2008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 2008

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.			Marks	
Name	(Please print full name, underlining family name)					

Choose the correct answer, and circle the letter preceding it.

1 Answer the following questions.

(1) A ball is thrown at angles 45° and 30° above the horizontal with the same initial speed. What multiple of the horizontal range at angle 30° is that at angle 45° ?

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

(e) $\frac{1}{2}$ (f) $\frac{2}{\sqrt{3}}$ (g) $\sqrt{\frac{2}{3}}$ (h) $\frac{1}{\sqrt{3}}$

(2) An electric charge Q is stored in a parallel-plate capacitor with capacitance C. The distance between the plates in this capacitor is tripled, keeping the electric charge unchanged. How much work is done from outside in this process?

(a) $3CQ$ (b) $2CQ$ (c) CQ (d) $\frac{1}{2}CQ$ (e) $\frac{1}{3}CQ$

(f) $\frac{3Q^2}{C}$ (g) $\frac{2Q^2}{C}$ (h) $\frac{Q^2}{C}$ (i) $\frac{Q^2}{2C}$ (j) $\frac{Q^2}{3C}$

(3) An air bubble of volume 1 cm^3 is located in water at a depth of 50m beneath the surface where the temperature is 17℃. When the bubble goes up slowly to the surface where the temperature is 27℃, how much will its volume be? Take the atmospheric pressure to be 1 atm. Assume that the pressure increases 1 atm for every 10 m depth.

(a) 4.8cm^3　　(b) 5.0cm^3　　(c) 5.2cm^3

(d) 5.8cm^3　　(e) 6.0cm^3　　(f) 6.2cm^3

(4) When a train running at a speed of 72 km/h approaches a crossing signal, a passenger in the train hears the siren at 720Hz. What frequency does the passenger detect after the train passes the crossing signal? Take the speed of sound in air to be 340 m/s.

(a) 640Hz　　(b) 680Hz　　(c) 720Hz　　(d) 765Hz　　(e) 810Hz

(5) In the α decay of a $^{238}_{92}U$ nucleus, what is the ratio, v/V, of the speed v of the emitted α particle to the speed V of the daughter nucleus?

(a) 58.5　　(b) 118　　(c) $\sqrt{58.5}$　　(d) $\sqrt{118}$　　(e) 1

2 There are 4 points, A, B, C, and D on a smooth horizontal plane as shown in figure 1. AC=BC=CD=a, and AB and CD are mutually perpendicular. First we assume that a charge $+q$ is placed at A and a charge $-q$ is placed at B. $q>0$ and the Coulomb constant is k.

(1) Find the direction of the electric field at point D.

(a) A → B (b) B → A (c) C → D (d) D → C

(2) Find the magnitude of the electric field at point D.

(a) $\frac{kq}{a^2}$ (b) $\frac{kq}{\sqrt{2}a^2}$ (c) $\frac{kq}{2a^2}$

(d) $\frac{kq}{a}$ (e) $\frac{kq}{\sqrt{2}a}$ (f) $\frac{kq}{2a}$

(3) What is the relation between the electric potential V_C at point C and the electric potential V_D at point D?

(a) $V_C > V_D$ (b) $V_C = V_D$ (c) $V_C < V_D$

Next, we assume that a charge $+q$ is placed at both points A and B, and a particle of mass m, charge $-q$ moves on the straight line including CD.

(4) The particle is initially at rest at point C. Find the work required to move the particle slowly from point C to D.

(a) $\frac{2kq}{a^2}$ (b) $\frac{(2-\sqrt{2})kq}{a^2}$ (c) $\frac{(2+\sqrt{2})kq}{a^2}$

(d) $\frac{2kq}{a}$ (e) $\frac{(2-\sqrt{2})kq}{a}$ (f) $\frac{(2+\sqrt{2})kq}{a}$

(5) The particle at point D starts to move with initial speed v toward the point C and reaches the point of infinity. Find the minimum speed v that is required to make the particle reach the point of infinity.

(a) $\sqrt{\frac{2kq^2}{ma^2}}$ (b) $\sqrt{\frac{2\sqrt{2}kq^2}{ma^2}}$ (c) $\sqrt{\frac{4kq^2}{ma^2}}$

(d) $\sqrt{\frac{2kq^2}{ma}}$ (e) $\sqrt{\frac{2\sqrt{2}kq^2}{ma}}$ (f) $\sqrt{\frac{4kq^2}{ma}}$

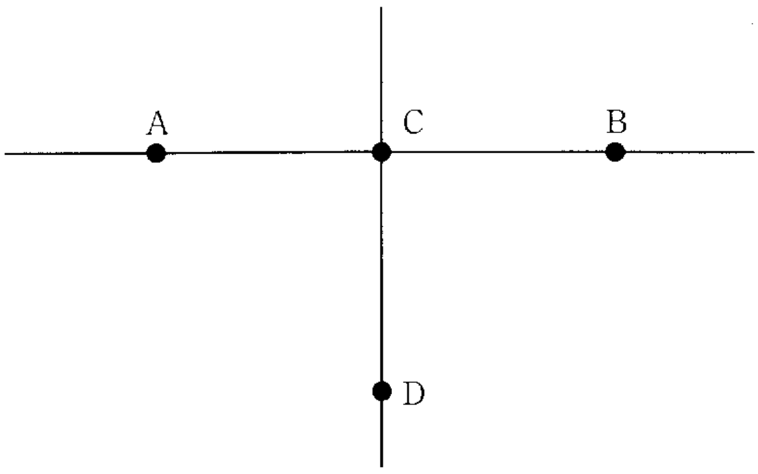

Fig. 1

3 A point object P of mass m is sliding along a frictionless wall of a radius of curvature, R_0, in a vertical plane as shown in Fig. 2. Assume that the point object is initially at rest at the point A and starts to move toward the bottom B. The angle between the normal (to the wall) at A and the vertical line is θ_0 radians, and assumed to be small.

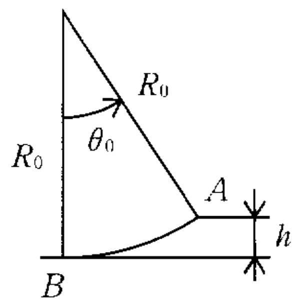

Fig. 2

(1) The elevation h between the points A and B is approximately

(a) $R_0\theta_0$ (b) $R_0\theta_0^2$ (c) $\frac{1}{2}R_0\theta_0^2$ (d) $\frac{1}{2}R_0\theta_0$

where $\sin\theta_0 \approx \theta_0$, $\cos\theta_0 \approx 1-\frac{1}{2}\theta_0^2$.

(2) The speed of the point object at B, $v_{\max}$, is given by

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

where g is an acceleration constant due to gravity.

(3) The arc length $\widehat{AB}$ is given by

(a) $\frac{1}{2}R_0\theta_0$ (b) $R_0\theta_0$ (c) $2R_0\theta_0$ (d) $R_0\theta_0^2$

(4) The time $\bar{t}$ which is defined as $\bar{t}=\widehat{AB}/\,v_{\max}$ is given by

(a) $\sqrt{0.5R_0/g}$ (b) $\sqrt{R_0/g}$ (c) $\sqrt{2R_0/g}$ (d) $2\sqrt{R_0/g}$

(5) The ratio of the actual time t reaching B from A to $\bar{t}$, $t/\bar{t}$, satisfies

(a) $t/\bar{t}>2$ (b) $t/\bar{t}=2$ (c) $t/\bar{t}=\pi/2$

(d) $t/\bar{t}=1$ (e) $t/\bar{t}<1$

4 A container of volume 10 ℓ includes 0.2 mol oxygen gas and 0.3 mol nitrogen gas. Assume the atomic weight of oxygen is 16 and that of nitrogen 14.

(1) The total mass of the gas in the container is

(a) 7.4g (b) 10.6g (c) 11.6g (d) 14.8g

(2) Let the universal gas constant be R [J・mol^{-1}・K^{-1}]. Let the specific heat ratio be k, then for a single component gas, specific heat at a constant pressure c_p is given by $c_p = \frac{k}{k-1}R$. For a monoatomic molecule gas k=5/3, for a diatomic molecule gas k=7/5, and for a triatomic molecule gas k=9/7. The heat capacity (at a constant pressure) of oxygen in the container is

(a) $0.5R$(J・K^{-1}) (b) $0.7R$(J・K^{-1}) (c) $0.9R$(J・K^{-1})

(3) The total heat capacity in the container (at a constant pressure) is approximately

(a) $0.62R$(J・K^{-1}) (b) $0.87R$(J・K^{-1}) (c) $1.0R$(J・K^{-1})

(d) $1.25R$(J・K^{-1}) (e) $1.75R$(J・K^{-1})

(4) Let the speed (root-mean-square speed) of an oxygen gas molecule be v_1, and that of a nitrogen gas molecule v_2. Which of the following holds?

(a) $v_1 > v_2$ (b) $v_1 = v_2$ (c) $v_1 < v_2$

5 It is assumed that standing water waves are generated in a channel of two vertical parallel side walls (separated by distance L) with mean water depth h, where water waves are reflected at the walls and the channel length is sufficiently large compared with L. Assume that the frequency of the standing waves is the lowest of the possible values.

(1) The number of observed nodes in the channel (including nodes on the walls if any) is

(a) 0 (b) 1 (c) 2 (d) 3 (e) 4

(2) The number of observed antinodes in the channel (including antinodes on the walls if any) is

(a) 0 (b) 1 (c) 2 (d) 3 (e) 4

(3) The wave length of the corresponding water wave is

(a) L (b) $2L$ (c) $3L$ (d) $4L$