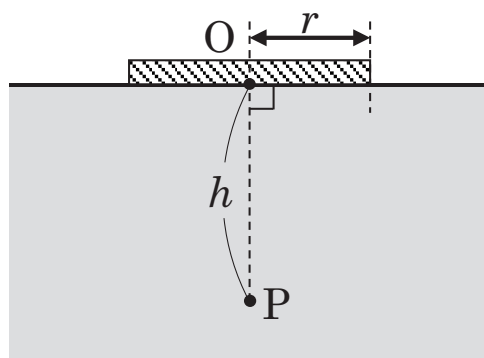


Fig. 1-3

2. An object with mass m is launched from point O at an angle θ ($0 < \theta < \pi/2$) with respect to the ground and a velocity $v(> 0)$ at time $t = 0$ as shown in Fig. 2. The x -axis and y -axis are taken in the horizontal and vertical directions, respectively. The acceleration of gravity is denoted by g . Answer the following questions.

(1) The object reaches its highest point at time $t = t_0$. Find time t_0 .

- | | | |
|--------------------------------|--------------------------------|-------------------------------|
| (a) $\frac{v \cos \theta}{g}$ | (b) $\frac{v}{g}$ | (c) $\frac{v \sin \theta}{g}$ |
| (d) $\frac{v \sin 2\theta}{g}$ | (e) $\frac{v \cos 2\theta}{g}$ | (f) $\frac{v}{2g}$ |

(2) When the object reaches its highest point, its x coordinate is a . Find the correct formula for a .

- | | | |
|-----------------------------------|-----------------------------------|---|
| (a) $\frac{v^2 \sin^2 \theta}{g}$ | (b) $\frac{v^2 \cos^2 \theta}{g}$ | (c) $\frac{v^2 \sin^3 \theta}{g}$ |
| (d) $\frac{v^2 \cos^3 \theta}{g}$ | (e) $\frac{v^2}{g}$ | (f) $\frac{v^2 \sin \theta \cos \theta}{g}$ |

(3) Find the y coordinate of the highest point.

- | | | |
|------------------------------------|------------------------------------|----------------------------------|
| (a) $\frac{v^2 \sin^2 \theta}{2g}$ | (b) $\frac{v^2 \cos^2 \theta}{2g}$ | (c) $\frac{v^2 \sin \theta}{2g}$ |
| (d) $\frac{v^2 \cos \theta}{2g}$ | (e) $\frac{v^2 \sin \theta}{g}$ | (f) $\frac{v^2 \cos \theta}{g}$ |

(4) The object hits the ground at $x = b$. Find the correct formula for b .

- | | | |
|----------------------------------|--|---------------------------------|
| (a) $\frac{2v^2 \sin \theta}{g}$ | (b) $\frac{2v^2 \cos \theta}{g}$ | (c) $\frac{v^2 \sin \theta}{g}$ |
| (d) $\frac{v^2 \cos \theta}{g}$ | (e) $\frac{2v^2 \sin \theta \cos \theta}{g}$ | (f) $\frac{2v^2}{g}$ |

(5) When $\theta = \theta_0$, b takes the maximum. Find the angle θ_0 .

- | | | |
|---------------------|---------------------|---------------------|
| (a) $\frac{\pi}{2}$ | (b) $\frac{\pi}{3}$ | (c) $\frac{\pi}{4}$ |
| (d) $\frac{\pi}{5}$ | (e) $\frac{\pi}{6}$ | (f) $\frac{\pi}{8}$ |

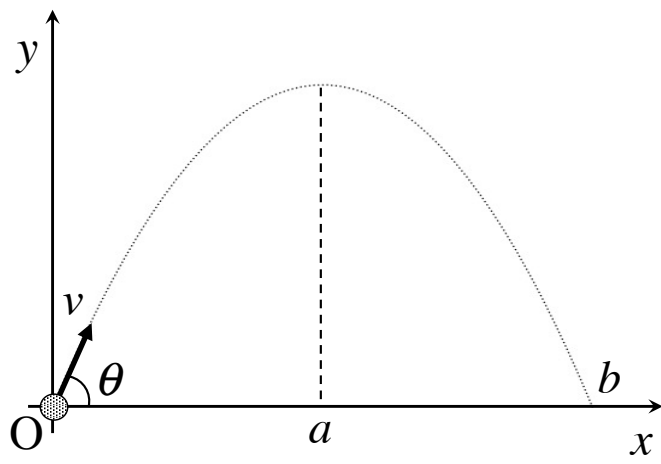


Fig. 2

3. As shown in Fig. 3, a uniform magnetic field of magnetic flux density B is applied vertically from front to back to a sufficiently wide region ABCD. A charged particle of mass m and charge q enters region ABCD from point F perpendicular to AB with a speed v . The charged particle moves as shown in the figure and exits the region from point G perpendicular to AB. Answer the following questions.

- (1) Find the correct one for the charge q and the speed v' at point G.

- (a) $q > 0, \quad v' > v$ (b) $q > 0, \quad v' = v$ (c) $q > 0, \quad v' < v$
 (d) $q < 0, \quad v' > v$ (e) $q < 0, \quad v' = v$ (f) $q < 0, \quad v' < v$

- (2) Find the magnitude of the Lorentz force on the particle.

- (a) $-\frac{qB}{v}$ (b) $-\frac{qv}{B}$ (c) $-qvB$
 (d) $\frac{qB}{v}$ (e) $\frac{qv}{B}$ (f) qvB

- (3) Find the direct distance L between points F and G.

- (a) $\frac{m}{qvB}$ (b) $\frac{2m}{qvB}$ (c) $\frac{mv}{qB}$
 (d) $\frac{2mv}{qB}$ (e) $\frac{mv}{2qB}$ (f) $\frac{2mB}{qv}$

- (4) Find the time for the particle to move from point F to point G.

- (a) $\frac{m\pi}{2qB}$ (b) $\frac{2m\pi}{qB}$ (c) $\frac{m\pi}{qB}$
 (d) $\frac{m}{qB\pi}$ (e) $\frac{2m}{qB\pi}$ (f) $\frac{m}{qB}$

- (5) In a similar manner, a particle with three times of mass m and twice of the charge q enters region ABCD from point F perpendicular to AB with a speed v , and exits the region from point G' which is different from point G. Find the direct distance between point F and point G' using L obtained in the above question (3).

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

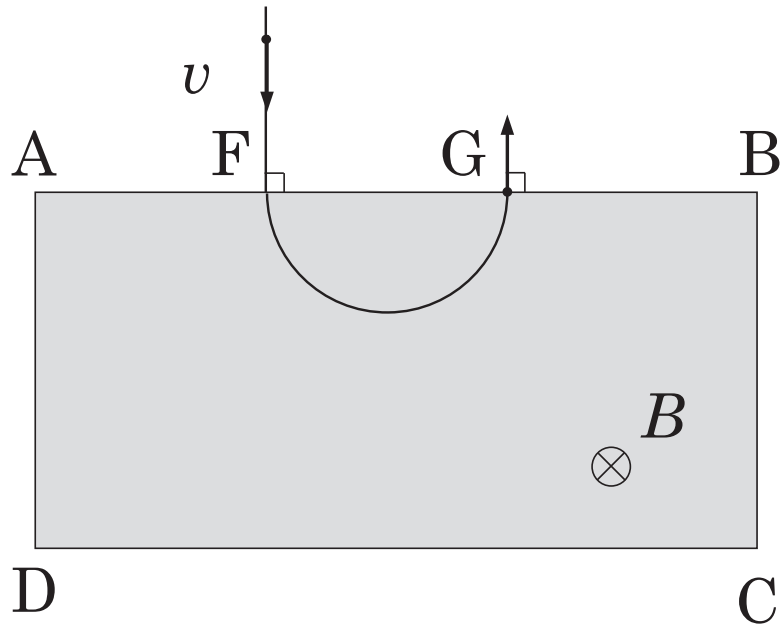


Fig. 3

4. A monatomic ideal gas with n moles is confined within a cubic container of volume $V = L^3$, as shown in Fig. 4. As shown in the figure, the x -, y -, and z -axes are taken along the sides of the cubic container. The gas comprises N molecules, each with a mass of m . The system is in thermal equilibrium at temperature T . The universal gas constant is represented as R , and the Boltzmann constant as k . Answer the following questions.

- (1) The pressure exerted by the gas on the container walls is a result of the molecules colliding with the walls. Consider a molecule in motion with a positive x -component velocity of v_x . Assuming an elastic collision, find the change in momentum when this molecule strikes the wall parallel to the y - z plane.

- | | | |
|------------|--------------|-------------|
| (a) mv_x | (b) $mv_x/2$ | (c) $v_x/2$ |
| (d) v_x | (e) $2v_x$ | (f) $2mv_x$ |

- (2) A molecule is in motion with a velocity v_x , where v_x is positive, as in the previous question. Find the time interval between collisions of this molecule with one of the two walls parallel to the y - z plane.

- | | | |
|-----------------------|-----------------------|----------------------|
| (a) $\frac{4L}{v_x}$ | (b) $\frac{2L}{v_x}$ | (c) $\frac{L}{2v_x}$ |
| (d) $\frac{L^2}{v_x}$ | (e) $\frac{L}{v_x^2}$ | (f) $\frac{L}{4v_x}$ |

- (3) Let the velocity of one molecule be (v_x, v_y, v_z) . Denoting the average value of v_x^2 by $\overline{v_x^2}$ and the average value of $v^2 = v_x^2 + v_y^2 + v_z^2$ by $\overline{v^2}$, find the pressure of the gas.

- | | | |
|-------------------------------------|-----------------------------------|-------------------------------------|
| (a) $\frac{m}{V}\overline{v^2}$ | (b) $\frac{m}{3V}\overline{v^2}$ | (c) $\frac{mN}{2V}\overline{v_x^2}$ |
| (d) $\frac{3mN}{V}\overline{v_x^2}$ | (e) $\frac{mN}{3V}\overline{v^2}$ | (f) $\frac{mN}{V}\overline{v^2}$ |

- (4) Find the internal energy of the gas.

- | | | |
|----------------------|----------------------|----------------------|
| (a) $\frac{1}{2}nRT$ | (b) $\frac{3}{2}nRT$ | (c) $\frac{5}{2}nRT$ |
| (d) nRT | (e) $3nRT$ | (f) $5nRT$ |

- (5) Find the root-mean-square speed, $\sqrt{\overline{v^2}}$.

(a) $\sqrt{\frac{kT}{2m}}$

(b) $\sqrt{\frac{3kT}{2m}}$

(c) $\sqrt{\frac{kT}{2m}}$

(d) $\sqrt{\frac{kT}{2m}}$

(e) $\sqrt{\frac{3kT}{m}}$

(f) $\sqrt{\frac{5kT}{m}}$

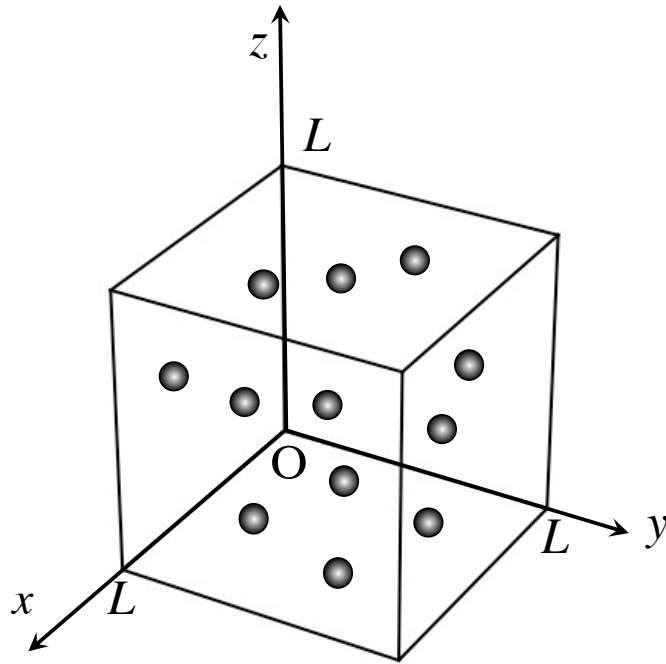


Fig. 4

5. As shown in Fig. 5-1, light with the wavelength λ emitted from a light source at A in the atmosphere is divided into two beams by the half-mirror at H. The refractive index of the atmosphere is assumed to be 1. The half-mirror is positioned at a 45-degree angle to the incoming light ray, One beam is reflected off the half-mirror and then off the mirror at M_1 . Afterward, this beam passes through the half-mirror and reaches the detector at B. The other beam first passes through the half-mirror and is then reflected off the mirror at M_2 . Subsequently, this beam is reflected by the half-mirror and reaches the detector at B. The distance between the half-mirror and the mirror at M_1 is denoted by L_1 . The distance to the mirror at M_2 from the half-mirror is denoted by L_2 and is larger than L_1 . Answer the following questions.

(1) By adjusting the horizontal position of the mirror at M_2 while maintaining $L_2 > L_1$, the difference $L_2 - L_1$ changes. The intensity of the light observed at B is strongest when $L_2 - L_1 = d_1$. Find the relationship between λ and d_1 . Here, p is an integer.

(a) $d_1 = 2p^2\lambda$ (b) $d_1 = p^2\lambda$ (c) $2d_1 = p^2\lambda$

(d) $d_1 = 2p\lambda$ (e) $d_1 = p\lambda$ (f) $2d_1 = p\lambda$

(2) By increasing $L_2 - L_1$ from d_1 , the intensity of the light observed at B diminishes. By further increasing $L_2 - L_1$, the light intensity is strongest again at $L_2 - L_1 = d_2$. Find the correct expression for λ .

(a) $2(d_2 - d_1)$ (b) $d_2 - d_1$ (c) $\frac{1}{2}(d_2 - d_1)$

(d) $2(d_1 - d_2)$ (e) $d_1 - d_2$ (f) $\frac{1}{2}(d_1 - d_2)$

We then place a rectangular glass with thickness w and refractive index n at G, as shown in Fig. 5-2. The glass is positioned perpendicular to the light beam and remains situated between the half-mirror and the mirror at M_2 in subsequent steps.

(3) The intensity of the light observed at B is strongest when $L_2 - L_1 = d_3$. Find the relationship between λ and d_3 . Here, q is an integer.

(a) $d_3 + nw = q\lambda$ (b) $2(d_3 + nw) = q\lambda$

(c) $2(d_3 + w) = nq\lambda$ (d) $d_3 + (n - 1)w = q\lambda$

(e) $2[d_3 + (n - 1)w] = q\lambda$ (f) $2(d_3 + w) = (n - 1)q\lambda$

(4) By increasing $L_2 - L_1$ from d_3 , the intensity of the light observed at B diminishes. By further increasing $L_2 - L_1$, the intensity of the light is strongest again at $L_2 - L_1 = d_4$. Find the correct expression for λ .

- (a) $n(d_4 - d_3)$ (b) $2n(d_4 - d_3)$ (c) $2(d_4 - d_3)$
 (d) $(n - 1)(d_4 - d_3)$ (e) $2(n - 1)(d_4 - d_3)$ (f) $4(d_4 - d_3)$

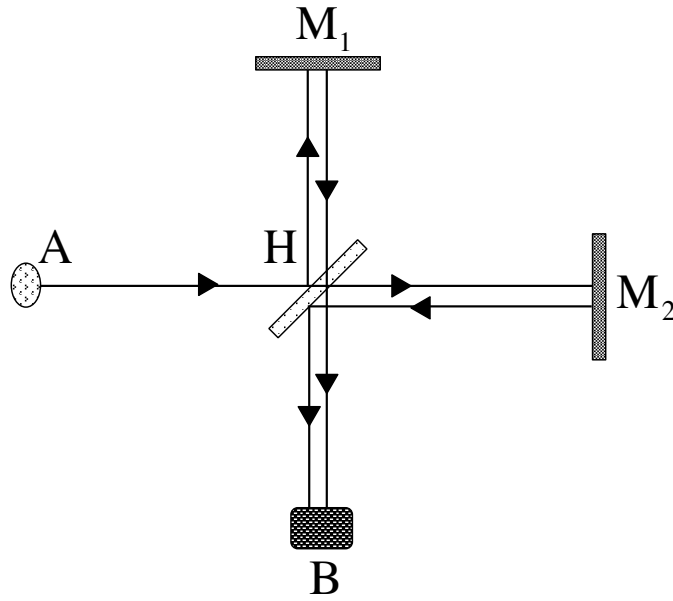


Fig. 5-1

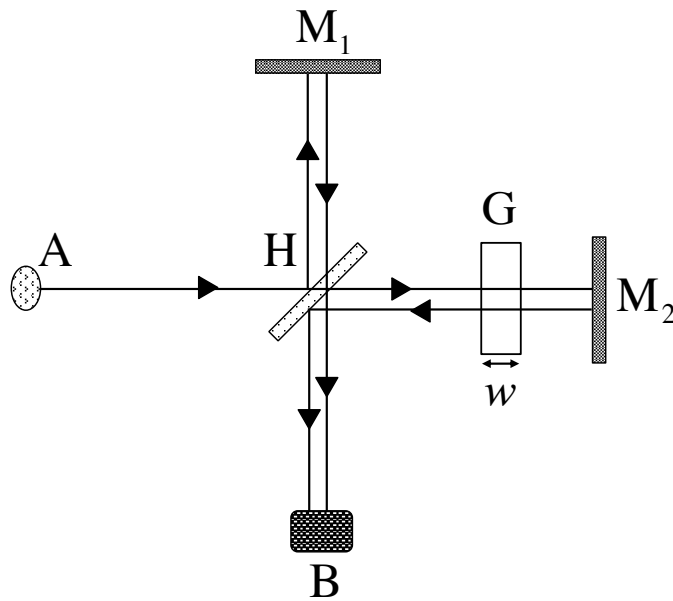


Fig. 5-2