2019 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 2019

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**.

(2019)

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 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 car at rest starts moving along a straight line and stops at time $t = 80$ s. The velocity v of the car changes as a function of time t as shown in Fig.1-1. Find the distance that the car travels.

(a)	5000 m	(b)	4000 m	(c)	3000 m
(d)	2000 m	(e)	1000 m	(f)	500 m

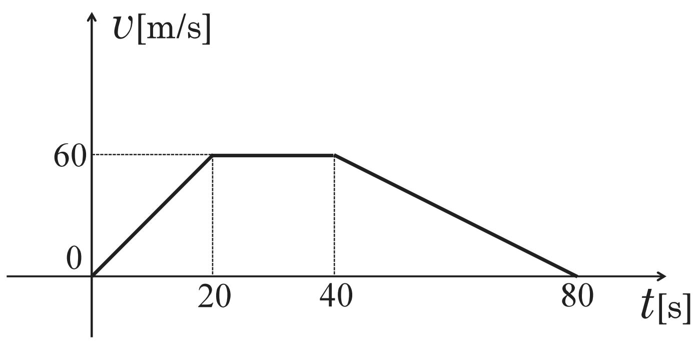

Fig. 1-1

(2) A small ball at rest falls down from a height of h above the ground and bounces repeatedly. The coefficient of restitution between the ball and the ground is denoted as e, and the acceleration of gravity as g. Find the maximum height of the ball between the nth and the $(n+1)$th impact with the ground.

(a) he (b) $h(1-e)^n$ (c) he^n

(d) he^{2n} (e) he^{2n+2} (f) he^{2n-2}

(3) Two long straight wires, with the same current I flowing in the opposite direction, are placed parallel to each other with a distance of $2d$ as shown in Fig. 1-2. Find the magnitude of magnetic field H at point P.

(a) $\dfrac{I}{2\pi d}$ (b) $\dfrac{I}{\pi d}$ (c) $\dfrac{\pi I}{d}$

(d) $\dfrac{2\pi I}{d}$ (e) $\dfrac{I}{d}$ (f) $\dfrac{I}{2d}$

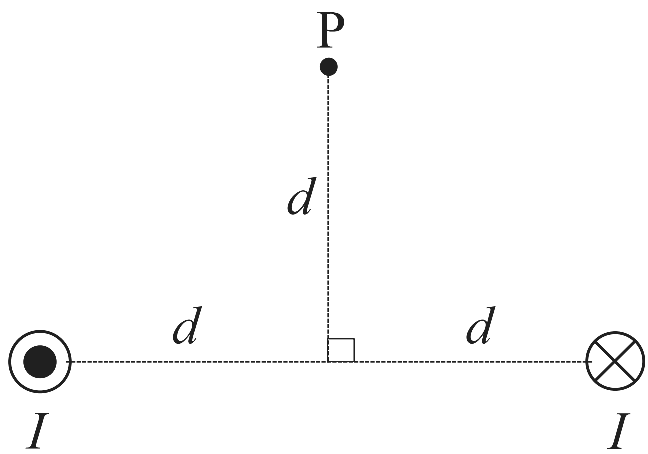

Fig. 1-2

(4) A sinusoidal wave travels in the positive x-direction with a constant speed of 2 m/s. Figure 1-3 shows a snapshot of the wave at $t = 0$ s as a function of x. Find the formula for the displacement y at time t.

(a)	$2\sin\pi(x-2t)$	(b)	$3\sin\frac{\pi}{2}(x-2t)$	(c)	$3\sin\frac{\pi}{4}(x-2t)$
(d)	$3\sin\frac{\pi}{2}(2x-t)$	(e)	$3\sin\pi(x-t)$	(f)	$3\sin\frac{\pi}{4}(2x-t)$

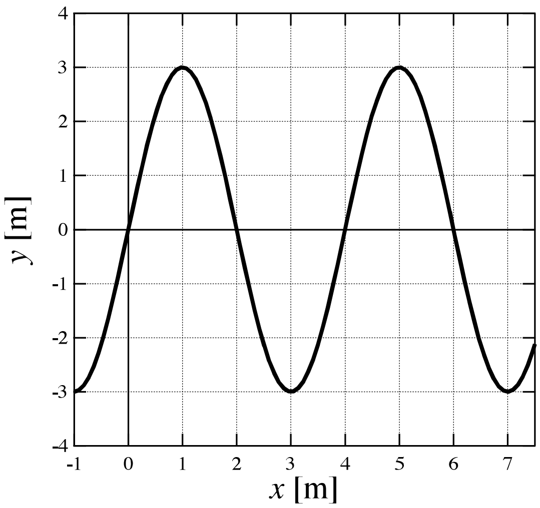

Fig. 1-3

(5) A movable piston is fitted in a tube as shown in Fig. 1-4. A speaker near the open end of the tube emits sound waves with a frequency of 555 Hz. When the piston moves from the left end to the right, the first and second resonances are produced at distances 14 cm and 44 cm from the open end, respectively. Find the speed of the sound waves.

(a)	344 m/s	(b)	338 m/s	(c)	333 m/s
(d)	328 m/s	(e)	322 m/s	(f)	311 m/s

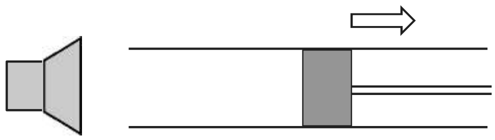

Fig. 1-4

2. Consider the circuit shown in Fig. 2-1, consisting of a resistor R, a capacitor C, an inductor (coil) L, a switch S, and a battery with voltage V. At the beginning, the switch is in position **b** and the capacitor is uncharged. Then the switch is changed to position **a**. After having been in position **a** for a long time, the switch is changed to position **c**. Answer the following questions.

(1) Find the current I_0 through the resistor just after the switch is changed to position **a**.

(a)	CV	(b)	$\frac{1}{2}CV$	(c)	$\frac{V}{3R}$
(d)	$\frac{V}{2R}$	(e)	$\frac{V}{R}$	(f)	0

(2) Find the charge on the capacitor after having been in position **a** for a long time.

(a)	$C(V + RI_0)$	(b)	$C(V - RI_0)$	(c)	$\frac{1}{2}CV^2$
(d)	CV^2	(e)	$\frac{1}{2}CV$	(f)	CV

(3) Find the Joule heat generated in the resistor by the time the capacitor is fully charged.

(a)	0	(b)	$\frac{1}{2}CV^2$	(c)	$\frac{1}{3}CV^2$
(d)	$\frac{1}{4}CV^2$	(e)	$\frac{2}{3}CV^2$	(f)	CV^2

(4) At time $t = 0$, the switch is moved from position **a** to position **c**. How does the current I_L, which flows into the inductor (coil), change as a function of time? Find one appropriate graph in Fig. 2-2.

(5) Find the maximum value of I_L.

(a)	$\sqrt{\frac{C}{L}}V$	(b)	$\sqrt{\frac{L}{C}}V$	(c)	$\sqrt{LC}V$
(d)	$\frac{1}{\sqrt{LC}}V$	(e)	$\frac{V}{R}$	(f)	$\frac{V}{2R}$

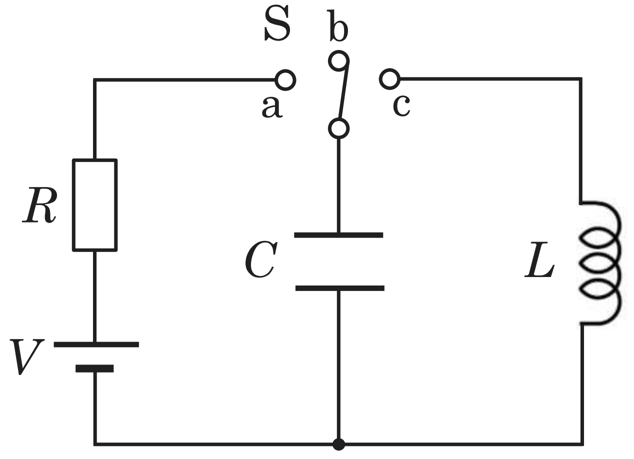

Fig. 2-1

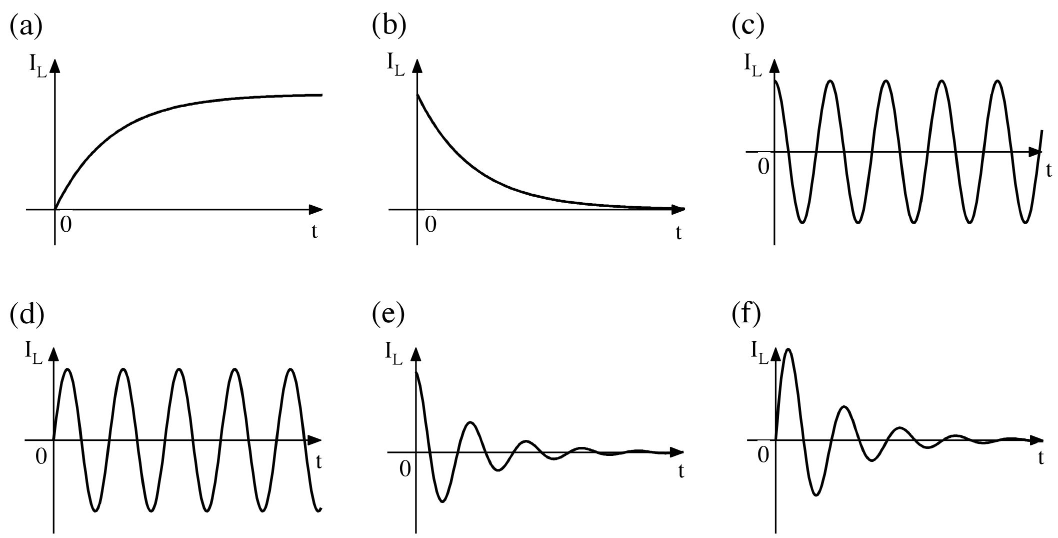

Fig. 2-2

3. An object of mass m is moving with a speed v on a frictionless plane as shown in Fig. 3. The object reaches at the end of the plane, $x = 0$ and $y = h$, at time $t = 0$, and jumps into the air. There is a slope in the $x > 0$ region as shown in Fig. 3. The acceleration of gravity is denoted as g. Answer the following questions.

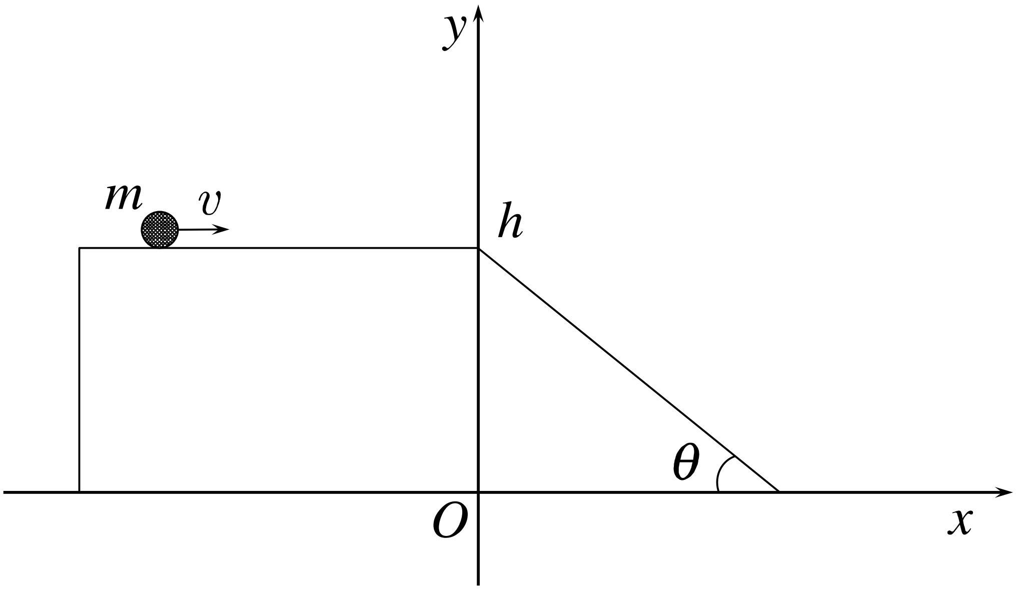

Fig. 3

(1) Find the x coordinate of the object at time $t(> 0)$ when the object is in the air.

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

(d) vt　(e) $\frac{1}{2}vt^2$　(f) $\frac{v}{t}$

(2) Find the y coordinate of the object at time $t(> 0)$ when the object is in the air.

(a) $-\frac{1}{2}gt^2$　(b) gt^2　(c) h

(d) $h - gt$　(e) $h - gt^2$　(f) $h - \frac{1}{2}gt^2$

(3) If v is larger than a speed v_c, the object does not hit the slope and directly drops to the horizontal plane at $y = 0$. Find the expression of v_c.

(a) $\dfrac{\sqrt{2gh}}{\tan\theta}$ (b) $\dfrac{\sqrt{2gh}}{2}$ (c) $\dfrac{\sqrt{2gh}}{2\tan\theta}$

(d) $\sqrt{gh}$ (e) $\dfrac{\sqrt{gh}}{2}$ (f) $\dfrac{\sqrt{gh}}{\tan\theta}$

(4) If v is less than v_c, the object hits the slope. Find the x coordinate of the impact point.

(a) $\dfrac{v^2}{g}\sin\theta$ (b) $\dfrac{v^2}{g}\tan\theta$ (c) $\dfrac{v^2}{g}\cos\theta$

(d) $\dfrac{2v^2}{g}\sin\theta$ (e) $\dfrac{2v^2}{g}\tan\theta$ (f) $\dfrac{2v^2}{g}\cos\theta$

4. A non-adiabatic cylinder with cross-sectional area A is placed at normal air pressure and is filled with an ideal gas as shown in Fig. 4(a). The cylinder is closed by an adiabatic piston with mass m. The pressure of the air is P and the temperature of the air is T. In equilibrium, the height of the piston is h from the bottom and the temperature of the gas is T. An object of mass M is placed on the piston, and the height of the piston becomes h_1 in equilibrium as shown in Fig. 4(b). The acceleration of gravity is denoted as g. Answer the following questions.

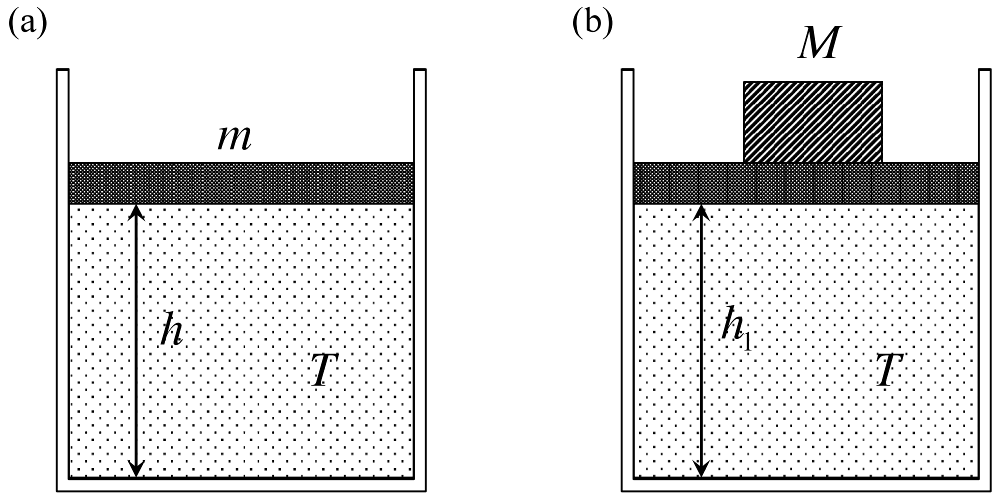

Fig. 4

(1) Find the expression of h_1.

(a) h (b) $\dfrac{PA+mg}{PA+(M+m)g}h$

(c) $\dfrac{mg}{PA+(M+m)g}h$ (d) $\dfrac{PA+(M+m)g}{PA+Mg}h$

(2) Find the work done on the gas by the air when the height of the piston changes from h to h_1.

(a) 0 (b) $\dfrac{Mg(PA+Mg)h}{PA+Mg}$ (c) $\dfrac{MgPAh}{PA}$

(d) $\dfrac{MgPAh}{PA+Mg}$ (e) $\dfrac{MgPAh}{PA+mg}$ (f) $\dfrac{MgPAh}{PA+(M+m)g}$

We then cover the system with adiabatic walls and remove the object with mass M. In equilibrium, the height of the piston becomes h_2.

(3) Find the temperature of the gas.

(a) T (b) $\dfrac{h}{h_2}T$ (c) $\dfrac{h_2+h}{h}T$

(d) $\dfrac{h}{h+h_2}T$ (e) $\dfrac{h_2}{h}T$ (f) $\dfrac{h_2+h}{h_2}T$

We then remove the adiabatic walls. In equilibrium, the height of the piston becomes h_3.

(4) Find the expression of h_3.

(a) h (b) h_2 (c) $2h$

(d) $2h_2$ (e) $h/2$ (f) $h_2/2$

5. A light ray of wavelength λ traveling through air is incident on a flat thin soap film at an angle θ to the normal, as shown in Fig. 5. The thickness of the film is d. The path of the light ray is bent toward the normal in the film with the refraction angle ϕ. We assume that the index of refraction of air is 1 and denote the index of refraction of the film by n. Answer the following questions.

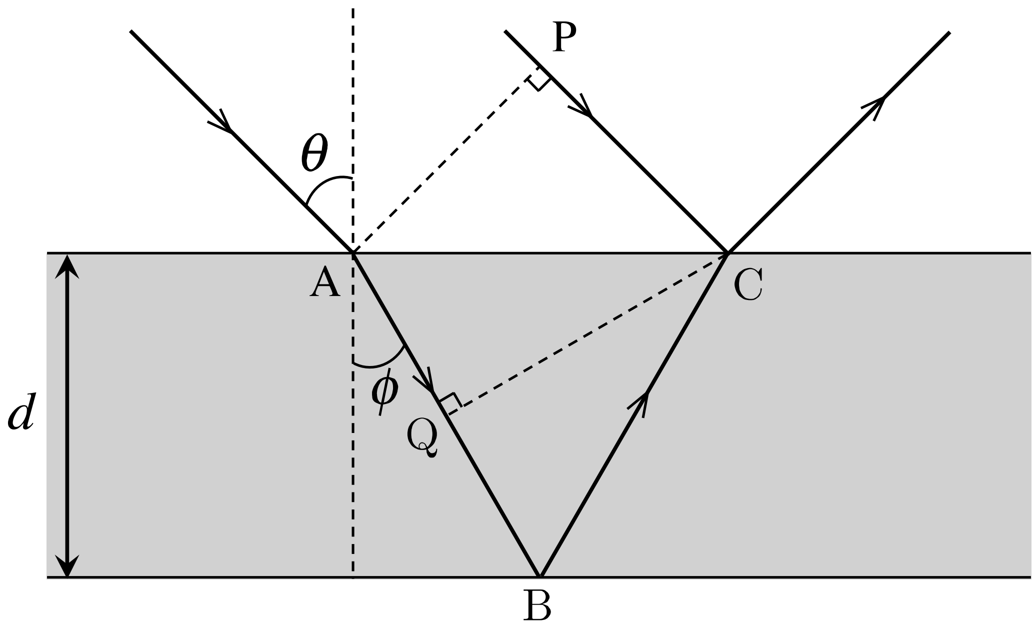

Fig. 5

(1) Find the wavelength of the light ray in the film.

(a) $\dfrac{\lambda}{n^2}$ (b) $\dfrac{\lambda}{n}$ (c) $\dfrac{\lambda}{\sqrt{n}}$

(d) $n\lambda$ (e) $\sqrt{n}\lambda$ (f) λ

(2) Find the relationship between θ and ϕ.

(a) $\tan\theta = n\tan\phi$ (b) $\cos\theta = n^2\cos\phi$ (c) $\cos\theta = n\cos\phi$

(d) $\sin\theta = n\sin\phi$ (e) $\sin\theta = \dfrac{\sin\phi}{n}$ (f) $\cos\theta = \dfrac{\cos\phi}{n}$

(3) If a certain condition is satisfied, constructive interference occurs between the light reflected at C and the light traveling through the path ABC. The condition is expressed using a non-negative integer, m. Find this condition.

(a) $\mathrm{QB}+\mathrm{BC}=\left(m+\frac{1}{2}\right)\frac{\lambda}{n}$ (b) $\mathrm{AB}+\mathrm{PC}=m\lambda$

(c) $\mathrm{QB}+\mathrm{BC}=m\lambda$ (d) $\mathrm{AB}+\mathrm{BC}=\left(m+\frac{1}{2}\right)\frac{\lambda}{n}$

(4) Find the expression of d when the condition in (3) is satisfied, and constructive interference occurs.

(a) $\dfrac{m\lambda}{2n\cos\phi}$ (b) $\dfrac{(2m+1)\lambda}{4n\cos\phi}$ (c) $\dfrac{(2m+1)\lambda}{4n\sin\phi}$

(d) $\dfrac{(2m+1)\lambda}{4\cos\phi}$ (e) $\dfrac{m\lambda}{4n\sin\phi}$ (f) $\dfrac{m\lambda}{2\cos\phi}$