

2023 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) SCHOLARSHIP 2023

学科試験問題
EXAMINATION QUESTIONS

高等専門学校留学生
COLLEGE OF TECHNOLOGY STUDENTS

物理
PHYSICS

注意 ☆試験時間は 60 分

PLEASE NOTE: THE TEST PERIOD IS 60 MINUTES

(2023)

PHYSICS

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

Marks	
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If the answer is a number, round off your answers to two significant figures.

1. (1) Object A was thrown up vertically from the ground (height 0 m) with an initial velocity v_A m/s. At the same time, object B was dropped vertically from a height of 120 m. After 3.0 s, the two objects collided in midair. In this situation, answer the following questions. Note that the acceleration of gravity is 9.8 m/s^2 .

(1-1) Calculate the initial velocity v_A m/s of the object A.

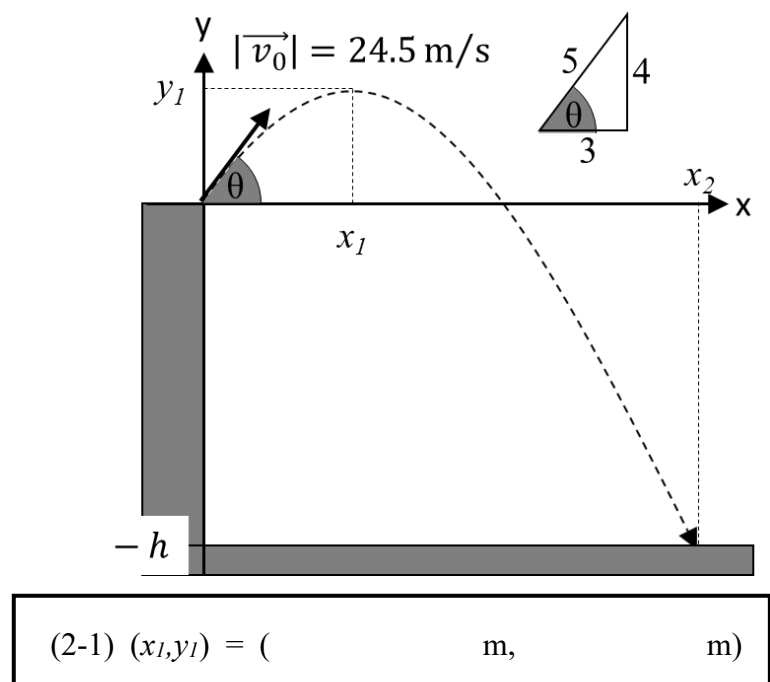
(1-1)	m/s
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(1-2) Calculate the height of the collision point.

(1-2)	m
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(2) An object was thrown obliquely from the top of a building at a height of h m with an initial velocity of 24.5 m/s at an angle $\theta = \tan^{-1}\left(\frac{4}{3}\right)$ as shown in the figure. The object hits the ground after 6.0 s. The origin of the x and y axes is the initial position. In this situation, answer the following questions. Note that the acceleration of gravity is $g = 9.8 \text{ m/s}^2$.

(2-1) Calculate the coordinates (x_I, y_I) of highest position.

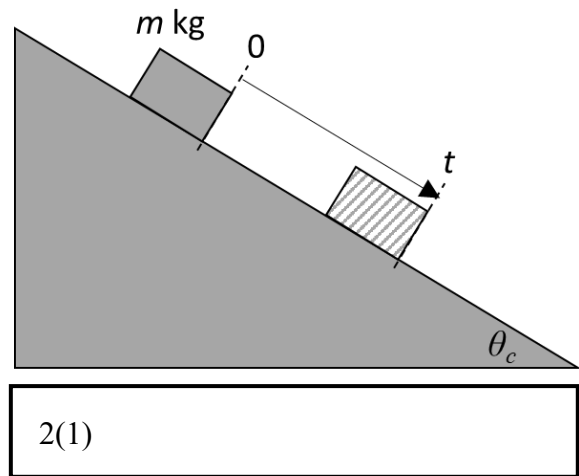


(2-2) Calculate the height of this building.

(2-2) m

2. An object of mass m kg was placed on an inclined rough plate at an angle θ with the horizontal. As the angle was slowly increased, the object began to slide down the plate at a certain angle θ_c , as shown in figure. In this situation, answer the following questions. Note that the acceleration of gravity is g , the coefficient of static friction between the object and the slope is μ , and the coefficient of dynamic friction is μ' .

(1) Choose the correct relationship between the coefficient of static friction μ and the angle of inclination θ_c from the following options (a) – (f) and write the letter you chose.



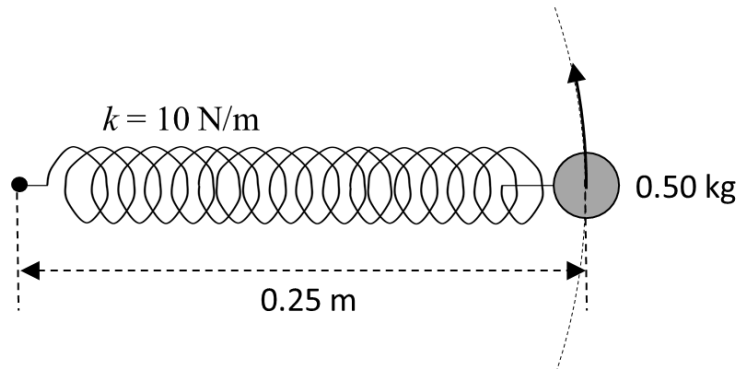
(a) $\mu < \sin \theta_c$ (b) $\mu < \cos \theta_c$ (c) $\mu < \tan \theta_c$ (d) $\mu \sin \theta_c < 1$ (e) $\mu \cos \theta_c < 1$ (f) $\mu \tan \theta_c < 1$

(2) Assume that the time when the object starts sliding was $t = 0$ and the time when the object is sliding down on the slope is t . Choose the correct magnitude (absolute value) of the work done by friction by time t from the following options (a) - (d) and write the letter you chose.

2(2)

(a) $\frac{\mu' m \sin \theta_c}{2} (gt)^2 (\sin \theta_c - \mu' \cos \theta_c)$ (b) $\frac{\mu' m \cos \theta_c}{2} (gt)^2 (\sin \theta_c - \mu' \cos \theta_c)$
(c) $\frac{\mu' m \sin \theta_c}{2} (gt)^2 (\mu' \sin \theta_c - \cos \theta_c)$ (d) $\frac{\mu' m \cos \theta_c}{2} (gt)^2 (\mu' \sin \theta_c - \cos \theta_c)$

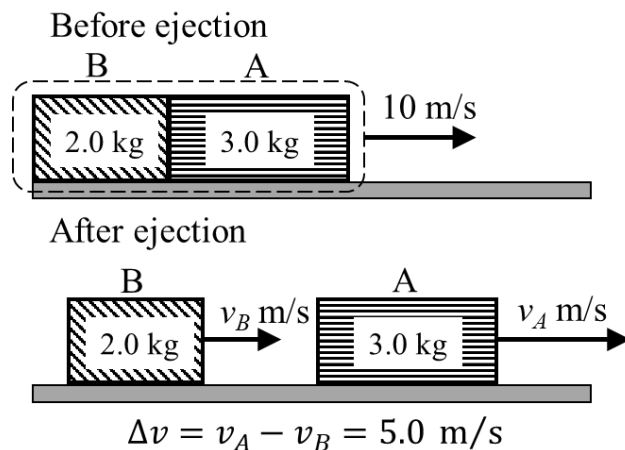
3. A light (negligible mass) spring has natural length 0.20 m and the spring constant of $k=10 \text{ N/m}$. One end of the spring was attached to the center of the smooth horizontal surface, the other side to an object with a mass of 0.50 kg. The object was set to move in a constant velocity circular motion. The length of the spring became 0.25 m. In this situation, calculate the period of the circular motion. Use $\pi = 3.1$ as the circumference.



3

s

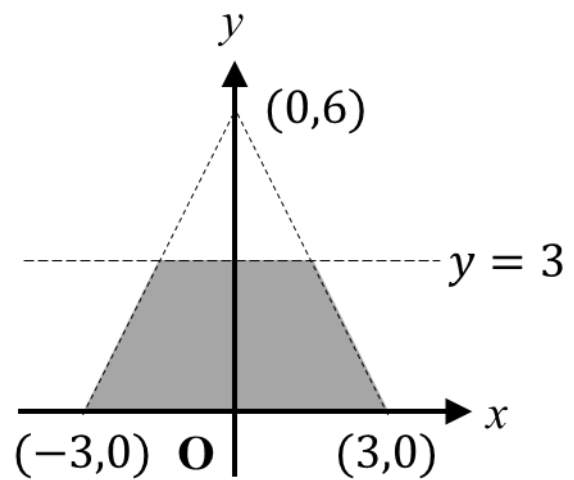
4. A 5.0 kg object consists of two parts A and B was moved with constant velocity of 10 m/s on a smooth (negligible friction) plane. 2.0 kg part B was ejected backward from object A. If the relative velocity of object A and part B after the ejection was $\Delta v = 5.0 \text{ m/s}$, calculate the velocity of object A after the ejection.



4

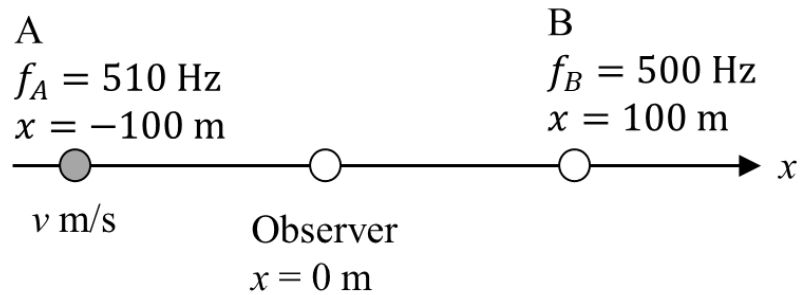
m/s

5. Calculate the coordinates of the center of gravity of a thin (negligible thickness) and uniformly dense trapezoidal plate (height 3.0 m, top 3.0 m, bottom 6.0 m) as shown in the figure.



5		$(x, y) = ($	m,	m)
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6. Two sound source A ($f_A = 510 \text{ Hz}$, $x = -100 \text{ m}$) and a sound source B ($f_B = 500 \text{ Hz}$, $x = 100 \text{ m}$) were located along the x-axis. When source A is moved on the x-axis at $v \text{ m/s}$, the beat tone that the observer at origin disappeared. In this situation, calculate the velocity of sound source. Note that the velocity of the sound is $v_s = 3.4 \times 10^2 \text{ m/s}$ and there is no wind.



6

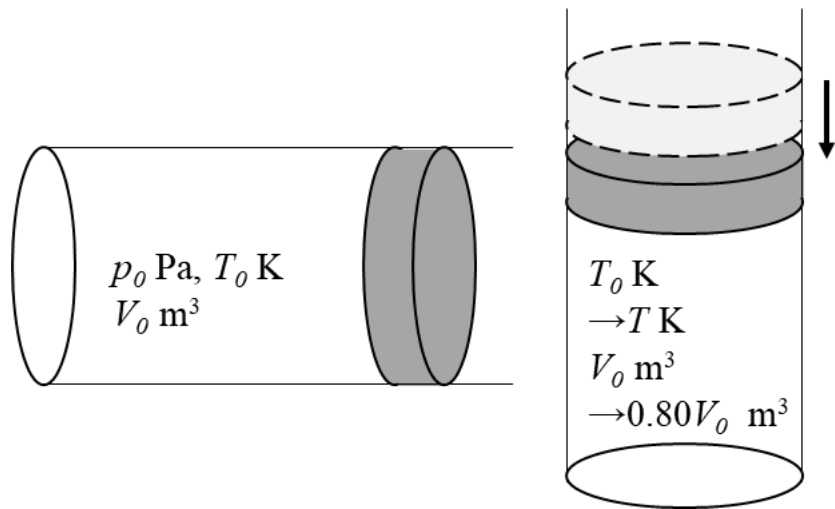
m/s

7. (1) A container with negligible heat capacity contained 50 g of -20°C ice. When this ice was heated by a heater for 90 seconds, it turned into water at 40°C . Calculate the power of this heater. Assume that all the heat given to the ice and water is used to heat the ice and water, and that it does not leak into the container or outside, and that it heats up evenly. Note that the specific heat capacity (specific heat) of ice is $2.1 \text{ J/g} \cdot \text{K}$, the specific heat capacity (specific heat) of water is $4.2 \text{ J/g} \cdot \text{K}$, and the heat of melting of ice is $3.3 \times 10^2 \text{ J/g}$. respectively.

(1)

W

(2) A gas was confined in a container with a smoothly moving (negligible friction) piston. The cross-sectional area of the piston was $S \text{ m}^2$. When the container was placed on a horizontal floor, the pressure the volume and the temperature were $p_0 \text{ Pa}$, $V_0 \text{ m}^3$, and $T_0 \text{ K}$, respectively. When the container was replaced vertically, the piston descended due to the weight of the piston and the volume decreased to $0.8 V_0 \text{ m}^3$ and the temperature of the gas changed to $T \text{ K}$. Choose the correct weight of the piston from the following options (a) - (d) and write the letter you chose.

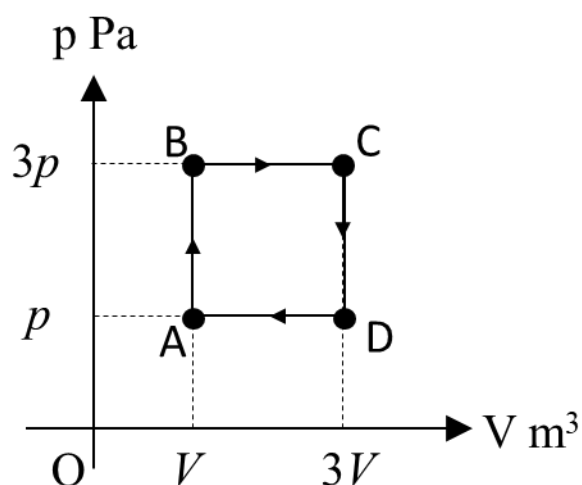


(2)

(a) $Sp_0 \left(\frac{5T_0 - 4T}{4T} \right)$ (b) $Sp_0 \left(\frac{5T - 4T_0}{4T_0} \right)$ (c) $Sp_0 \left(\frac{4T_0 - 5T}{5T} \right)$ (d) $Sp_0 \left(\frac{4T - 5T_0}{5T_0} \right)$

8. An n mole ideal gas was taken through the cycle $A \rightarrow B \rightarrow C \rightarrow D \rightarrow A$, as shown in the pV diagram. The processes $A \rightarrow B$ and $C \rightarrow D$ were isovolumetric, while the processes $B \rightarrow C$ and $D \rightarrow A$ were isobaric changes. Answer the following questions about the heat engine that repeated this process. Note that the temperature in state A be T_A K and the gas constant be R J/mol $\cdot$ K.

(1) Calculate the total amount of heat received by the gas from the outside during the process $A \rightarrow B \rightarrow C$.



(1)

J

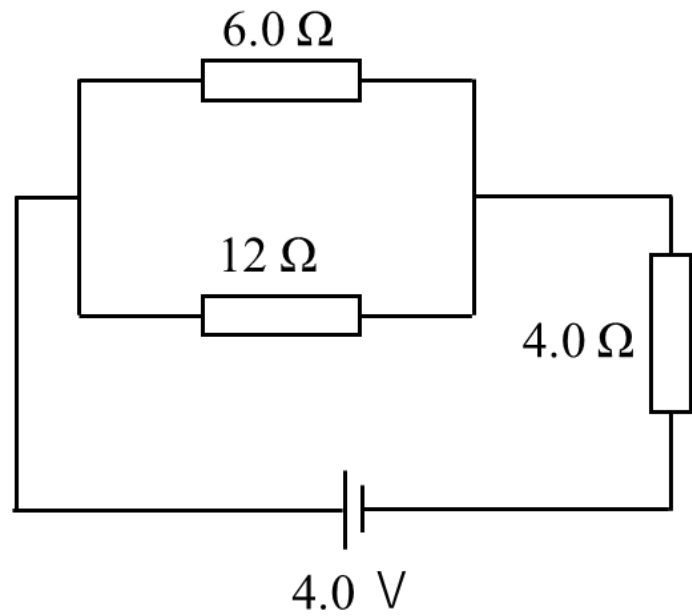
(2) Calculate the total amount of heat released by the gas from the outside during the process $C \rightarrow D \rightarrow A$.

(2)	J
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(3) Calculate the thermal efficiency of this heat engine.

(3)

9. (1) Calculate the total power delivered to the electric circuit shown in the figure. Note that the internal resistance of the battery and the resistance of the wire are assumed to be negligible.



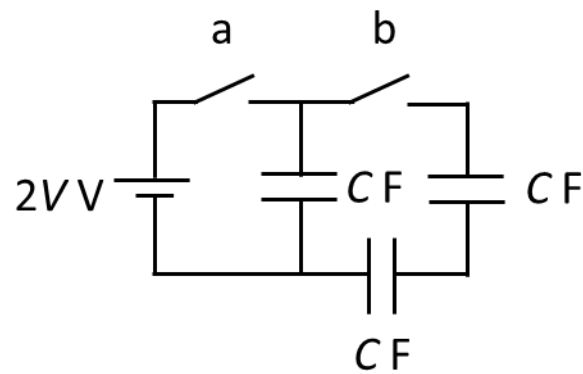
(1)	W
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(2) Consider the electrical circuit shown in the figure. The three capacitors had same capacitance C F and the electromotive force of the battery was $2V$ V and the internal resistance is negligible. Initially, there is no charge stored in the capacitors. For this circuit, the following two procedures were used to store charge in the capacitors. Note that the resistance of the wire is assumed to be negligible.

(i) The energy stored in the capacitor group when switch a is turned on, switch a is turned off after a sufficient time, and switch b is turned on is E_1 .

(ii) The energy stored in the capacitor group when both switch a and b are turned ON and switch a is turned OFF after a sufficient time has elapsed is E_2 .

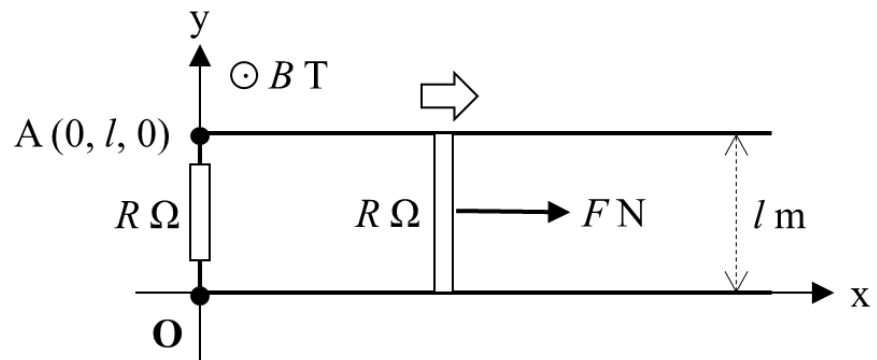
Choose the correct difference $\Delta E = |E_2 - E_1|$ of the energy stored in the procedure (i) and (ii) from the following options (a) - (d) and write the letter you chose.



(2)

(a) $\frac{1}{2}CV^2$ (b) $\frac{2}{3}CV^2$ (c) CV^2 (d) $2CV^2$

11. As shown in the figure, two parallel conductor rails were placed at a separation of l m in a magnetic field of uniform flux density B T in the positive direction of the z -axis. The origin O and point A are connected by a resistance of $R \Omega$. A light (negligible weight) conductor rod with a resistance of $R \Omega$ was placed on the rail in parallel to the y -axis. The rod was pulled by an external force F N in the positive direction of the x -axis. In this situation, the motion was constant velocity, v m/s. Choose the correct external force F at this time from the following options (a) - (f) and write the letter you chose. Note that the resistance of the conductors is assumed to be negligible.



11

- (a) $\frac{vBl}{2R}$ (b) $\frac{vBl}{R}$ (c) $\frac{2vBl}{R}$ (d) $\frac{vB^2l^2}{2R}$ (e) $\frac{vB^2l^2}{R}$ (f) $\frac{2vB^2l^2}{R}$