2017 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 JAPANESE GOVERNMENT（MONBUKAGAKUSHO）SCHOLARSHIPS 2017

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**.

(2017)

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 script and on the answer sheet.

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

1. Answer the following questions.

(1) A graph of velocity v versus time t for a mass particle moving along a straight line is shown in Fig. 1-1. From $t = 0$ to $t = t_1$ and from $t = t_1$ to $t = t_2$ the particle moves at constant acceleration. The velocity at $t = t_1$ is v_1 and the velocity at $t = t_2$ is v_2. Find the distance traveled from $t = 0$ to $t = t_2$.

(a) $\frac{1}{2}(v_1 t_1 + v_2 t_2)$ (b) $\frac{v_1 t_2 - v_2 t_1 + v_2 t_2}{2}$ (c) $v_1 t_1 + v_2 t_2$

(d) $v_1 t_2 - v_2 t_1 + v_2 t_2$ (e) $\frac{1}{2}(v_1 t_2 + v_2 t_1)$ (e) $(v_2 - v_1)(t_2 - t_1)$

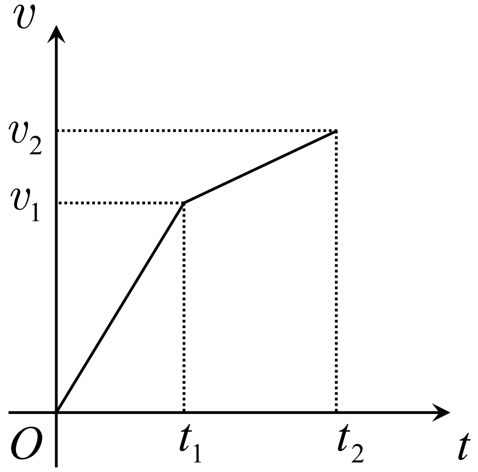

Fig. 1-1

(2) A monatomic ideal gas expands at a constant pressure, P, from a volume of V_1 to a volume of V_2. Find the heat required for this process.

(a) $\frac{1}{2}P(V_2 - V_1)$ (b) $\frac{3}{2}P(V_2 - V_1)$ (c) $P(V_2 - V_1)$

(d) $\frac{5}{2}P(V_2 - V_1)$ (e) PV_2 (f) PV_1

(3) A block of mass m attached to a spring with a force constant k is free to move on a frictionless horizontal surface. The angular frequency of the spring is denoted by $\omega = \sqrt{\frac{k}{m}}$. The block is released from a resting position after the spring is stretched a distance of d. The direction of the stretch is taken as the positive direction. Which is the correct graph of the velocity of the block versus time in Fig. 1-2 from (a) to (d)?

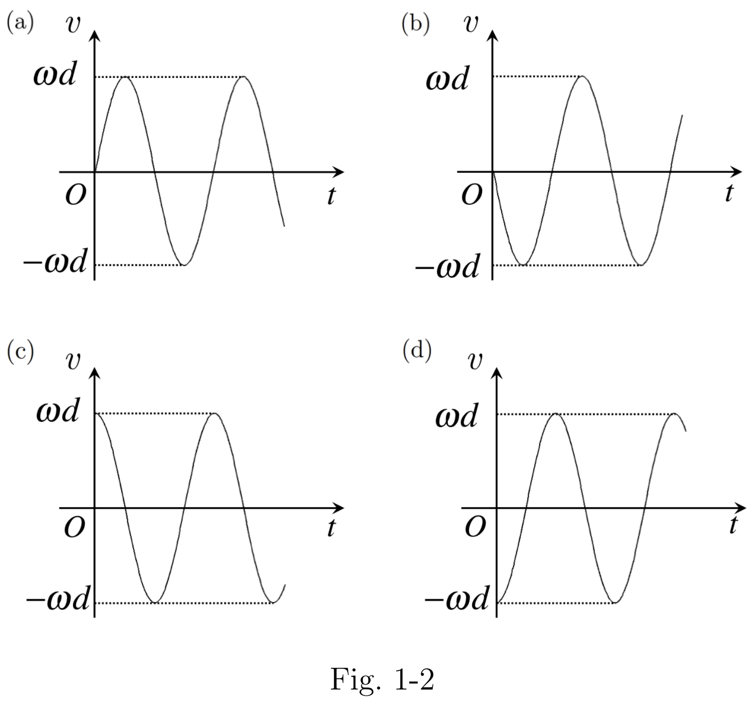

Fig. 1-2

(4) A positive charge q on a frictionless, horizontal surface is attached to a spring with a force constant k. The charge and the spring are aligned along the x-axis as shown in Fig. 1-3 (a). The initial position of the charge q is $x = 0$ and the spring is in equilibrium. When a positive charge Q is placed on the x-axis at $x = \ell$, the spring is compressed by d and the charge q is stable as shown in Fig. 1-3 (b). The permittivity of free space is denoted by ε_0. Find the formula for the charge Q.

(a) $\frac{4\pi\varepsilon_0}{q} kd\,(\ell + d)^2$ (b) $\frac{4\pi\varepsilon_0}{q} kd\ell$ (c) $\frac{4\pi\varepsilon_0}{q} kd\,(\ell + d)$

(d) $\varepsilon_0 q$ (e) $\frac{4\pi\varepsilon_0}{q} kd^2\ell$ (f) $\frac{4\pi\varepsilon_0}{q} kd^2\,(\ell + d)$

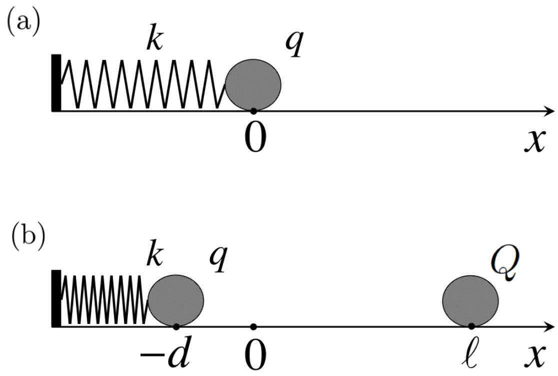

Fig. 1-3

(5) A person looking into an empty container is able to see the far edge of the container's bottom surface as shown in Fig. 1-4 (a). The height of the container is h and its width is d. When the container is completely filled with a fluid of index of refraction n, the person viewing it from the same angle θ shown in Fig. 1-4 (a) and (b) can see the center of a coin placed on the bottom as shown in Fig. 1-4 (b). The distance between the center of the coin and the far edge is x. Find the formula for the refractive index n.

(a) $\frac{d - x}{d}$ (b) $\sqrt{\frac{h^2 + (d - x)^2}{h^2 + d^2}}$

(c) $\frac{d - x}{d}\sqrt{\frac{h^2 + d^2}{h^2 + (d - x)^2}}$ (d) $\frac{d}{d - x}\sqrt{\frac{h^2 + (d - x)^2}{h^2 + d^2}}$

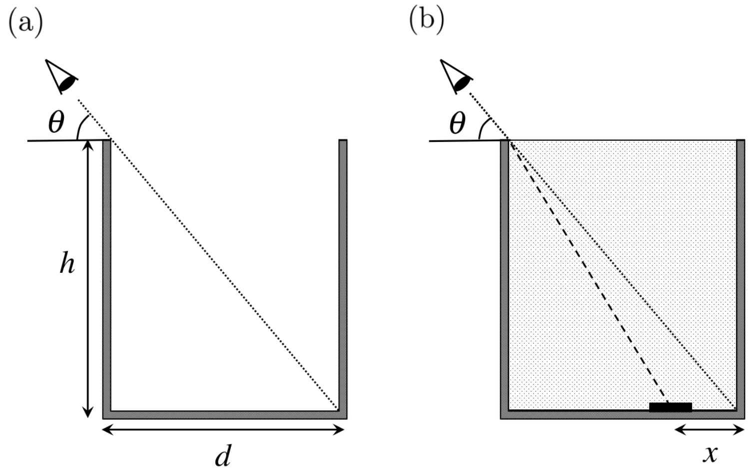

Fig. 1-4

2. A parallel-plate capacitor with a plate separation of d as shown in Fig. 2 (a) has a capacitance C in the absence of a dielectric. Answer the following questions:

(1) When the potential difference between the two plates is V, how much charge is on each capacitor.

(a)	$4CV$	(b)	$\frac{1}{2}CV$	(c)	CV^2
(d)	CV	(e)	$\frac{1}{2}CV^2$	(f)	$\frac{1}{2}C^2V$

(2) Find the electric field created between the two plates in the case of (1).

(a)	V^2/d	(b)	V/d	(c)	V/d^2
(d)	CV/d	(e)	C/d	(f)	C/d^2

(3) A slab of dielectric of relative permittivity ε and thickness $d/2$ is inserted between plates as shown in Fig. 2 (b). This capacitor is equivalent to two capacitors C_1 and C_2 connected in a series as shown in Fig. 2 (c). Find the capacitance of C_1 in Fig. 2 (c).

(a)	εC	(b)	$(\varepsilon + 1)C$	(c)	C/ε
(d)	$2C/\varepsilon^2$	(e)	$2\varepsilon C$	(f)	$2C/(\varepsilon + 1)$

(4) Find the capacitance of the capacitor shown in Fig. 2 (b).

(a)	$\frac{2\varepsilon}{\varepsilon + 1}C$	(b)	$4\varepsilon C$	(c)	$2(\varepsilon + 1)C$
(d)	$\frac{\varepsilon + 1}{2\varepsilon}C$	(e)	$\frac{\varepsilon}{\varepsilon + 1}C$	(f)	$\frac{2\varepsilon + 1}{\varepsilon}C$

(5) Two dielectrics with relative permittivity ε_1 and ε_2 each fill half the space between the two plates as shown in Fig. 2 (d). Find the capacitance of this capacitor.

(a) $(\varepsilon_1 + \varepsilon_2)C$ (b) $\frac{\varepsilon_1\varepsilon_2}{2(\varepsilon_1 + \varepsilon_2)}C$ (c) $\frac{\varepsilon_1 + \varepsilon_2}{2}C$

(d) $\frac{\varepsilon_1 + \varepsilon_2}{\varepsilon_2}C$ (d) $\frac{\varepsilon_1 + \varepsilon_2}{\varepsilon_1\varepsilon_2}C$ (d) $\frac{\varepsilon_1 + \varepsilon_2}{\varepsilon_1}C$

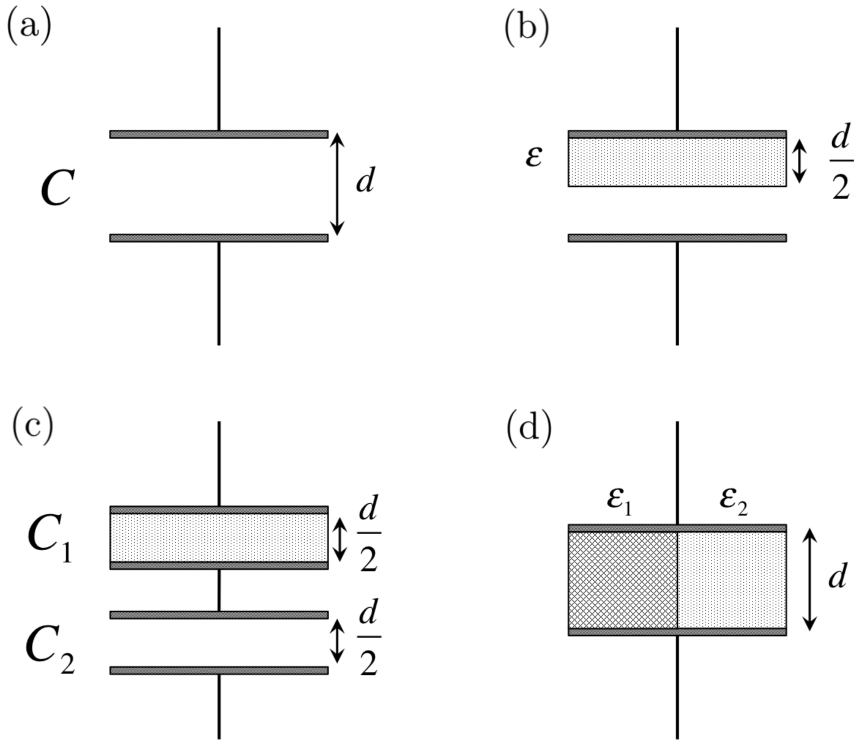

Fig. 2

3. A hemisphere of radius R is fixed on a horizontal floor, as shown in Fig. 3. A small ball of mass m slides down from the top of the hemisphere at point A with zero initial speed. There is no friction between the ball and the surface of the hemisphere. After sliding down the surface, the ball leaves the surface of the hemisphere at point B and hits the horizontal floor at point C. As the ball slides between A and B on the surface of the hemisphere, the position of the ball is described by the angle θ shown in the figure. The acceleration of gravity is denoted as g. Answer the following questions.

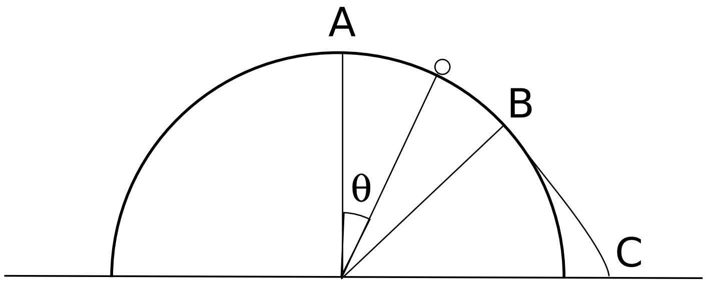

Fig. 3

(1) Find the speed of the ball when the ball is at a position on the hemisphere described by the angle θ.

(a) $\sqrt{2gR\sin\theta}$ (b) $\sqrt{2gR\cos\theta}$ (c) $\sqrt{2gR(1-\sin\theta)}$

(d) $\sqrt{2gR(1-\cos\theta)}$ (e) $\sqrt{\frac{gR}{2}\sin\theta}$ (f) $\sqrt{\frac{gR}{2}\cos\theta}$

(g) $\sqrt{\frac{gR}{2}(1-\sin\theta)}$ (h) $\sqrt{\frac{gR}{2}(1-\cos\theta)}$

(2) Find the normal force acting from the hemisphere to the ball when the ball is on the hemisphere at a position described by the angle θ.

(a) $mg\cos\theta$ (b) $mg\sin\theta$ (c) $mg(2-\cos\theta)$

(d) $mg(2-\sin\theta)$ (e) $mg(3\cos\theta-2)$ (f) $mg(3\sin\theta-2)$

(g) $mg(3-4\cos\theta)$ (h) $mg(3-4\sin\theta)$

(3) The position B at which the ball leaves the hemisphere is described by the angle θ_B. Find $\cos\theta_B$.

(a) $\frac{1}{2}$ (b) $\frac{\sqrt{3}}{2}$ (c) $\frac{2}{3}$

(d) $\frac{\sqrt{5}}{3}$ (e) $\frac{3}{4}$ (f) $\frac{\sqrt{7}}{4}$

(4) Find the speed of the ball immediately before the ball reaches the point C.

(a) $\sqrt{\frac{1}{2}gR}$ (b) $\sqrt{gR}$ (c) $\sqrt{2gR}$

(d) $\sqrt{5gR}$ (e) $\sqrt{\frac{1}{2}gR}$ (f) $\sqrt{\frac{1}{5}gR}$

(5) Find the speed of the ball in the horizontal direction immediately before the ball reaches the point C.

(a) $\sqrt{\frac{2}{3}gR}$ (b) $\sqrt{\frac{3}{2}gR}$ (c) $\sqrt{\frac{8}{9}gR}$

(d) $\sqrt{\frac{9}{8}gR}$ (e) $\sqrt{\frac{8}{27}gR}$ (f) $\sqrt{\frac{27}{8}gR}$

(g) $\sqrt{\frac{7}{15}gR}$ (h) $\sqrt{\frac{15}{7}gR}$

4. One mole of an ideal monatomic gas is taken through the cycle A → B → C → A as shown in Fig. 4. B → C is an isothermal process at temperature T_0, in which the gas absorbs the heat Q_0. The universal gas constant is denoted as R. Answer the following questions.

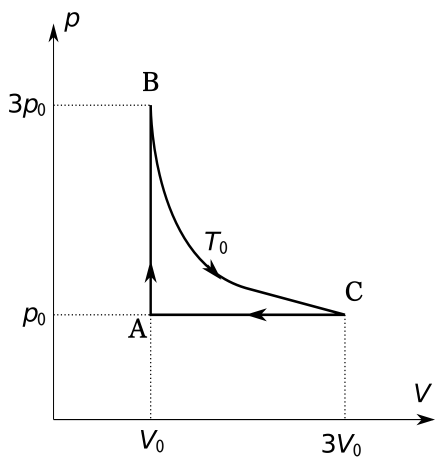

Fig. 4

(1) Find the temperature of the gas at A.

(a) $\frac{1}{9}T_0$ (b) $\frac{1}{3}T_0$ (c) T_0

(d) $3T_0$ (e) $9T_0$

(2) Find the heat absorbed by the gas in the process A → B.

(a) $-2RT_0$ (b) $-RT_0$ (c) $-\frac{2}{3}RT_0$

(d) 0 (e) $\frac{2}{3}RT_0$ (f) RT_0

(g) $2RT_0$ (h) $-Q_0$ (i) Q_0

(3) Find the work done by the gas in the process B $\to$ C.

(a)	$-2RT_0$	(b)	$-RT_0$	(c)	$-\frac{2}{3}RT_0$
(d)	0	(e)	$\frac{2}{3}RT_0$	(f)	RT_0
(g)	$2RT_0$	(h)	$-Q_0$	(i)	Q_0

(4) Find the work done by the gas in the process C $\to$ A.

(a)	$-2RT_0$	(b)	$-RT_0$	(c)	$-\frac{2}{3}RT_0$
(d)	0	(e)	$\frac{2}{3}RT_0$	(f)	RT_0
(g)	$2RT_0$	(h)	$-Q_0$	(i)	Q_0

(5) Select a correct relation for the sign of the net work W done by the gas and the net heat Q absorbed by the gas per cycle.

(a)	$W > 0, Q > 0$	(b)	$W = 0, Q > 0$	(c)	$W < 0, Q > 0$
(d)	$W > 0, Q = 0$	(e)	$W = 0, Q = 0$	(f)	$W < 0, Q = 0$
(g)	$W > 0, Q < 0$	(h)	$W = 0, Q < 0$	(i)	$W < 0, Q < 0$

5. Two small speakers are driven in phase by the same oscillator. They are placed at A and B separated by 6 m as shown in Fig. 5. An observer listens to the sound from the speakers at a position along a straight line PQ which is parallel to and separated by 8 m from the straight line AB. A point O on PQ is at the same distance from A and B. The observer moves from O toward Q. The position of the observer is described by x. At O, the observer hears the sound of constructive interference from the two speakers. As the observer moves from O, the sound becomes weaker. At $x = 3$ m, the observer hears the minimum sound for the first time. In the questions (1) - (3) below, the speed of sound in the air is 3.4×10^2 m/s. Answer the following questions.

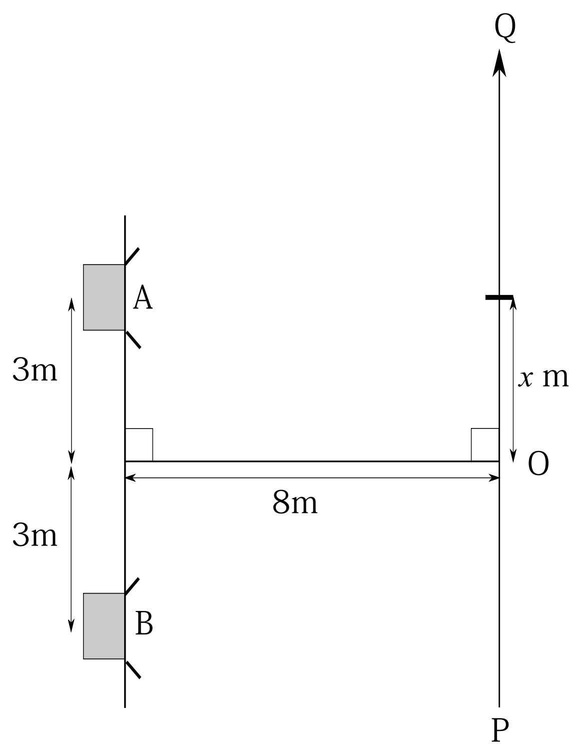

Fig. 5

(1) Find the wavelength of the sound wave.

(a) 8 m (b) 4 m (c) 3 m

(d) 2 m (e) 1 m

(2) Find the frequency of the sound wave.

(a) 4.3×10^1 Hz	(b) 8.5×10^1 Hz	(c) 1.1×10^2 Hz
(d) 1.7×10^2 Hz	(e) 2.6×10^2 Hz	(f) 3.4×10^2 Hz
(g) 6.8×10^2 Hz	(h) 1.0×10^3 Hz	(i) 1.4×10^3 Hz

(3) As the frequency of the speakers is increased, the observer at $x = 3$ m experiences an increase in the sound. Further increasing the frequency, the sound reaches its maximum and then decreases, and finally returns to its minimum again. Find the closest frequency of the sound wave when the sound reaches its minimum again.

(a) 4.3×10^1 Hz	(b) 8.5×10^1 Hz	(c) 1.1×10^2 Hz
(d) 1.7×10^2 Hz	(e) 2.6×10^2 Hz	(f) 3.4×10^2 Hz
(g) 6.8×10^2 Hz	(h) 1.0×10^3 Hz	(i) 1.4×10^3 Hz

(4) The frequency of the speakers is fixed at the value of problem (2). Find the correct description for the change of the value of x at which the observer hears minimum sound when the temperature of the air increases and the speed of sound in the air changes.

(a) Increase	(b) No change	(c) Decrease