2007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 2007

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.

(2007)

PHYSICS

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

Marks	

Choose the correct answer, and put a circle around the symbol preceding the answer. In problem 2, write the symbol of the correct answer in the box.

1 Answer the following questions.

(1) A block of mass M is placed on a horizontal frictionless surface and is attached to a spring of force constant k as in Fig.1. Initially the spring is at its natural length and the block is at rest. Then a bullet of mass m and speed v collides horizontally with the block and stops inside the block. The block with the bullet starts to move towards the right and compresses the spring. Find the maximum distance of compression.

(a) $\dfrac{mv}{k}$ (b) $\sqrt{\dfrac{m}{k}}v$ (c) $\dfrac{mv}{kM}$ (d) $\dfrac{m}{\sqrt{kM}}v$

(e) $\dfrac{mv}{k(M+m)}$ (f) $\dfrac{mv}{\sqrt{k(M+m)}}$ (g) $\dfrac{(M+m)v}{km}$ (h) $\dfrac{(M+m)v}{\sqrt{km}}$

Fig. 1

(2) Consider the circuit shown in Fig.2, consisting of four resistors of resistances R_1, R_2, R_3, R_4 and a battery of voltage E. Find the voltage that the high-resistance voltmeter V shows.

(a) $\dfrac{R_1R_2-R_3R_4}{(R_1+R_2)(R_3+R_4)}E$

(b) $\dfrac{R_1R_4-R_2R_3}{(R_1+R_3)(R_2+R_4)}E$

(c) $\dfrac{R_1R_3-R_2R_4}{(R_1+R_4)(R_2+R_3)}E$

(d) $\dfrac{R_1R_2+R_3R_4}{(R_1+R_2)(R_3+R_4)}E$

(e) $\dfrac{R_1R_4+R_2R_3}{(R_1+R_3)(R_2+R_4)}E$

(f) $\dfrac{R_1R_3+R_2R_4}{(R_1+R_4)(R_2+R_3)}E$

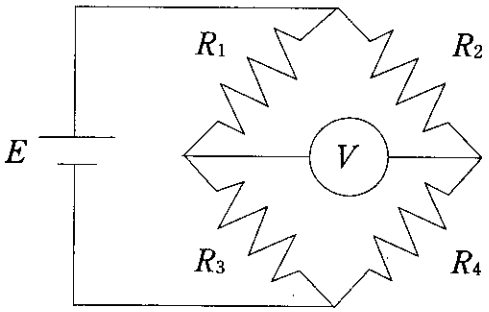

Fig. 2

(3) A cylinder with a frictionless piston is placed horizontally in an atmosphere of pressure $1.0\times10^5\mathrm{N/m^2}$ as shown in Fig.3. A gas in the cylinder is initially at a temperature of 300 K with a volume of $6.0\times10^{-3}\mathrm{m^3}$. Then, the gas is heated slowly to 400 K. How much work is done by the gas in this process?

(a) $-500\mathrm{J}$ (b) $-300\mathrm{J}$ (c) $-200\mathrm{J}$

(d) $200\mathrm{J}$ (e) $300\mathrm{J}$ (f) $500\mathrm{J}$

Fig. 3

(4) Spherical waves of wavelength 8cm are generated in the same phase from two point sources S_1 and S_2 which are separated by a distance 12cm as shown in Fig.4. Point A is separated from S_2 by 16cm and S_2A is perpendicular to S_1S_2. Are the spherical waves generated from S_1 and S_2 constructive or destructive at point A?

(a) constructive (b) destructive

(c) neither constructive nor destructive

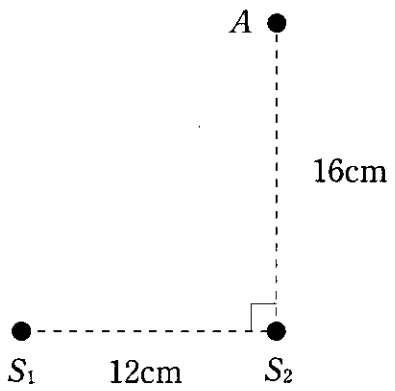

Fig. 4

(5) In the fission process of a $^{235}_{92}U$ nucleus, several neutrons are emitted. When $^{144}_{56}Ba$ and $^{89}_{36}Kr$ are produced in the fission, how many neutrons are emitted?

(a) 1 (b) 2 (c) 3 (d) 4 (e) 5

2 Consider the circuit shown in Fig.5, consisting of a battery of voltage E, a switch S, and a parallel-plate capacitor with capacitance C. The capacitor consists of two parallel conducting plates of equal area A separated by a distance d. After the switch S is closed and the capacitor is fully charged, a conducting plate of thickness $d/3$ and area A is inserted slowly between the plates of the capacitor. The inserted conducting plate is kept parallel to the conducting plates of the capacitor. Select answers to the questions from (a) to (z) below, and write the symbol of the answer in the box.

(1) Find the capacitance of the capacitor after the conducting plate is inserted.

(2) How much is the increase in the charge stored in the capacitor caused by inserting the conducting plate?

(3) How much is the increase in the energy stored in the capacitor caused by inserting the conducting plate?

(4) How much work is done by the battery during the insertion of the conducting plate?

(5) How much work is done by the force applied to the conducting plate during its insertion?

(6) Next, the switch S is opened, and the conducting plate is removed slowly. How much work is done by the force applied to the conducting plate to remove it?

(a) $\frac{1}{4}C$ (b) $\frac{3}{8}C$ (c) $\frac{1}{2}C$ (d) $\frac{3}{4}C$ (e) $\frac{3}{2}C$

(f) $\frac{1}{8}CE$ (g) $\frac{1}{4}CE$ (h) $\frac{3}{8}CE$ (i) $\frac{1}{2}CE$ (j) CE

(k) $\frac{3}{2}CE$ (l) $2CE$ (m) $-\frac{1}{8}CE^2$ (n) $-\frac{1}{4}CE^2$ (o) $-\frac{3}{8}CE^2$

(p) $-\frac{1}{2}CE^2$ (q) $-CE^2$ (r) $-\frac{3}{2}CE^2$ (s) $-2CE^2$ (t) $\frac{1}{8}CE^2$

(u) $\frac{1}{4}CE^2$ (v) $\frac{3}{8}CE^2$ (w) $\frac{1}{2}CE^2$ (x) CE^2 (y) $\frac{3}{2}CE^2$

(z) $2CE^2$

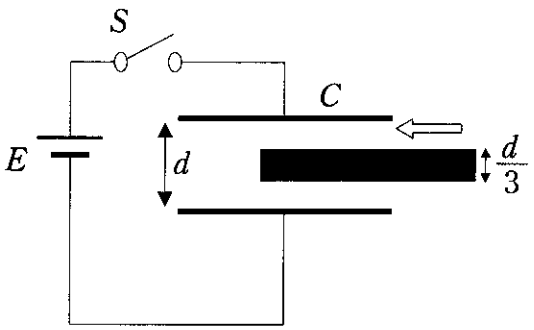

Fig. 5

3 A uniform thin straight bar AE is at rest inside a hemisphere in the configuration shown in Fig.6, under the assumption that friction between the bar and the hemisphere is negligible. This configuration is possible as long as the length of the bar remains within a limited range. The center of the hemisphere is on the vertical plane containing the two points A and B. The upper plane BC of the hemisphere is kept horizontal. The directions $\vec{AD}$ and $\vec{BD}$ mean the direction of the force acting on the bar (from the hemisphere) at point A and that on the bar at point B respectively. $\vec{DG}$ is the direction of the force of gravity acting on the bar, where G is the center of gravity of the bar. The angle θ ($\equiv \angle ABC$) means the angle between the bar and the horizontal line, and $\alpha \equiv \angle ABD$, $\beta \equiv \angle BAD$.

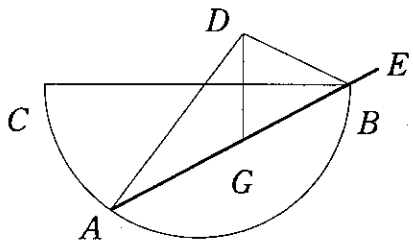

Fig. 6 Configuration

(1) For α, which of the following is correct?

(a) $\alpha \approx 0$ (b) $\alpha = \theta$ (c) $\alpha = 2\theta$ (d) $\alpha = \pi/2$

(2) For β, which of the following is correct?

(a) $\beta \approx 0$ (b) $\beta = \theta$ (c) $\beta = 2\theta$ (d) $\beta = \pi/2$

(3) Is the case $\theta = \pi/4$ possible or impossible?

(a) Possible (b) Impossible

(4) Is the case $\theta = 5\pi/24$ possible or impossible?

(a) Possible (b) Impossible

(5) In case of $\theta = \pi/6$, choose the suitable ratio of the length of the bar to the diameter of the hemisphere from the following.

(a) 3/2 (b) $\sqrt{2}$ (c) $3\sqrt{3}/4$ (d) 5/4 (e) $2/\sqrt{3}$

4 The speed of sound in an ideal gas at rest is given by $\sqrt{\varkappa p/\rho}$, where $\varkappa$: specific heat ratio (≡ specific heat at constant pressure/specific heat at constant volume), p : pressure, ρ : density.

(1) Which of the following is correct?

(a) $0 < \varkappa < \frac{1}{2}$ (b) $\varkappa = \frac{1}{2}$ (c) $\frac{1}{2} < \varkappa < 1$

(d) $\varkappa = 1$ (e) $1 < \varkappa < 2$

(2) Let the density of O_2 (oxygen gas) and that of N_2 (nitrogen gas) at 273.15 K and 1.0×10^5 Pa be $(\rho)_{O_2}$ and $(\rho)_{N_2}$ respectively. The molecular weights of O_2 and N_2 are approximately 32 and 28 respectively. Which of the following is correct?

(a) $(\rho)_{O_2} < (\rho)_{N_2}$ (b) $(\rho)_{O_2} = (\rho)_{N_2}$ (c) $(\rho)_{O_2} > (\rho)_{N_2}$

(3) Let the speed of sound in oxygen gas and in nitrogen gas be v_{O_2} and v_{N_2}. Which of the following is correct?

(a) $v_{O_2} < v_{N_2}$ (b) $v_{O_2} = v_{N_2}$ (c) $v_{O_2} > v_{N_2}$

(4) Let v_w be the speed of sound in water at 273.15 K and 1.0×10^5 Pa. Which of the following is correct?

(a) $v_w < v_{N_2}$ (b) $v_w = v_{N_2}$ (c) $v_w > v_{N_2}$

5 An ambulance is running on an expressway at a speed of 60 km/h from east to west (from A to B) as shown in Fig.7 with a siren of 880 Hz. Let the frequencies of the siren sound detected by an observer located at a point O be ν_A and ν_B when the vehicle just passes point A and point B respectively. Point C is just to the north of O and $\overline{OC}=\overline{AC}=\overline{BC}=100\,\mathrm{m}$. Here the sound velocity in calm air is 340 m/s.

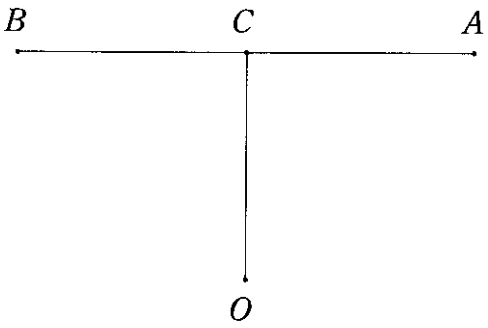

Fig. 7 Configuration

(1) In the case of calm weather (no wind), which is the approximate value of ν_A/ν_B-1?

(a) -0.10 (b) -0.07 (c) 0.0 (d) 0.07 (e) 0.10

(2) In the case of an east wind of 5 m/s (18 km/h), which is the approximate value of ν_A/ν_B-1?

(a) 0.0 (b) 0.03 (c) 0.07 (d) 0.10 (e) 0.13

(3) In the case of a north wind of 5 m/s (18 km/h), which is the approximate value of ν_A/ν_B-1?

(a) -0.03 (b) 0.0 (c) 0.03 (d) 0.07 (e) 0.10