2014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 2014

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**.

Physics

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

(2014)

Marks	

Answer Sheet

1	(1)	
	(2)	
	(3)	
	(4)	
	(5)	
2	(1)	
	(2)	
	(3)	
	(4)	
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3	(1)	
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4	(1)	
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5	(1)	
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	(3)	
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	(5)	

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 the answer sheet below.

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

1. Answer the following questions.

(1) Two objects with mass M and m are on a flat horizontal table. A horizontal spring with spring constant k is attached to the two objects as shown in Fig.1-1. If the system is released from rest when the spring is stretched by ℓ, find the maximum velocity of the object with mass m.

(a) $\sqrt{\dfrac{k\ell^2}{m}}$ (b) $\sqrt{\dfrac{k\ell^2}{(M+m)}}$ (c) $\sqrt{\dfrac{Mk\ell^2}{m(M+m)}}$

(d) $\sqrt{\dfrac{k\ell^2}{M}}$ (e) $\sqrt{\dfrac{k\ell^2}{|M-m|}}$ (f) $\sqrt{\dfrac{Mk\ell^2}{m(|M-m|)}}$
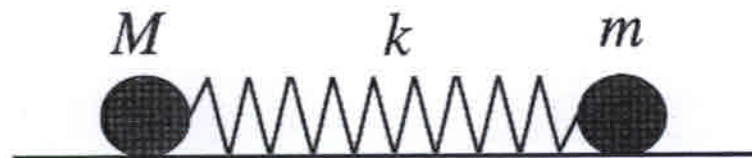

Fig. 1-1

(2) An object is launched horizontally from the earth's surface. Let R be the radius of the earth and g the acceleration of gravity on the surface of the earth. Find the minimum speed to escape the earth's gravity.

(a) $\sqrt{gR}$ (b) $\sqrt{4gR}$ (c) gR

(d) $\sqrt{\frac{g}{R}}$ (e) $\sqrt{2gR}$

(3) There is a room of volume 100m³. The pressure is kept constant at 1.0×10^5Pa. At 270K and this pressure, the density of air is 1.3kg/m³. Find the mass of air that escapes when the temperature of the room increases from 270K to 300K.

(a) 0.13kg   (b) 1.3kg   (c) 13kg

(d) 0.12kg   (e) 1.2kg   (f) 12kg

(4) Consider the circuit shown in Fig. 1-4, consisting of three capacitors C_1, C_2, and C_3, a battery of voltage E, and a switch S. Initially the capacitors are uncharged. Find the charge that has accumulated in the capacitor C_1 after the switch has been closed for a sufficient period of time.

(a) $(C_1 + C_3)E$ (b) $\frac{C_1 C_3}{C_1 + C_2 + C_3}E$ (c) $\frac{C_1 C_2}{C_1 + C_2 + C_3}E$

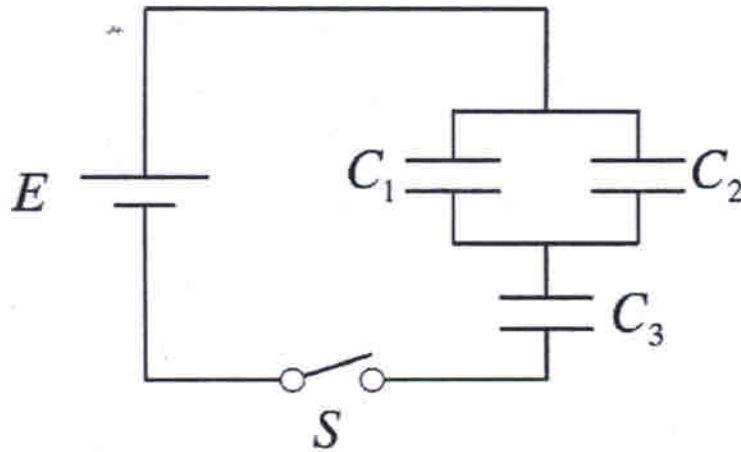(d) $(C_1 + C_2 + C_3)E$ (e) $\frac{C_1 C_3}{C_1 + C_2}E$ (f) $\frac{C_1 C_2}{C_3}E$

Fig. 1-4

(5) Figure 1-5 shows light entering a water droplet with radius r in the air. The light ray enters the droplet at P and the point O is the center of the droplet. Let n be the index of refraction for water. Find the formula for the angle of refraction ϕ.

(a) $\cos\phi = \frac{nr}{h}$ (b) $\cos\phi = \frac{h}{nr}$ (c) $\cos\phi = \frac{nh}{r}$

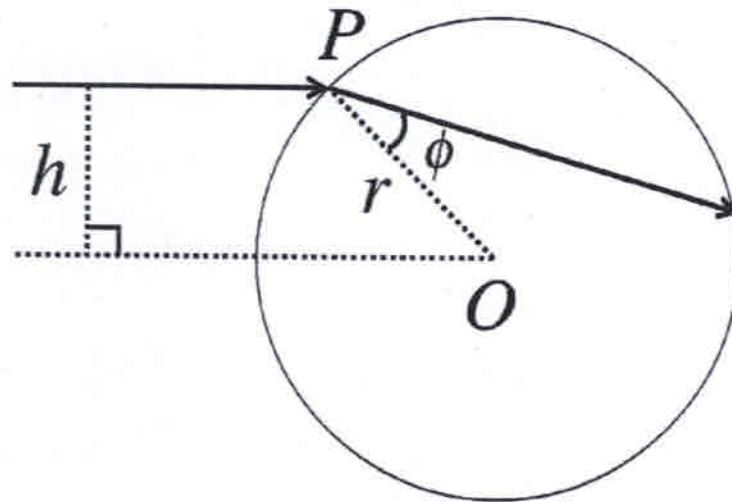(d) $\sin\phi = \frac{nh}{r}$ (e) $\sin\phi = \frac{nr}{h}$ (f) $\sin\phi = \frac{h}{nr}$

Fig. 1-5

2. In Fig. 2-1, a current I flows through a thin strip of metal. The strip has a thickness a, width b, and length c. We assume that there are n electrons with a charge of $-q(<0)$ per unit volume and they all move with speed v.

(1) Find the number of electrons passing through the strip in time t.

(a)	$nabct$	(b)	$nabt$	(c)	nc^2vt
(d)	$nabvt$	(e)	$nbcvt$	(f)	$ncavt$

(2) Which of the following is the correct formula for the magnitude of the current I?

(a)	$qnabc$	(b)	$qnabv$	(c)	$qnab$
(d)	$nabc$	(e)	$nabv$	(f)	nab

Now we apply a magnetic field B perpendicular to the strip as shown in Fig. 2-2. A voltage V, which is perpendicular to the current and the magnetic field, is produced by charge accumulation on sidewalls.

(3) Find the magnitude of the magnetic force on the electrons moving with speed v.

(a)	qB	(b)	vB	(c)	bcB
(d)	$bcvB$	(e)	qvB	(f)	$qbcB$

(4) Find the formula for V.

(a)	Bbc	(b)	Bab	(c)	Bvc
(d)	Bva	(e)	$Bbcv$	(f)	Bvb

(5) Find the formula for n that contains B, I, and V.

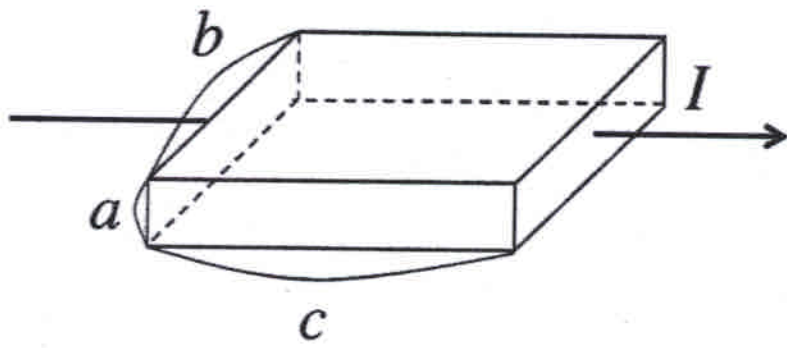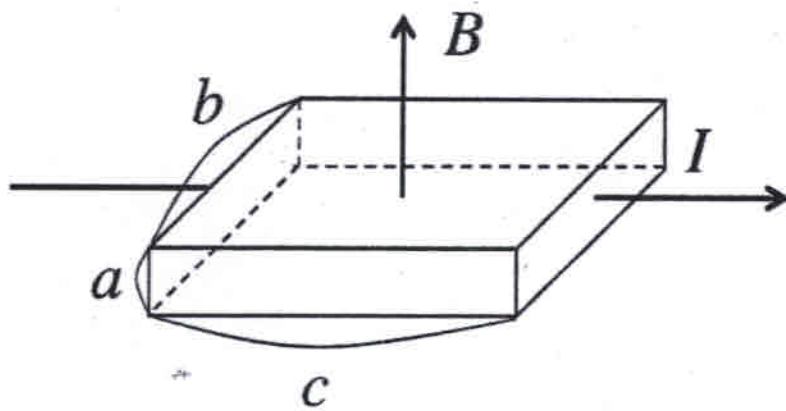|					
(a)	$\frac{BI}{qbV}$	(b)	$\frac{BI}{qaV}$	(c)	$\frac{BI}{qcV}$
(d)	$\frac{BI}{aV}$	(e)	$\frac{BI}{bV}$	(f)	$\frac{BI}{cV}$

Fig. 2-1

Fig. 2-2

3. A small ball of mass m is connected to a fixed point O by a light string of length a, as shown in Fig. 3. The small ball is initially at rest at A and is released gently. The height of A is the same as that of O. At C which is located right below O, there is a thin nail directing perpendicularly to a vertical plane which includes OA. The distance OC is denoted as b. a and b satisfy $a/2 < b < a$. Air resistance to the ball and to the string may be ignored. The acceleration of gravity is denoted as g. Answer the following questions.
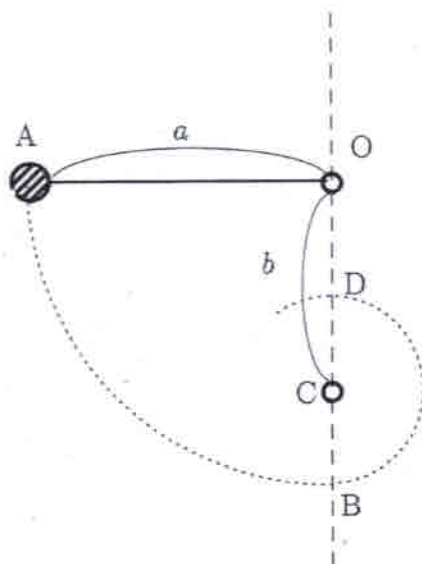

Fig. 3

(1) Find the speed of the small ball when it reaches B, which is located right below O.

(a)	$\sqrt{\frac{3g}{a}}$	(b)	$\sqrt{\frac{2g}{a}}$	(c)	$\sqrt{\frac{g}{a}}$
(d)	$\sqrt{\frac{g}{2a}}$	(e)	$\sqrt{\frac{g}{3a}}$	(f)	$\sqrt{3ga}$
(g)	$\sqrt{2ga}$	(h)	$\sqrt{ga}$	(i)	$\sqrt{\frac{ga}{2}}$
(j)	$\sqrt{\frac{ga}{3}}$	(k)	$\sqrt{\frac{3a}{g}}$	(l)	$\sqrt{\frac{2a}{g}}$
(m)	$\sqrt{\frac{a}{g}}$	(n)	$\sqrt{\frac{a}{2g}}$	(o)	$\sqrt{\frac{a}{3g}}$

(2) Find the magnitude of the tension in the string just before the small ball reaches B.

(a)	mg	(b)	$2mg$	(c)	$3mg$
(d)	$5mg$	(e)	$\frac{1}{2}mg$	(f)	$\frac{1}{3}mg$
(g)	$\frac{1}{5}mg$				

(3) After passing B, the small ball moves around in a circular motion centered at C. The string does not bend in the circular motion. Find the magnitude of the tension in the string when the small ball is at D which is located on OB.

(a)	$\frac{3a-5b}{a+b}mg$	(b)	$\frac{-3a+5b}{a+b}mg$	(c)	$\frac{5a-3b}{a+b}mg$
(d)	$\frac{-5a+3b}{a+b}mg$	(e)	$\frac{3a-5b}{a-b}$	(f)	$\frac{-3a+5b}{a-b}mg$
(g)	$\frac{5a-3b}{a-b}$	(h)	$\frac{-5a+3b}{a-b}$		

(4) Find the relation which a and b must satisfy so that the small ball reaches D without any bending of the string.

(a)	$a > \frac{3}{5}b$	(b)	$a < \frac{3}{5}b$
(c)	$a > \frac{5}{3}b$	(d)	$a < \frac{5}{3}b$

(5) Consider the case of $b = a/2$. In this case, the string bends before the small ball reaches D after passing through B. Find the speed of the small ball when the string starts to bend.

(a)	$\sqrt{\frac{3g}{a}}$	(b)	$\sqrt{\frac{2g}{a}}$	(c)	$\sqrt{\frac{g}{a}}$
(d)	$\sqrt{\frac{g}{2a}}$	(e)	$\sqrt{\frac{g}{3a}}$	(f)	$\sqrt{3ga}$
(g)	$\sqrt{2ga}$	(h)	$\sqrt{ga}$	(i)	$\sqrt{\frac{ga}{2}}$
(j)	$\sqrt{\frac{ga}{3}}$	(k)	$\sqrt{\frac{3a}{g}}$	(l)	$\sqrt{\frac{2a}{g}}$
(m)	$\sqrt{\frac{a}{g}}$	(n)	$\sqrt{\frac{a}{2g}}$	(o)	$\sqrt{\frac{a}{3g}}$

4. One mole of a monatomic ideal gas is taken through the cycle shown in Fig. 4. Starting from A where the pressure and the volume are p_0 and V_0, respectively, the state of the gas is changed through B, C, D, and returns to A. Answer the following questions.
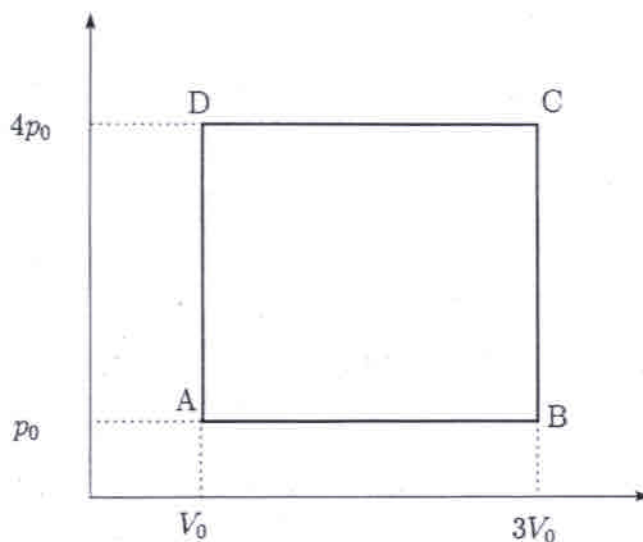

Fig. 4

(1) What multiple of the temperature at C is that at A?

(a)	$\frac{1}{12}$	(b)	$\frac{1}{4}$	(c)	$\frac{1}{3}$
(d)	1	(e)	3	(f)	4
(g)	12				

(2) Find the work done by the gas in the process A → B.

(a)	$\frac{1}{6}p_0V_0$	(b)	$\frac{1}{4}p_0V_0$	(c)	$\frac{1}{3}p_0V_0$
(d)	$\frac{1}{2}p_0V_0$	(e)	p_0V_0	(f)	$2p_0V_0$
(g)	$3p_0V_0$	(h)	$4p_0V_0$	(i)	$6p_0V_0$

(3) Choose the process in which the thermal heat the gas receives from outside is at a maximum, among four processes, A→B, B→C, C→D, and D→A.

(a)	A→B	(b)	B→C
(c)	C→D	(d)	D→A

(4) Find the thermal heat the gas receives from outside in the process of question (3).

(a) $\frac{1}{2}p_0 V_0$ (b) $p_0 V_0$ (c) $\frac{3}{2}p_0 V_0$

(d) $\frac{9}{2}p_0 V_0$ (e) $\frac{13}{2}p_0 V_0$ (f) $\frac{21}{2}p_0 V_0$

(g) $\frac{27}{2}p_0 V_0$ (h) $\frac{31}{2}p_0 V_0$ (i) $\frac{35}{2}p_0 V_0$

(5) Find the net thermal heat which the gas emits in the entire process from A to A through A→B→C→D→A.

(a) $\frac{1}{2}p_0 V_0$ (b) $p_0 V_0$ (c) $\frac{3}{2}p_0 V_0$

(d) $\frac{9}{2}p_0 V_0$ (e) $5p_0 V_0$ (f) $6p_0 V_0$

(g) $\frac{27}{2}p_0 V_0$ (h) $\frac{31}{2}p_0 V_0$ (i) $19p_0 V_0$

5. There are an observer A, a speaker B which emits sound waves of frequency f, a wall D which reflects sound waves, and an observer C who is in front of the wall D and always moves with the wall D, as shown in Fig. 5. The speed of sound is denoted as V. Find the answer to the following questions from the list of possible answers shown below and write the correct letter on the answer sheet.
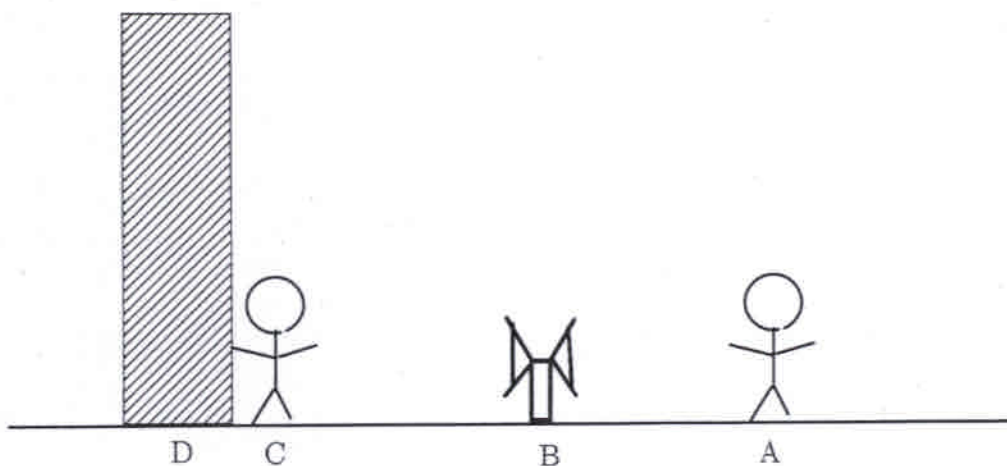

Fig. 5

(1) Observer A, the wall D, and observer C are at rest. The speaker B moves to the right with a speed of v. Find the frequency of the sound which observer A hears directly from the speaker B.

(2) Under the same conditions as indicated in question (1), find the frequency of the sound which observer A hears and which is reflected at the wall D.

(3) Under the same conditions as indicated in question (1), find the number of beats per second that observer A hears.

(4) Observer A and the speaker B are at rest. The wall D and observer C moves to the right with a constant speed v. Find the frequency that observer C hears.

(5) Under the same conditions as indicated in question (4), find the frequency of the sound which observer A hears and which is reflected at the wall D.

(a) $f\frac{V+v}{V}$

(b) $f\frac{V-v}{V}$

(c) $f\frac{V}{V+v}$

(d) $f\frac{V}{V-v}$

(e) $f\frac{V+v}{V-v}$

(f) $f\frac{V-v}{V+v}$

(g) $f\frac{2Vv}{V^2-v^2}$

(h) $f\frac{Vv}{V^2-v^2}$

(i) $f\frac{V^2-v^2}{2Vv}$

(j) $f\frac{V^2-v^2}{Vv}$

(k) $f\frac{V^3+v^3}{V^2-v^2}$

(l) $f\frac{V^2-v^2}{V^2+v^2}$