2018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（MEXT）SCHOLARSHIPS 2018

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**.

(2018)

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 this examination script and on the answer sheet.

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

1. Answer the following questions.

(1) An object of mass m is launched horizontally with a speed v at a height of h above the ground level as shown in Fig. 1-1. Let θ be the impact angle to the ground and g be the acceleration of gravity. Find the formula of $\tan\theta$.

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

(d) $\dfrac{2v}{\sqrt{gh}}$ (e) $\dfrac{\sqrt{gh}}{v}$ (f) $\dfrac{v}{\sqrt{gh}}$

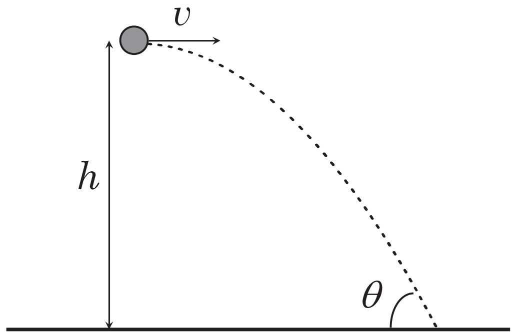

Fig. 1-1

(2) An object of mass m is attached to a light spring with a force constant k and a natural length l_0. The object is moving on a frictionless flat horizontal table with a uniform circular motion as shown in Fig. 1-2. The center of the circle O is at the other end of the spring. During this motion, the length of the spring is extended by αl_0 ($\alpha > 0$) from the natural length. Find the speed v of the object.

(a) $\sqrt{\frac{(1+\alpha)\alpha m}{k}}l_0$ (b) $\sqrt{\frac{m}{k}}(1+\alpha)l_0$ (c) $\sqrt{\frac{m}{k}}\alpha l_0$

(d) $\sqrt{\frac{k}{m}}(1+\alpha)l_0$ (e) $\sqrt{\frac{(1+\alpha)\alpha k}{m}}l_0$ (f) $\sqrt{\frac{k}{m}}\alpha l_0$

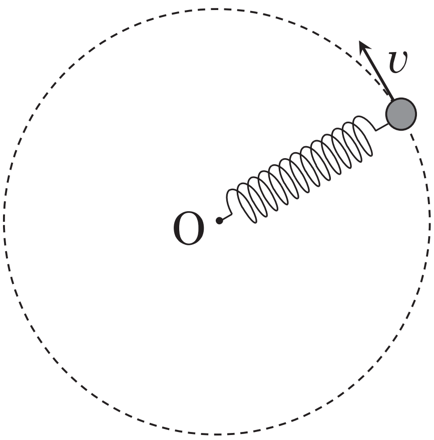

Fig. 1-2

(3) A charged particle of mass m and charge q is in a uniform electric field E. Initially the particle is at rest, and then accelerated by the electric field. Find the time for the particle to travel at a distance of d from the initial location.

(a) $\frac{md}{2qE}$ (b) $\sqrt{\frac{md}{qE}}$ (c) $\frac{2md}{qE}$

(d) $\sqrt{\frac{md}{2qE}}$ (e) $\frac{md}{qE}$ (f) $\sqrt{\frac{2md}{qE}}$

(4) A screen is placed at a large distance L from a plate where two slits S_1 and S_2 are notched. These slits are separated by a distance of d as shown in Fig. 1-3. A monochromatic light from a single slit S_0 with a wavelength of λ passes through the two slits S_1 and S_2. Bright and dark interference fringes appear on the screen. Find the distance from the screen center O to the third dark line.

(a)	$\dfrac{L\lambda}{d}$	(b)	$\dfrac{2L\lambda}{d}$	(c)	$\dfrac{3L\lambda}{d}$
(d)	$\dfrac{L\lambda}{2d}$	(e)	$\dfrac{3L\lambda}{2d}$	(f)	$\dfrac{5L\lambda}{2d}$

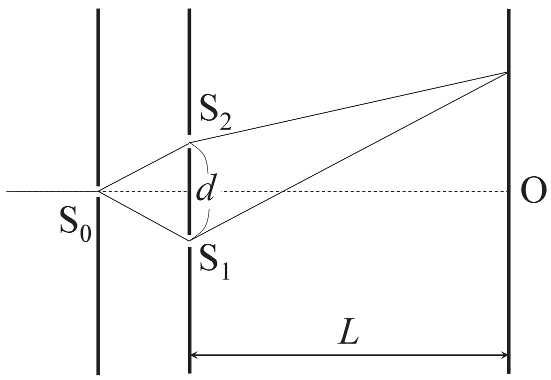

Fig. 1-3

(5) An observer is moving away at a constant speed of 5 m/s from a speaker which is emitting sound waves at a frequency of 660 Hz. The sound speed is 330 m/s. When the sound source S and the observation point O are located as shown in Fig. 1-4, what frequency of the sound will the observer hear?

(a)	650 Hz	(b)	652 Hz	(c)	654 Hz
(d)	660 Hz	(e)	666 Hz	(f)	668 Hz

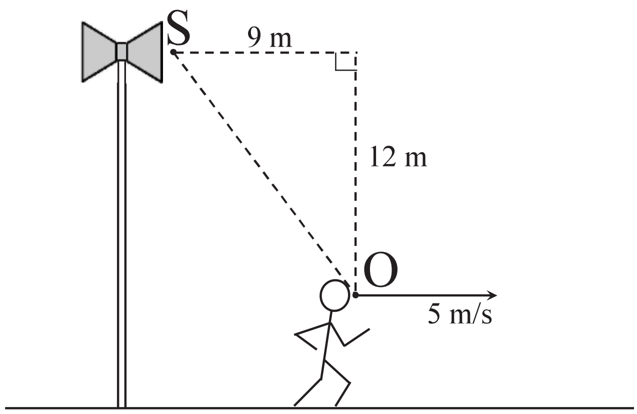

Fig. 1-4

2. The region on the right hand side of line XY is filled with a uniform magnetic field of flux density B pointing out from back to front as shown in Fig. 2. A square coil abcd with a side length of l enters the magnetic field region with a constant speed v. Line XY and side ab are parallel to each other. The resistance of the coil is R. At a time t=0, side ab of the coil passes line XY. Answer the following questions in the case of $0 < t < l/v$.

(1) Find the magnitude of the magnetic flux which passes through the coil at the time t.

(a) Blt (b) Bl^2t (c) $vBlt$

(d) vB^2lt (e) vBl^2t (f) vBt

(2) Find the magnitude of the electromotive force induced in the coil.

(a) vB (b) vBl (c) vB^2l

(d) Bl (e) Bl^2 (f) vBl^2

(3) Find the induced current which flows in the coil.

(a) $\dfrac{vBl^2}{R}$ (b) $\dfrac{Bl}{R}$ (c) $\dfrac{vB^2l}{R}$

(d) $\dfrac{vB}{R}$ (e) $\dfrac{vBl}{R}$ (f) $\dfrac{Bl^2}{R}$

(4) Find the direction of the induced current which flows in the coil.

(a) a $\rightarrow$ b $\rightarrow$ c $\rightarrow$ d (b) a $\rightarrow$ d $\rightarrow$ c $\rightarrow$ b

(5) Find the magnitude of the external force to maintain the constant speed v of the coil.

(a) $\dfrac{B^2l}{R}$ (b) $\dfrac{vBl^2}{R}$ (c) $\dfrac{Bl^2}{R}$

(d) $\dfrac{vB^2l^2}{R}$ (e) $\dfrac{vB^2l}{R}$ (f) $\dfrac{B^2l^2}{R}$

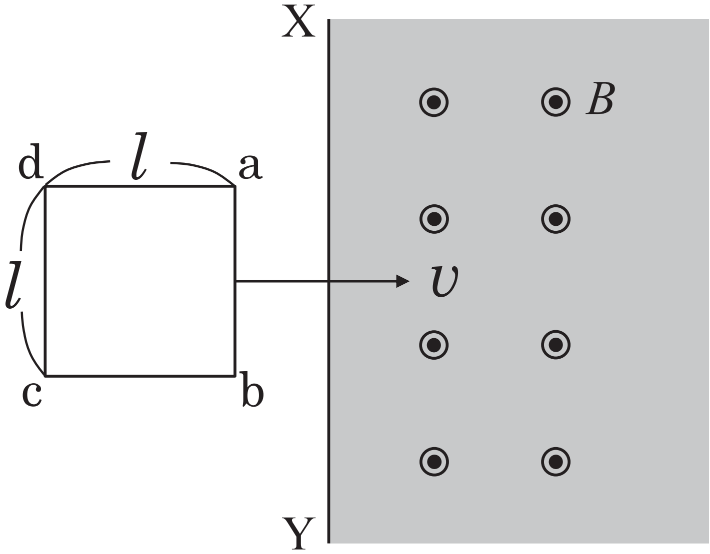

Fig. 2

3. At the surface of the earth the acceleration of gravity has the value $g = 9.8$ m/s^2. The constant of universal gravitation is given by $G = 6.67 \times 10^{-11}$ N$\cdot$ m^2/kg^2. Answer the following questions.

(1) The radius of the earth is 6.4×10^3 km. Find the mass of the earth using the values of g and G.

(a) 6.0×10^{24} kg (b) 6.0×10^{18} kg (c) 6.0×10^{30} kg

(d) 2.0×10^{30} kg (e) 2.0×10^{36} kg (f) 2.0×10^{24} kg

(2) An object can escape from the gravitational attraction of a planet if the object has a large enough speed. The minimum value of this speed is called the escape speed. Find the escape speed of the earth.

(a) 1.1×10^2 m/s (b) 1.1×10^3 m/s (c) 1.1×10^4 m/s

(d) 7.9×10^2 m/s (e) 7.9×10^3 m/s (f) 7.9×10^4 m/s

(3) The mass of Jupiter is about 320 times larger than the earth and the radius of Jupiter is about 11 times larger than the earth. What is the ratio of the escape speed from Jupiter to that of the earth?

(a) 2.1 (b) 5.4 (c) 11

(d) 18 (e) 29 (f) 320

(4) A satellite moves in a circular orbit around the earth. If the satellite's orbital period is equal to the Earth's rotational period, what is the radius of the satellite's orbit?

(a) 4.2×10^6 m (b) 4.2×10^7 m (c) 4.2×10^8 m

(d) 6.4×10^6 m (e) 6.4×10^7 m (f) 6.4×10^8 m

4. One mole of a monatomic ideal gas is taken through the cycle shown in Fig. 4. In the process AB the gas pressure increases from P_0 to $4P_0$ at constant volume $V = V_0$. In the process BC the gas volume increases from V_0 to $4V_0$ at constant pressure $P = 4P_0$. In the process CD the gas pressure decreases from $4P_0$ to P_0 at constant volume $V = 4V_0$. In the process DA the gas volume decreases from $4V_0$ to V_0 at constant pressure $P = P_0$. The gas has a molar specific heat at constant volume, $C_V = 3R/2$ with R the universal gas constant. Answer the following questions.

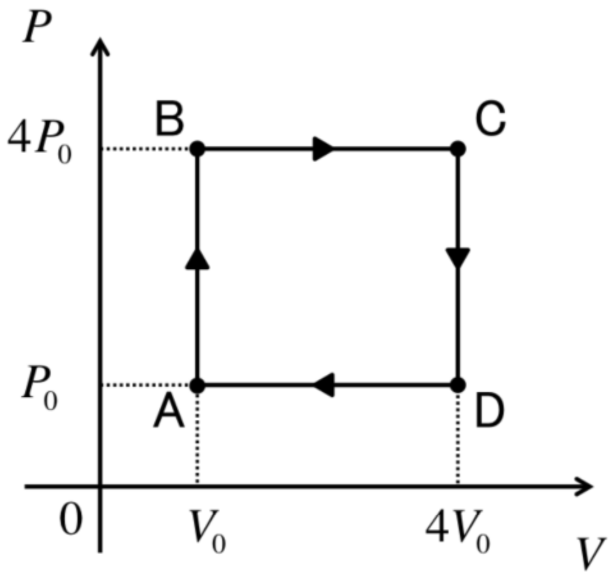

Fig. 4

(1) Find the thermal energy transferred into the system in the process AB.

(a) P_0V_0 (b) $3P_0V_0$ (c) $\frac{11}{2}P_0V_0$

(d) $\frac{9}{5}P_0V_0$ (e) $\frac{9}{2}P_0V_0$ (f) $\frac{7}{2}P_0V_0$

(2) Find the thermal energy transferred into the system in the process BC.

(a) $18P_0V_0$ (b) $24P_0V_0$ (c) $30P_0V_0$

(d) $\frac{25}{2}P_0V_0$ (e) $\frac{45}{2}P_0V_0$ (f) $\frac{75}{2}P_0V_0$

(3) Find the net work done by the gas per cycle.

(a) $16P_0V_0$ (b) $4P_0V_0$ (c) $3P_0V_0$

(d) $12P_0V_0$ (e) $15P_0V_0$ (f) $9P_0V_0$

(4) Find the thermal efficiency of the cycle.

(a) $\dfrac{3}{10}$ (b) $\dfrac{3}{5}$ (c) $\dfrac{2}{5}$

(d) $\dfrac{6}{23}$ (e) 0 (f) 1

5. A sound wave travels in the positive x-direction. As the sound wave propagates the air pressure P changes above and below the normal atmospheric pressure, P_0. At $x = 0$, $\Delta P = P - P_0$ varies time-dependently in a sinusoidal manner as shown in Fig. 5-1. The horizontal axis represents time t. Answer the following questions.

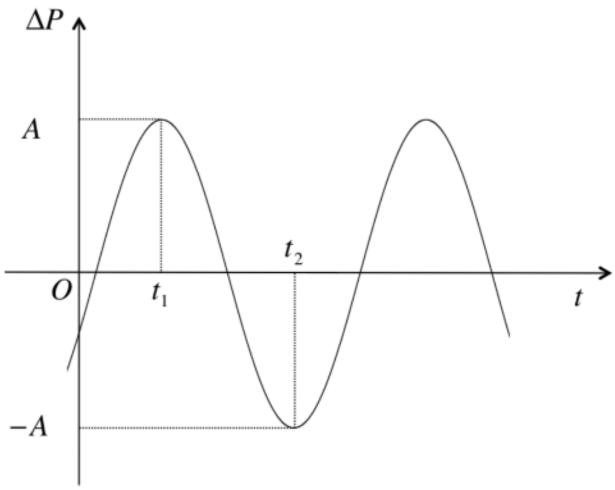

Fig. 5-1

(1) Find the amplitude of ΔP.

(a) $A/3$ (b) $A/2$ (c) A

(d) $2A$ (e) $3A$ (f) $4A$

(2) Find the period of the oscillation.

(a) $(t_2 - t_1)/2$ (b) $t_2 - t_1$ (c) $2(t_2 - t_1)$

(d) $3(t_2 - t_1)$ (e) $4(t_2 - t_1)$ (f) $5(t_2 - t_1)$

(3) The speed of the sound wave is v. Find the wavelength of the sound wave.

(a) $2v(t_2 - t_1)$ (b) $v(t_2 - t_1)$ (c) $\dfrac{v(t_2 - t_1)}{2}$

(d) $\dfrac{v(t_2 - t_1)}{\pi}$ (e) $\dfrac{v(t_2 - t_1)}{2\pi}$ (f) $\dfrac{v(t_2 - t_1)}{4\pi}$

(4) A snapshot of ΔP as a function of x at a certain time t is shown in Fig. 5-2. Which is the highest density point?

(a) a (b) b

(c) c (d) d

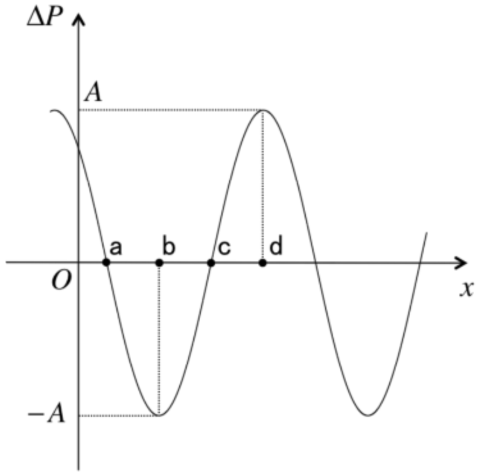

Fig. 5-2