2012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 2012

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.**

Fill the boxes at the top of the "Answer Sheet" (Nationality, No., Name), first.

In each question, select a suitable answer, and put the symbol selected (a, b, c, ...) to the corresponding space in the answer sheet.

1. Answer the following questions.

(1) Object A of mass m and object B of mass M are tied by a string and are on a smooth and flat floor, as shown in Fig. 1-1. A force of magnitude F is applied to object B in the horizontal direction. Find the magnitude of the tension in the string.

(a)	F	(b)	$\frac{m}{M}F$	(c)	$\frac{M}{M+m}F$
(d)	$\frac{m}{M+m}F$	(e)	$\frac{M}{M-m}F$	(f)	$\frac{m}{M-m}F$

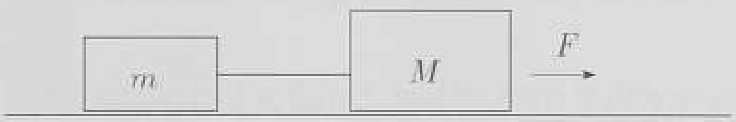

Fig. 1-1

(2) Consider the circuit shown in Fig. 1-2, consisting of two resistors of resistances R_1 and R_2, a capacitor of capacitance C, a battery of voltage E, and a switch S. Find the charge accumulated in the capacitor after the switch has been closed for a sufficient period of time.

(a) CE (b) $\frac{CE}{R_1}$ (c) $\frac{CE}{R_2}$
(d) $\frac{CE}{R_1+R_2}$ (e) $\frac{R_1}{R_1+R_2}CE$ (f) $\frac{R_2}{R_1+R_2}CE$

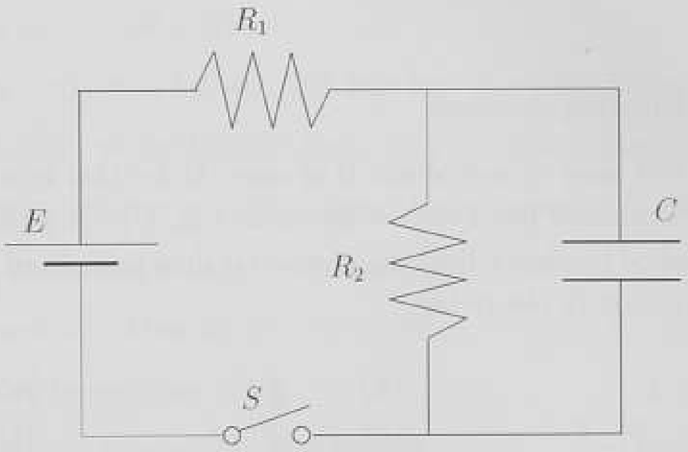

Fig. 1-2

(3) A cylinder with a cross section S with a frictionless piston with a mass of M is fixed at the angle θ in a vertical direction, as shown in Fig. 1-3. Find the pressure inside the cylinder. The atmospheric pressure is denoted as p_0 and the acceleration of gravity is denoted as g.

(a) $p_0 + MgS\cos\theta$ (b) $p_0 - MgS\cos\theta$ (c) $p_0 + MgS\sin\theta$
(d) $p_0 - MgS\sin\theta$ (e) $p_0 + \frac{Mg}{S}\cos\theta$ (f) $p_0 - \frac{Mg}{S}\cos\theta$
(g) $p_0 + \frac{Mg}{S}\sin\theta$ (h) $p_0 - \frac{Mg}{S}\sin\theta$

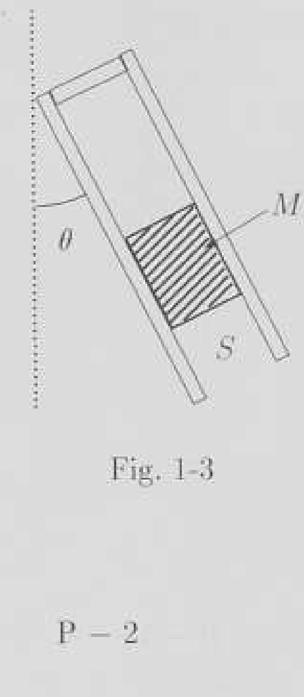

Fig. 1-3

(4) Object 2 with an index of refraction n_2 is placed on object 1 with an index of refraction n_1, as shown in Fig. 1-4. $n_2 > n_1$ is assumed. When a light is incident on object 2 at point A with the incidence angle θ, there occurs total internal reflection at point B. Find the relationship fulfilled by θ, n_1, and n_2.

(a) $\sin\theta < \frac{n_1}{n_2}$ (b) $\sin\theta < \frac{n_2}{n_1}$ (c) $\sin\theta < \sqrt{n_2 - n_1}$

(d) $\sin\theta < \sqrt{n_2^2 - n_1^2}$ (e) $\cos\theta < \frac{n_1}{n_2}$ (f) $\cos\theta < \frac{n_2}{n_1}$

(g) $\cos\theta < \sqrt{n_2 - n_1}$ (h) $\cos\theta < \sqrt{n_2^2 - n_1^2}$

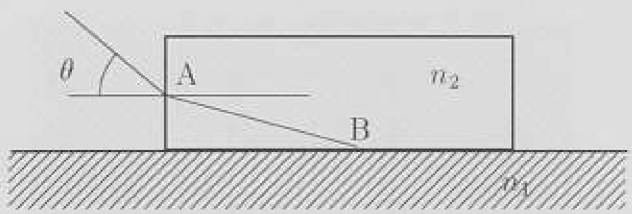

Fig. 1-4

(5) When a light is irradiated to a solid sodium, the emission of photoelectrons is observed if the wavelength of the light is shorter than 5.26×10^{-7}[m]. Find the approximate value of the work function of the solid sodium. Use the following numbers if necessary: the speed of light 3.00×10^{8}[m/s], and the Planck's constant 6.63×10^{-34}[J·s].

(a) 1.05×10^{-19} [J] (b) 1.16×10^{-19} [J] (c) 3.78×10^{-19} [J]

(d) 1.05×10^{-31} [J] (e) 1.16×10^{-31} [J] (f) 3.78×10^{-31} [J]

2. A single-turn coil of a rectangular shape falls down in a space where a uniform magnetic field of magnitude B in a horizontal direction exists above a certain height, as shown in Fig. 2-1. At a sufficiently later time after the bottom of the coil entered in the space without a magnetic field, the coil falls down at a constant speed v. The resistance, the mass, and the horizontal width of the single-turn coil is R, M, and L, respectively. The face of the coil is perpendicular to the magnetic field. The length of the coil in vertical direction is sufficiently long. The acceleration of the gravity is denoted as g. Answer the following questions.

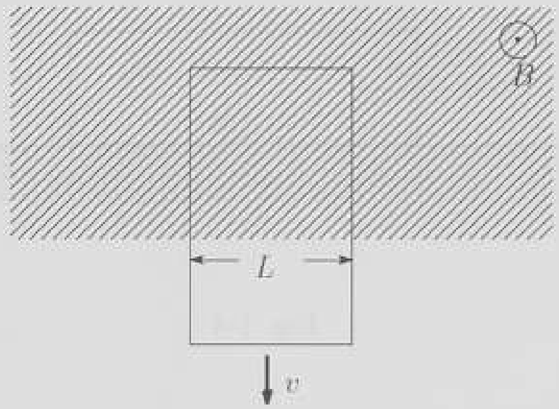

Fig. 2-1

(1) Find the electric current passing through the coil.

(a)	BvR	(b)	BvL	(c)	$\frac{BvR}{L}$
(d)	$\frac{BvL}{R}$	(e)	$\frac{BR}{vL}$	(f)	$\frac{BL}{vR}$

(2) Express the speed of the falling coil in terms of other quantities.

(a)	$\frac{RMg}{BL}$	(b)	$\frac{R^2Mg}{B^2L}$	(c)	$\frac{RMg}{B^2L^2}$
(d)	$\frac{LMg}{BR}$	(e)	$\frac{L^2Mg}{B^2R}$	(f)	$\frac{LMg}{B^2R^2}$

(3) Find the Joule heat produced in the coil per unit time.

(a)	$\frac{BvL}{R}$	(b)	$\frac{B^2vL}{R}$	(c)	$\frac{B^2v^2L^2}{R}$
(d)	$\frac{BvR}{L}$	(e)	$\frac{B^2vR}{L}$	(f)	$\frac{B^2v^2R^2}{L^2}$

(4) When the coil is doubly turned, what multiple of the falling speed is that of the single-turn coil.

(a) $\frac{1}{4}$ (b) $\frac{1}{2}$ (c) 1 (d) 2 (e) 4

3 A sufficiently small steel smooth spherical object is initially at rest at point A on the smooth surface of a finite parabolic curve AOB in a vertical plane as shown in Fig.3−1, where the point O stands for the bottom point, the tangential line at O being horizontal, the vertical height at point A (relative to O) being $2H$, the vertical height at point B (relative to O) being H, the horizontal distance between B and O being $2H$. At time $t = 0$, the object is released slowly to move down frictionlessly along the curve toward point B, where it departs into the air. The effects of the rotation of the object around its center is assumed to be negligible. The speed of the object at B is

(1) (a) $\sqrt{0.5gH}$, (b) $\sqrt{gH}$, (c) $\sqrt{2gH}$, (d) $2\sqrt{gH}$, (e) $2\sqrt{2gH}$,

where g stands for acceleration of gravity. The slope angle of the object orbit measured from the horizontal level just after release in the air at B is

(2) (a) $\pi/8$, (b)$\pi/6$, (c) $\pi/5$, (d) $\pi/4$, (e) $\pi/3$.

The highest object level attained, $y_{\max}$, (based on point O) after release in the air is

(3) (a) $H < y_{\max} < 1.2H$, (b) $1.2H \le y_{\max} < 1.4H$, (c)$1.4H \le y_{\max} < 1.55H$, (d)$1.55H \le y_{\max} \le 1.75H$, (e)$1.75H < y_{\max} \le 2H$.

Finally the object will reach a point C with the same horizontal level as that at O. The necessary time to travel to C from B is

(4) (a) $2\sqrt{H/g}$, (b) $(1+\sqrt{3})\sqrt{H/g}$, (c) $2\sqrt{2}\sqrt{H/g}$, (d) $3\sqrt{H/g}$, (e) $2\sqrt{3}\sqrt{H/g}$.

The horizontal distance between C and B is

(5) (a)$2H$, (b) $(1+\sqrt{3})H$, (c) $2\sqrt{2}H$, (d) $3H$, (e) $2\sqrt{3}H$.

The speed of the object at C is

(6) (a)$\sqrt{gH}$, (b) $\sqrt{2gH}$, (c)$\sqrt{3gH}$, (d) $2\sqrt{gH}$, (e)$\sqrt{6gH}$.

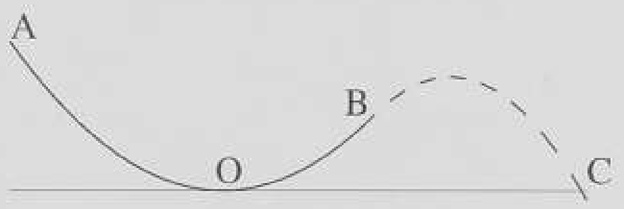

Fig. 3−1

4 Air consists of approximately 78 % Nitrogen in volume, 21 % Oxygen, and 1 % Argon. The atomic weight of Nitrogen is approximately 14, that of Oxygen 16, and that of Argon 40.

Nitrogen occupies air in weight by

(1) (a) 76 %, (b) 77 %, (c) 78 %, (d) 79 %.

The density of air at 0 °C, 0.1 MPa is

(2) (a) 0.65 kg/m^3, (b) 0.93 kg/m^3, (c) 1.29 kg/m^3, (d) 1.33 kg/m^3.

Theoretically the ratio of the specific heat, c_p, at constant pressure to the specific heat, c_v, at constant volume is 5/3 for mono-atomic gases, 7/5 for diatomic gases, 9/7 for triatomic gases. For a single component gas we have $c_p - c_v = R$, where R is a universal gas constant. Then for air, the value $(c_p - c_v)/R$ is

(3) (a) sufficiently larger than unity,

(b) approximately or exactly equal to unity,

(c) sufficiently smaller than unity.

The value c_p/c_v for air is approximately

(4) (a) 1.35, (b) 1.4, (c) 1.45, (d) 1.5, (e) 1.6 .

5 An electric fan in room at 25 °C is producing a small sound in a swinging mode from its frame. The source of sound is assumed to be coming with the interaction of flow and the guarding frame wire. The emitted sound frequency is assumed to be independent of the swinging angle. Maximum instantaneous swinging angular velocity is assumed to be 1 rad/s, and sound velocity in stationary air at 25 °C is 344 m/s.

In case of 3 m/s of emitted wind speed and of 300 Hz of emitted fluid dynamic frequency, the detected sound frequency by a person just in front of the fan is

(1) (a) exactly constant with time,

(b) strongly varying (more than 1 %),

(c) weakly varying (less than 1 %).

The highest or constant detected frequency by the person is

(2) (a) more than 307 Hz,

(b) approximately 306 Hz,

(c) approximately 303 Hz,

(d) approximately 300 Hz,

(e) approximately 297 Hz.

The detected frequency by a person standing far away is

(3) (a) nearly constant with time,

(b) strongly varying (more than 1 %),

(c) weakly varying (less than 1 %).