2006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 2006

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)		

Marks	

Choose the correct answer, and put a circle around the symbol preceding the answer.

1 Answer the following questions.

(1) A weight of mass m is connected to a spring of spring constant k. Initially the weight hangs down and is at rest. Support the weight by hand and lift it up slowly until the length of the spring is equal to its natural length. What is the work done by the hand during this process? Let the gravitational constant be g.

(a) $\frac{m^2g^2}{k}$ (b) $\frac{2m^2g^2}{k}$ (c) $\frac{m^2g^2}{2k}$ (d) $\frac{mg}{k}$ (e) $\frac{2mg}{k}$

(f) $\frac{mg}{2k}$ (g) kmg^2 (h) $2kmg^2$ (i) $\frac{kmg^2}{2}$

(2) Two point charges of magnitudes $+q$ and $-q$ are placed on the x-axis separated by a distance d, as shown in Fig. 1. The point P together with the points where the two charges are placed forms an equilateral triangle. What are the direction and the strength of the electric field at the point P? Let the constant of proportionality in Coulomb's law be k.

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

Strength (a) $k\frac{q}{d}$ (b) $k\frac{2q}{d}$ (c) $k\frac{\sqrt{3}q}{d}$ (d) $k\frac{q}{d^2}$ (e) $k\frac{2q}{d^2}$ (f) $k\frac{\sqrt{3}q}{d^2}$

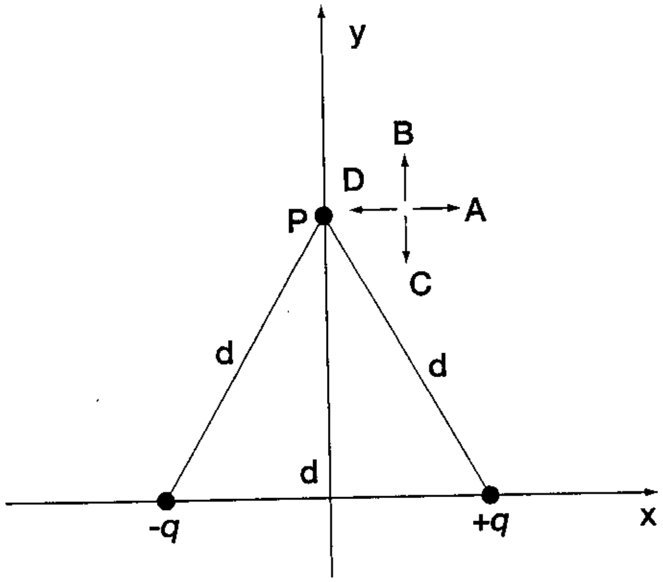

Fig. 1

(3) A longitudinal wave is propagating in the positive x direction. The displacement of the medium at a certain time is displayed in Fig. 2, where the displacement in the positive x direction is displayed as a positive y value. Where is the point at which the acceleration of the medium in the positive x direction is maximum?

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

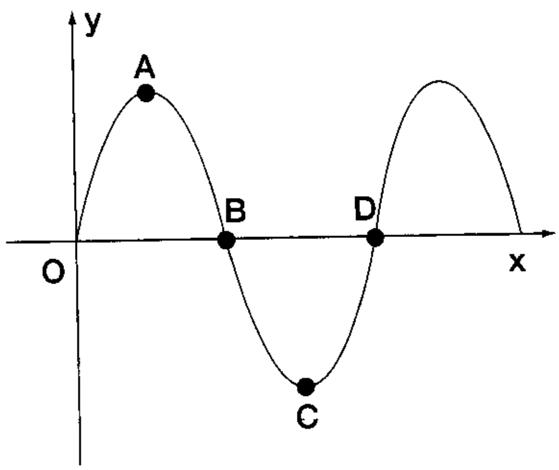

Fig. 2

(4) The atomic nucleus $^{238}_{92}U$ decays by α and β decays and changes atomic and mass numbers. What is the final stable nucleus after these decay processes?

(a) $^{208}_{82}Pb$ (b) $^{209}_{83}Bi$ (c) $^{206}_{82}Pb$ (d) $^{207}_{82}Pb$

2 Consider the electrical circuit shown in Fig. 3, consisting of an $E = 6$ [V] battery, two switches S_1 and S_2, two resistors $R_1 = 4$ [Ω] and $R_2 = 2$ [Ω], and a capacitor $C = 2$ [μF]. The internal resistance of the battery may be ignored. Initially the switches are both open and the capacitor has no charge. Close the switch S_1 at a certain time. At a sufficiently long time after the switch S_1 is closed, the capacitor is fully charged and the circuit becomes steady.

(1) Just after the switch S_1 is closed, what is the current flowing through the resistor R_1?

(a) 1.5[A]　(b) 3[A]　(c) 6[A]　(d) 12[A]　(e) 24[A]

(2) How much charge is stored in the capacitor C?

(a) 6[μC]　(b) 12[μC]　(c) 36[μC]　(d) 72[μC]　(e) 144[μC]

(3) During the period in which the capacitor is charged, how much work is done by the battery?

(a) 6[μJ]　(b) 12[μJ]　(c) 36[μJ]　(d) 72[μJ]　(e) 144[μJ]

(4) During the period in which the capacitor is charged, how much thermal heat is emitted from the resistor R_1?

(a) 6[μJ]　(b) 12[μJ]　(c) 36[μJ]　(d) 72[μJ]　(e) 144[μJ]

Keeping the switch S_1 closed, the switch S_2 is also closed. At a sufficiently long time after the switch S_2 is closed, the circuit becomes steady again.

(5) How much charge is stored in the capacitor C long after the switch S_2 is closed?

(a) 4[μC]　(b) 6[μC]　(c) 12[μC]　(d) 24[μC]　(e) 36[μC]

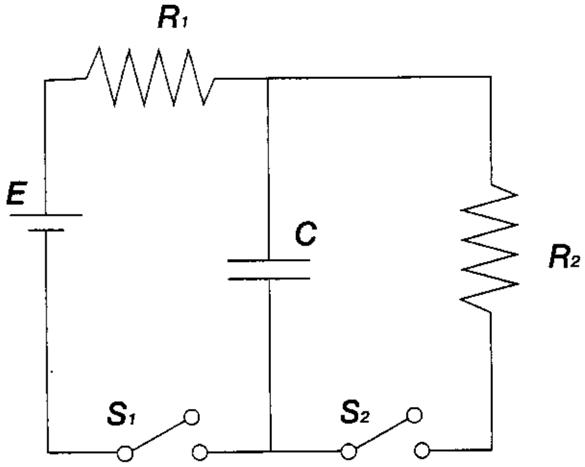

Fig. 3

3 A point object of mass m slides down from the top O of a smooth sphere of radius R with an initial slow speed v_0, and finally at a point $P(X, Y)$ the object takes off into the air with a speed v. The friction between the object and the sphere and that between the object and the air are assumed to be negligible. (x, y) is a Cartesian coordinate system, y being in the direction of gravity as shown in Fig. 4, and the sign of the angle θ specifying the point P is positive in case of the configuration as shown in Fig. 4.

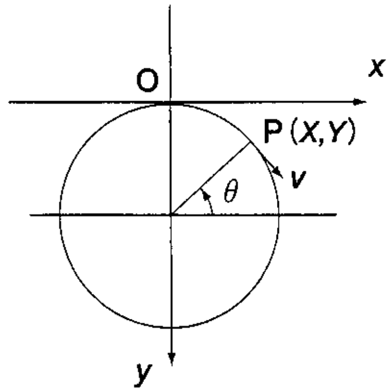

Fig. 4

(1) Find the appropriate energy balance equation if g stands for the acceleration constant of gravity:

(a) $\frac{m}{2}v^2 + mgY = \frac{m}{2}v_0^2$ (b) $\frac{m}{2}v^2 + mgY = 0$ (c) $\frac{m}{2}v^2 - mgY = \frac{m}{2}v_0^2$

(d) $\frac{m}{2}v^2 - mgY = 0$ (e) $\frac{m}{2}v^2 = \frac{m}{2}v_0^2$

(2) Select the appropriate geometric relation:

(a) $\sin\theta \fallingdotseq 1$ (b) $\sin\theta = \frac{R-Y}{R}$ (c) $\sin\theta = \frac{R+Y}{R}$

(d) $\sin\theta \fallingdotseq \frac{1}{2}$ (e) $\sin\theta \fallingdotseq 0$

(3) At the point P, the following force balance holds:

$$mg\sin\theta = m\frac{v^2}{R}$$

Eliminate v^2 from the energy balance equation to give

$$Y = C_1R + C_2\frac{v_0^2}{g}$$

where C_1 and C_2 are constants. Select the appropriate condition for C_1:

(a) $C_1 < \frac{1}{3}$ (b) $C_1 = \frac{1}{3}$ (c) $\frac{1}{3} < C_1 < \frac{1}{2}$

(d) $C_1 = \frac{1}{2}$ (e) $\frac{1}{2} < C_1$

(4) Select the appropriate condition for C_2:

(a) $C_2 < -\frac{1}{2}$ (b) $C_2 = -\frac{1}{2}$ (c) $-\frac{1}{2} < C_2 < -\frac{1}{3}$

(d) $C_2 = -\frac{1}{3}$ (e) $-\frac{1}{3} < C_2$

(5) After taking off, what kind of orbit does the object follow?

(a) straight line (constant speed) (b) straight line (accelerating)

(c) parabola (constant speed) (d) parabola (accelerating)

(e) parabola (decelerating)

4 One(1) mole of air is enclosed in an insulated rigid enclosure with a piston and an electric heater as shown in Fig. 5. Let p, V, T, R be the pressure of the air, the volume, the absolute temperature, and the universal gas constant. In this case

$$pV = RT$$

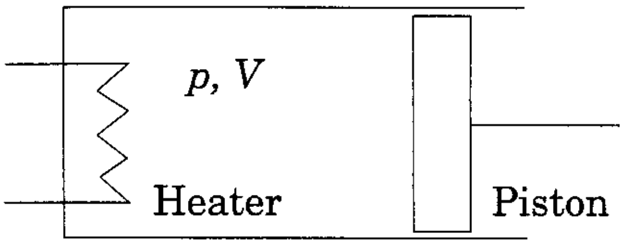

Fig. 5

Now consider the following situation: heat is supplied to the air through the heater so that the temperature is increased by 1K under a constant pressure.

(1) How much work is done by the piston? (Select the appropriate answer.)

(a) $-R \times 1\text{mol} \times 1\text{K}$ (b) $R \times 1\text{mol} \times 1\text{K}$ (c) 0 J

(d) $2R \times 1\text{mol} \times 1\text{K}$ (e) $-2\text{R} \times 1\text{mol} \times 1\text{K}$

(2) Let C be the specific heat of the air per mole (at constant pressure). Which is the appropriate supplied heat quantity?

(a) $R \times 1\text{mol} \times 1\text{K}$ (b) $-R \times 1\text{mol} \times 1\text{K}$ (c) $C \times 1\text{mol} \times 1\text{K}$

(d) $(C+R) \times 1\text{mol} \times 1\text{K}$ (e) 0 J

(3) Which is the appropriate relation?

(a) $C > R$ (b) $C = R$ (c) $R > C > 0.5R$

(d) $C = 0.5R$ (e) $0.5R > C$

(4) Let E and R_0 be the electric voltage supplied and the resistance of the heater respectively. How much heat is generated and transferred to the air per unit time? (Select the appropriate answer.)

(a) E (b) E/R_0 (c) E^2/R_0^2

(d) E^2/R_0 (e) E/R_0^2

5 It is known that a water wave in a lake produced by the pitching of a boat at anchor with a pitching period T propagates with a speed bT (b: some constant >0) if the lake is deep enough and the water is at rest. Assume that a boat moves at a slow constant speed V_0 with a pitching period T.

(1) First find the following value: $\left[\dfrac{\text{wave length in the forward direction}}{\text{wave length at rest}}\right]$

(a) $\dfrac{V_0}{bT}$ (b) 1 (c) $\dfrac{bT-V_0}{bT}$

(d) $\dfrac{V_0-bT}{bT}$ (e) $\dfrac{bT+V_0}{bT}$

(2) Second find the following value: $\left[\dfrac{\text{wave length in the backward direction}}{\text{wave length at rest}}\right]$

(a) $\dfrac{V_0}{bT}$ (b) 1 (c) $\dfrac{bT-V_0}{bT}$

(d) $\dfrac{V_0-bT}{bT}$ (e) $\dfrac{bT+V_0}{bT}$