(2016)

PHYSICS

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

Marks	

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1. Suppose a system of three objects: a book, a table, and the earth. Let W be the gravitational force acting on the book lying on the table, N be the normal force acting on the book from the table, P be the force with which the book pushes the table, and F be the universal gravitation acting on the earth from the book. Answer the questions below on the following pairs of the forces:

(a) W and N (b) W and P (c) W and F (d) N and P (e) N and F (f) P and F.

(1) Which pairs of the forces do satisfy the action-reaction law? Choose two correct answers from (a) - (f) and write the letter of your choice.

(1-1)
(1-2)

(2) Which pair of the forces is in the situation where the object is in equilibrium and no net force is acting? Choose a correct answer from (a) - (f) and write the letter of your choice.

(2)

2. The velocity v [m/s] of an object at time t [s] is given by $v = -4.0 + 2.0\,t$. Round off your answers to two significant figures.

(1) Calculate the magnitude of the force F acting on the object of mass m = 4.0 kg.

(1)	**N**

(2) Calculate the kinetic energy K of the object of mass m = 4.0 kg at time t = 3.0 s.

(2)	**J**

(3) Setting the initial position $x_0 = 0.0$ m of the object at time t = 0.0 s, calculate the time t ($t > 0.0$ s) at the position $x = 21$ m of the object.

(3)	**s**

3. An object of mass m [kg] is vertically thrown upward along the positive direction into the frictionless air. The object slows to rest and reaches at the highest point. Afterwards, the object accelerates along the negative direction and falls straight down. Let g be the magnitude of the gravitational acceleration.

(1) What is the force acting on the object just after the object is vertically thrown upward? Choose a correct answer below from (a) - (c) and write the letter of your choice.

(a) $-mg$ (b) 0 (c) mg

(1)

(2) What is the force acting on the object at the instant when the object is at rest at the highest point? Choose a correct answer below from (a) - (c) and write the letter of your choice.

(a) $-mg$ (b) 0 (c) mg

(2)

4. The displacement y [m] of a wave traveling in the positive x-direction is described by time t [s] and position x [m] of a medium as $y = 3.0 \sin\{2\pi (0.50\, t - 0.25\, x)\}$.

(1) Find the equation of the propagation of crest. Choose a correct answer below from (a) – (d) and write the letter of your choice.

(a) $x = 2.0\, t - 1.0$ (b) $x = 2.0\, t - 3.0$ (c) $x = -2.0\, t - 1.0$ (d) $x = -2.0\, t - 3.0$

(1)

(2) Find the displacement y [m] of the standing wave that is obtained by a superposition of a wave $3.0 \sin\{2\pi(0.50\, t - 0.25\, x)\}$ and a wave $3.0 \sin\{2\pi(0.50\, t + 0.25\, x)\}$. Choose a correct answer below from (a) – (d) and write the letter of your choice.

(a) $y = 6.0 \sin(0.50\pi x) \sin(\pi t)$ (b) $y = 6.0 \sin(0.50\pi x) \cos(\pi t)$

(c) $y = 6.0 \cos(0.50\pi x) \sin(\pi t)$ (d) $y = 6.0 \cos(0.50\pi x) \cos(\pi t)$

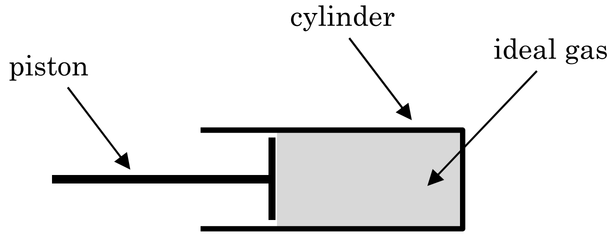
(2)

(3) Find the position of the node of the standing wave solved above. Choose a correct answer below from (a) – (d) and write the letter of your choice.

(a) $x = 0.5$ m (b) $x = 1.0$ m (c) $x = 1.5$ m (d) $x = 2.0$ m

(3)

5. Suppose a system of monoatomic ideal gas in a cylinder with a piston as shown in the figure. Answer the following questions. Round off your answers to two significant figures.



(1) The pressure p, the volume V, and the temperature T of the ideal gas at the initial state were $p_1 = 1.0\times10^5$ Pa, $V_1 = 1.2\times10^{-4}$ m^3, and $T_1 = 3.0\times10^2$ K, respectively. Next, the external force F slowly pushed the piston. As a result, the pressure and the volume at the final state changed as $p_2 = 1.2\times10^5$ Pa and $V_2 = 8.0\times10^{-5}$ m^3. Calculate the temperature T_2 at the final state.

(1)	K

(2) The pressure p and the volume V of the ideal gas at the initial state were $p = 1.5\times10^5$ Pa and $V_1 = 1.2\times10^{-4}$ m^3. Next, the external force F slowly pushed the piston at constant pressure. As a result, the volume changed as $V_2 = 8.0\times10^{-5}$ m^3. Calculate the work W of the external force F to the ideal gas.

(2)	J

(3) What is the molar specific heat c_v of monoatomic ideal gas at constant volume? Let R be the gas constant of ideal gas. Choose a correct answer below from (a) – (f) and write the letter of your choice.

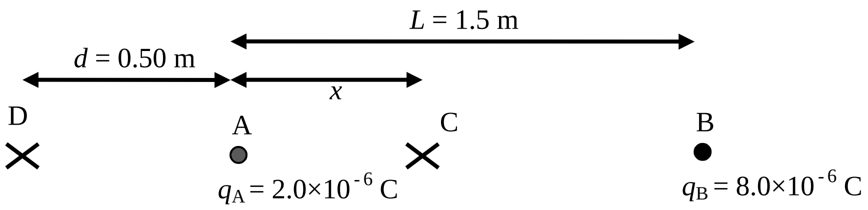
(a) $\frac{R}{2}$ (b) R (c) $\frac{3}{2}R$ (d) $2R$ (e) $\frac{5}{2}R$ (f) $2R$

(3)

(4) The pressure p, the volume V, and the temperature T of the ideal gas at the initial state were $p = 1.0\times10^5$ Pa, $V_1 = 6.0\times10^{-5}$ m^3, and $T_1 = 3.0\times10^2$ K, respectively. Next, the volume and the temperature changed as $V_2 = 8.0\times10^{-5}$ m^3 and T_2 at constant pressure. Calculate the amount of the heat Q to the ideal gas from the external system at this process.

(4)	**J**

6. Two positive charges $q_A = 2.0\times10^{-6}$ C and $q_B = 8.0\times10^{-6}$ C are located at the positions A and B as shown in the figure. The distance L between the positions A and B is 1.5 m. Let the proportionality constant k_e of Coulomb's low (Coulomb's constant) be $k_e = 9.0\times10^{9}\,\mathrm{N\cdot m^2/C^2}$. Round off your answers to two significant figures.



(1) The resultant electric field is equal to 0 at the position C which is located on the line AB. Calculate the length x from the position A to the position C.

(1)	**m**

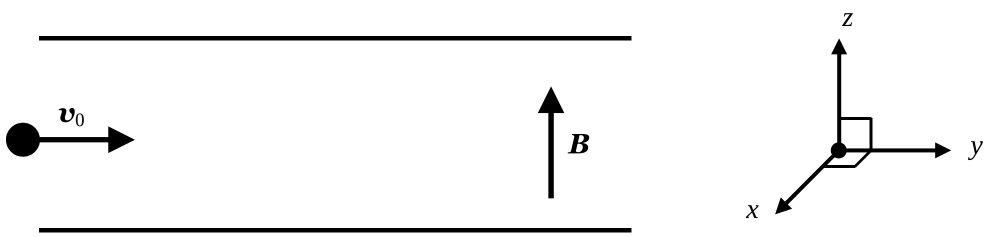
(2) Calculate the magnitude of the resultant electric field E_D at the position D with length $d = 0.50$ m from the position A. The position D is located on the line AB.

(2)	**N/C**

(3) Calculate the magnitude of the resultant electric potential φ_D at the position D. Note that the electric potential at infinity is taken to be 0.

(3)	**V**

7. An uniform magnetic flux density $B = 5.0\times10^{-3}$ T is applied parallel to the z-axis as shown in the figure. A particle with a positive charge of $q = 1.6\times10^{-19}$ C and a mass of $m = 2.4\times10^{-30}$ kg moves in the y-direction with a speed of $v_0 = 4.0\times10^{5}$ m/s. The particle enters the region where the magnetic field is applied. The particle moves with the rotational motion on the x-y plane in the region due to the Lorenz force. Round off your answers to two significant figures.



(1) Calculate the magnitude of the Lorenz force F on the particle.

(1) N

(2) Calculate the radius R of the rotational motion of the particle.

(2) m

(3) Calculate the period T of the rotational motion of the particle. You can use π = 3.14.

(3) s