2017 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 2017

学科試験　　　問題

EXAMINATION QUESTIONS

（高等専門学校留学生）

NATIONAL INSTITUTE OF TECHNOLOGY STUDENTS

物理

PHYSICS

注意　☆試験時間は 60 分

PLEASE NOTE: THE TEST PERIOD IS 60 MINUTES

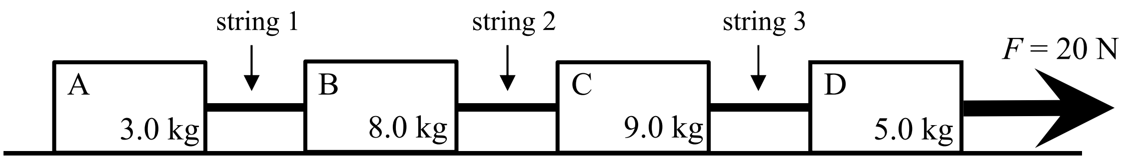
(2017)

PHYSICS

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

Marks	

1. As shown in the figure, blocks A (mass of 3.0 kg), B (mass of 8.0 kg), C (mass of 9.0 kg), and D (mass of 5.0 kg) are connected using massless strings 1, 2, and 3. When block D is pulled with a horizontal force F of 20 N, answer the following three questions. All answers must be given under two significant figures. Ignore the friction forces between the blocks and the floor.



(1) Find the acceleration a of the system (blocks A~D).

(1)	**m/s^2**

(2) Find the tension T_2 on string 2 (between block B and block C).

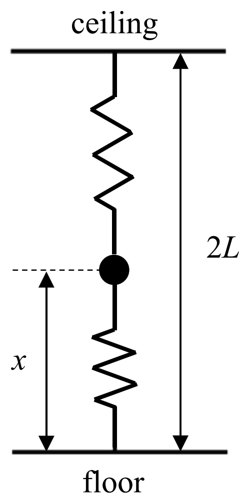
(2)	N

(3) Find the tension T_3 on string 3 (between block C and block D).

(3)	N

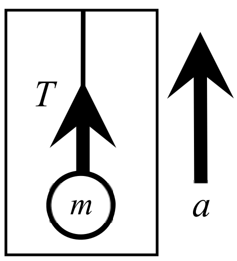
2. Answer the following two questions about dynamical equilibrium. Use the gravitational acceleration g [m/s^2] if necessary.

(1) As shown in the figure, two identical massless springs (spring constant of k [N/m] and original length of L [m]) and an object (mass of m [kg]) are connected in a straight line between a floor and a ceiling. When the object is in dynamical equilibrium, derive the distance x [m] from the floor. Ignore the size of the object.



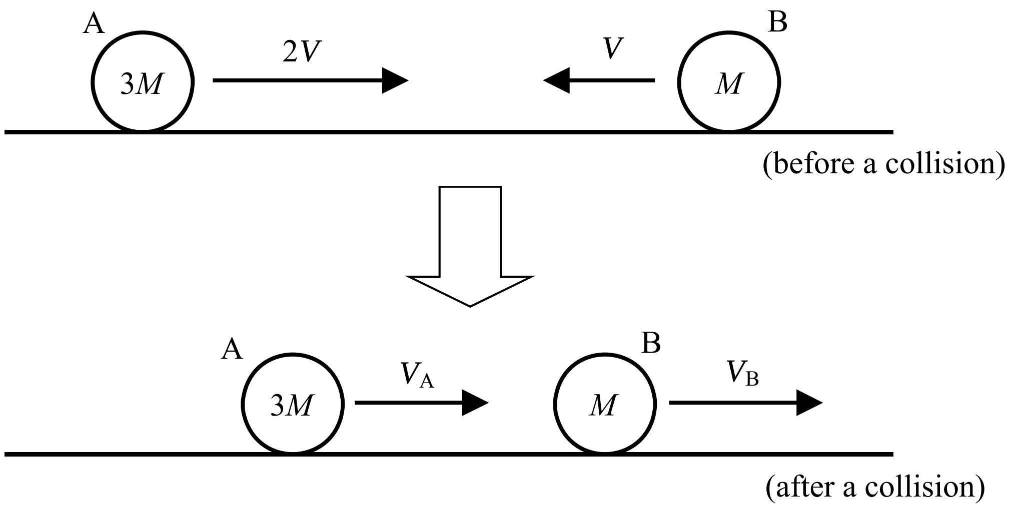
(1)	**[m]**

(2) As shown in the figure, an object (mass of m [kg]) is hanging from a massless string fixed on the ceiling of an elevator. When the object is in dynamical equilibrium in the elevator moving up with an acceleration of a [m/s^2], derive the tension T [N] on the string.



(2)	**[N]**

3. As shown in the figure, object A (mass of $3M$ [kg]) and object B (mass of M [kg]) are horizontally moving in the completely opposite direction, with speeds of $2V$ [m/s] and V [m/s], respectively. Derive the speeds of the two objects after a collision of them, and choose the best one among (A) ~ (F) and write the letter ((A) ~ (F)) of your choice. The coefficient of restitution in the collision is e. Ignore the friction forces between the objects and the floor.



(A) $\dfrac{5V+9Ve}{4}$ (B) $\dfrac{4V-3Ve}{4}$ (C) $\dfrac{5V-4Ve}{4}$

(D) $\dfrac{4V+7Ve}{4}$ (E) $\dfrac{5V-3Ve}{4}$ (F) $\dfrac{4V+3Ve}{4}$

V_A ;
V_B ;

4. Answer the following four questions. All answers must be given under two significant figures.

(1) Water (mass of 300 g) is in a cup with a mass of 400 g. Their initial Celsius temperature is 20 ℃. An object with a mass of 200 g and a Celsius temperature of 95 ℃ is then put into the cup. Find the Celsius temperature of water when they (the cup, water, and the object) are all in thermal equilibrium. Use 2.0 J/(g•K), 4.2 J/(g•K), and 0.90 J/(g•K) for the specific heat capacities of the cup, water, and the object, respectively. Ignore any other objects outside the system.

(1) ℃

(2) There is an ideal gas with an absolute temperature T_1 of 300 K, a volume V_1 of 3.0×10^{-2} m^3, and a pressure p_1 of 1.0×10^5 Pa. Then, the ideal gas is heated and compressed. Find the pressure p_2 [Pa] of the ideal gas when the absolute temperature and volume of the ideal gas become $T_2 = 400$ K and $V_2 = 2.5\times10^{-2}$ m^3, respectively.

(2) **Pa**

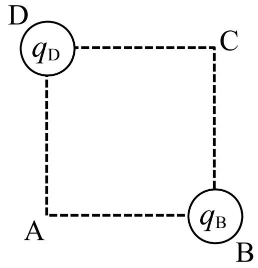
(3) A gas with a volume V_1 of 2.0×10^{-2} m^3 and a pressure p of 1.0×10^5 Pa is in a cylinder. The gas is compressed while keeping the pressure constant, and then the volume of the gas becomes $V_2 = 1.6\times10^{-2}$ m^3. Under the process, find the work W [J] which is given to the gas from the outside.

(3)	**J**

(4) There is an ideal gas of 2.0 mole monoatomic molecules. The initial Celsius temperature, volume, and pressure of the ideal gas are $t_1 = 27$ ℃, $V_1 = 9.0\times10^{-2}$ m^3, and $p = 1.0\times10^5$ Pa, respectively. Then, a heat $Q = 1.0\times10^4$ J is given to the ideal gas while keeping the pressure constant. Find the volume V_2 [m^3] when the Celsius temperature of the ideal gas becomes $t_2 = 227$ ℃. Use the gas constant R of 8.3 J/(mol•K) if necessary.

(4)	**m^3**

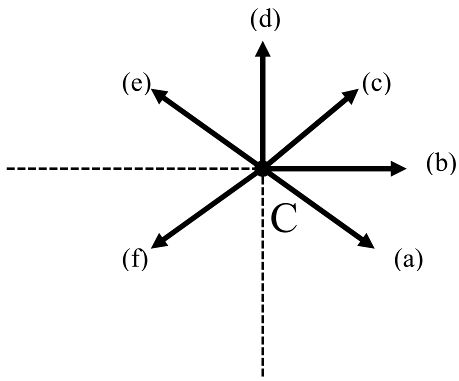
5. As shown in the figure, point charges $q_B = 2.0\times10^{-6}$ C and $q_D = 2.0\times10^{-6}$ C are at the corner B and D, respectively, of square ABCD with a length of a side of 3.0 m. Answer the following three questions under two significant figures. Use the Coulomb's law constant k_e of $9.0\times10^{9}\,\mathrm{N\cdot m^2/C^2}$ and $\sqrt{2} = 1.41$ if necessary.



(1) Find the magnitude F_B [N] of the force on q_B.

(1)	N

(2) Find the magnitude E_C [N/C] and the direction of the electric field at the corner C. For the direction, choose the best one among (a) ~ (f) in the following figure and write the letter ((a) ~ (f)) of your choice.



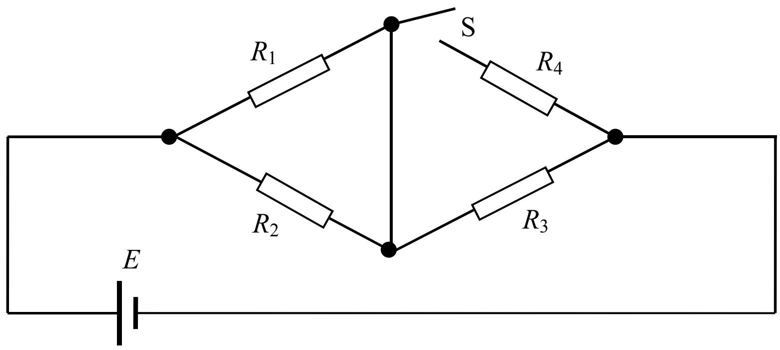
(2)	N/C

(2) direction ;

(3) Find the potential φ_C [V] at the corner C. Let the potential to be 0 at infinity.

(3)	**V**

6. As shown in the figure, a circuit is made using a battery (voltage $E = 7.0$ V), four resistors ($R_1 = 1.0\,\Omega$, $R_2 = 4.0\,\Omega$, $R_3 = 2.0\,\Omega$, and $R_4 = 3.0\,\Omega$), and switch S. Answer the following three questions under two significant figures.



(1) Find the current I_3 [A] in resister $R_{3,}$ with switch S open.

(1)	A

(2) Find the current I_2 [A] in resister $R_{2,}$ with switch S open.

(2)	A

(3) Find the current I_2 [A] in resister $R_{2,}$ with switch S closed.

(3)	A

7. A medium at x [m] position with a displacement y [m] in time t [s] causes a wave given as

$$y(x,t) = 3\cos\{\tfrac{\pi}{12}(12t - 5x)\}.$$

Answer the following three questions regarding this wave. All answers must be given under two significant figures.

(1) Find the speed v [m/s] of the wave.

(1)	**m/s**

(2) Find the period T [s] of the wave.

(2)	**s**

(3) Find the wavelength λ [m] of the wave.

(3)	**m**