2019 Enrolment The 1st

Japan University Examination

Advanced Physics

Examination Date: November 2017

(60 min)

Do not open the examination booklet until the starting signal for the exam is given.
Please read the following instructions carefully.
Please fill in the examinee no. and name below.

Instructions

1. The booklet contains 9 pages.
2. The answer sheet is one piece of one sided paper.
3. In the case that you notice there are parts in the booklet where the print is not clear or there are missing pages or misplaced pages, or the answer sheet is soiled, raise your hand to report to the invigilator.
4. There are 3 questions to be answered.
5. Fill the examinee no. and name in the answer sheet.
6. Use black pencil to write answers in the designated section in the answer sheet.
7. Memos and calculations can be written on the examination booklet.
8. When the signal to end the exam is given, check again to see that the examinee no. and name is filled in and submit the answer sheet and the examination booklet according to the invigilator's instructions.

Examinee'sNo.	Name

1

As shown in Figure 1, the slope AB and the horizontal plane BC are smoothly connected. Surface BC and the horizontal surface DE made a step connecting by the vertical surface CD, and cart Q which has surface FG of the same height as surface BC, is connected to surface CD.

Now, from point A on the slope AB with a height of h, the small object P is gently released and the velocity of P is v_0 on surface BC, and P finally slides into surface FG which is the top of the cart. The mass of the small object P and cart Q is m, the frictional force works only between P and surface FG, and its coefficient of kinetic friction is μ. In the case of [I] [II] below, please choose a correct answer from the options for each question and fill in the corresponding number. In additional, the magnitude of the gravitational acceleration is g, and for the velocity and acceleration, the right direction of Figure 1 is assumed to be positive.

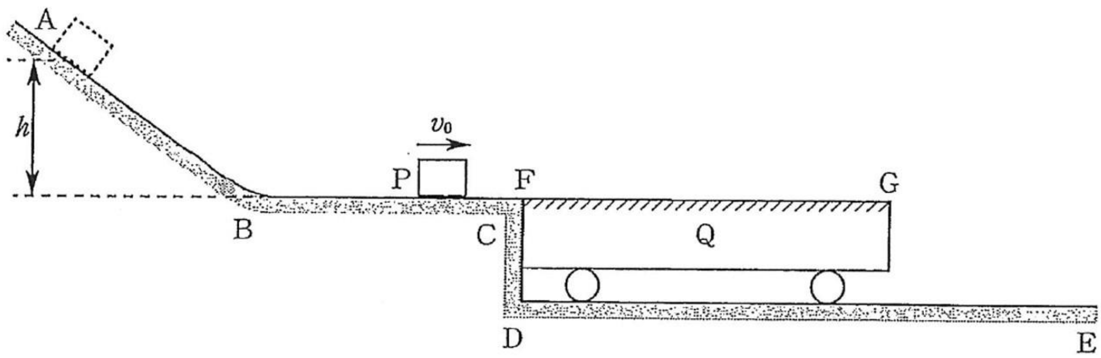


Figure 1

[I] Cart Q is fixed so it does not move.

(1) How much is the gravitational potential energy of the small object P at point A? Assume that the gravitational potential energy of P on surface BC is 0.

① 0　② $-\frac{1}{2}mgh$　③ $\frac{1}{2}mgh$　④ $-mgh$　⑤ mgh

(2) How much is the velocity v_0 of the small object P while sliding on surface BC?

① $\sqrt{gh}$　② gh　③ $\sqrt{2gh}$　④ $2gh$　⑤ $2\sqrt{gh}$

(3) How much is the acceleration of the small object P while sliding on surface FG?

① $-\frac{1}{2}\mu g$ ② $\frac{1}{2}\mu g$ ③ $-\mu g$ ④ μg ⑤ $-g$

(4) The small object P remains still on surface FG. What is the distance from the left end of the cart F to the position of P?

① $\frac{{v_0}^2}{2\mu g}$ ② $\frac{\mu {v_0}^2}{2g}$ ③ $\frac{{v_0}^2}{\mu g}$ ④ $\frac{\mu {v_0}^2}{g}$ ⑤ $(1-\mu)\frac{{v_0}^2}{2g}$

[II] Cart Q is free to move.

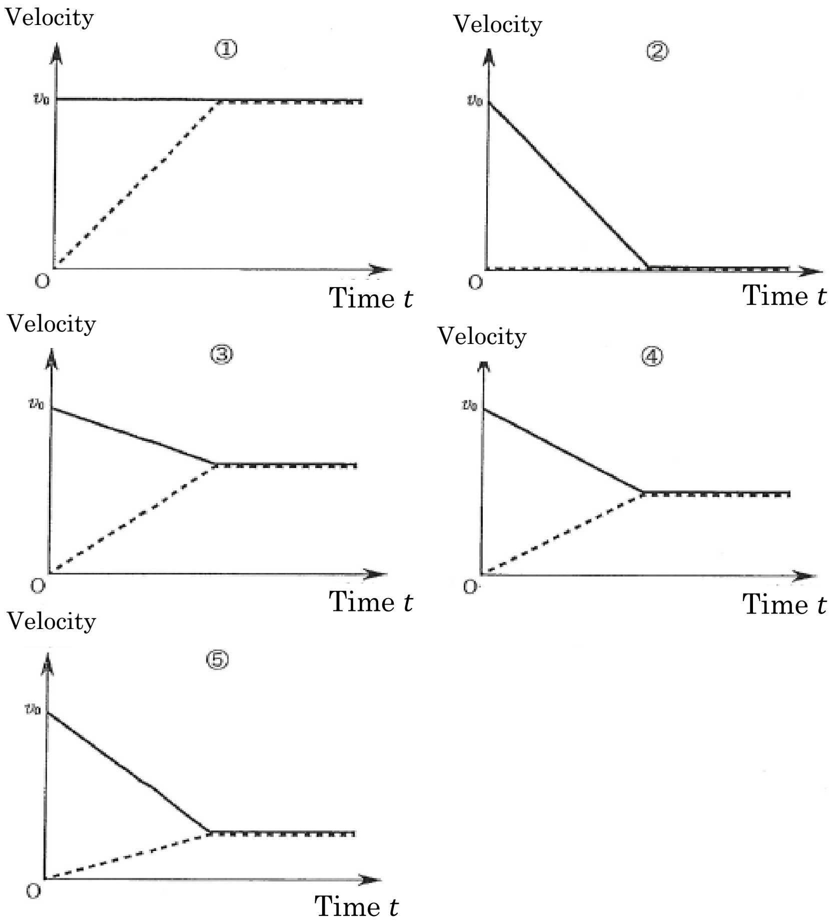
(5) When the small object P slides on cart Q (surface FG), how much is the acceleration of Q against the floor?

① $-\mu g$ ② μg ③ $-2\mu g$ ④ $2\mu g$ ⑤ $3\mu g$

(6) After the small object P finally stops on the cart Q, P and Q move together. Now how much is the velocity of P and Q?

① 0 ② $\frac{v_0}{3}$ ③ $\frac{v_0}{2}$ ④ $\frac{2}{3}v_0$ ⑤ v_0

(7) Assume that the instantaneous velocity of the small object P while passing F which is the left end of the cart is $t = 0$, how will the velocity of the small object P and cart Q change afterwards? In the following graphs, the velocity of P is indicated by a solid line (——),and the velocity of Q is indicated by a dashed line (----).



(8) How much distance did the small object P slide over cart Q?

① $\dfrac{{v_0}^2}{4\mu g}$ ② $\dfrac{\mu {v_0}^2}{4g}$ ③ $\dfrac{{v_0}^2}{2\mu g}$ ④ $\dfrac{\mu {v_0}^2}{2g}$

2

As shown in Figure 2, the two parallel smooth rails ab and cd, of which the distance between both is l, the angle from a horizontal surface is θ,and fix the above kit in the magnetic field (magnetic flux) of the vertically upward magnetic flux density B. The resistance of the resistance value R is connected between the rail ends of a and c. On the top of the rails, put the metal bar PQ of mass M which perpendicularly. When PQ is released in a state of rest, PQ starts to move vertically to the rails, and it will move at a constant velocity v_0. The rails are long enough, there is no friction between the rails and the metal bar, and the electric resistance except the resistance between ac and the magnetic field due to the electric current flowing through the circuit are negligible. Assume the magnitude of the gravitational acceleration is g, please choose a correct answer from the options for each question and fill in the corresponding number.

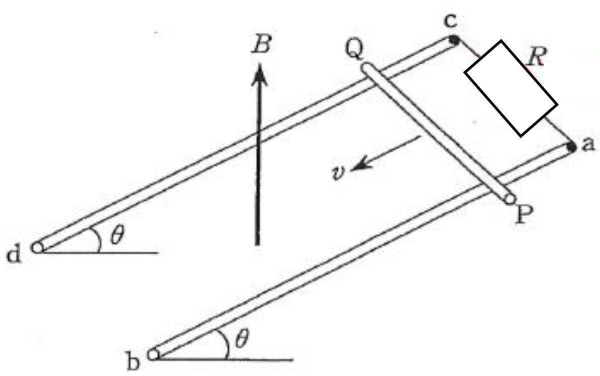


Figure 2

(1) When the velocity of PQ is v, how much is the induced electromotive force which occurs on the metal bar PQ when the velocity of PQ is v?

① vBl ② $vBl\sin\theta$ ③ $vBl\cos\theta$ ④ $vBl\tan\theta$

(2) How much is the electric current I flowing through the resistance at this instant?

① $\frac{vBl}{R}$ ② $\frac{vBl\sin\theta}{R}$ ③ $\frac{vBl\cos\theta}{R}$ ④ $\frac{vBl\tan\theta}{R}$

(3) Which direction is the electric current flowing through the resistance?

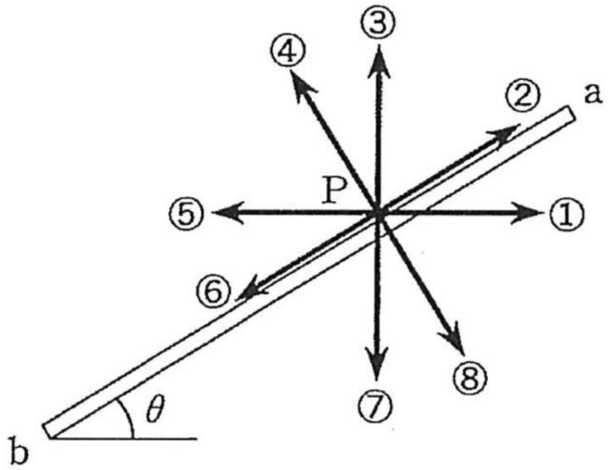
① From a to c ② From c to a

(4) How much of the force does the metal bar PQ receive from the magnetic field?

① IBl ② $IBl\sin\theta$ ③ $IBl\cos\theta$ ④ $IBl\tan\theta$

(5) What is the direction of force that the metal bar PQ received from the magnetic field?

Figure 2 viewed from the front side (P side)



(6) How much is the velocity v_0 when the metal bar PQ moves at a constant velocity v_0?

① $\dfrac{MgRcos^2\theta}{B^2l^2 \, sin\,\theta}$ ② $\dfrac{MgRcos\theta}{B^2l^2 \, sin^2\theta}$ ③ $\dfrac{MgRsin^2\theta}{B^2l^2 \, cos\,\theta}$ ④ $\dfrac{MgRsin\theta}{B^2l^2 \, cos^2\theta}$

⑤ $\dfrac{B^2l^2sin\theta}{MgR\,cos^2\theta}$ ⑥ $\dfrac{B^2l^2sin^2\theta}{MgR\,cos\,\theta}$ ⑦ $\dfrac{B^2l^2cos\theta}{MgR\,sin^2\theta}$ ⑧ $\dfrac{B^2l^2cos^2\theta}{MgR\,sin\,\theta}$

(7) When the metal bar PQ moves at a constant velocity v_0, how much of the Joule heat per unit time occurs in resistance?

① Mgv_0 ② $Mgv_0\sin\theta$ ③ $Mgv_0\cos\theta$ ④ $Mgv_0\tan\theta$

3

As shown in Figure 3, on one side of a piece of flat glass, there is a diffraction grating carved a large number of parallel grooves with a constant interval (lattice constant) d . On the other side where the diffraction grating has no groove, monochromatic light of wavelength λ is made incident vertically. On the screen which is far from the diffraction grating, several bright spots were observed around the intersection O which is the intersection of direction of light and the screen. Please choose a correct answer from the options for each question and fill in the corresponding number.

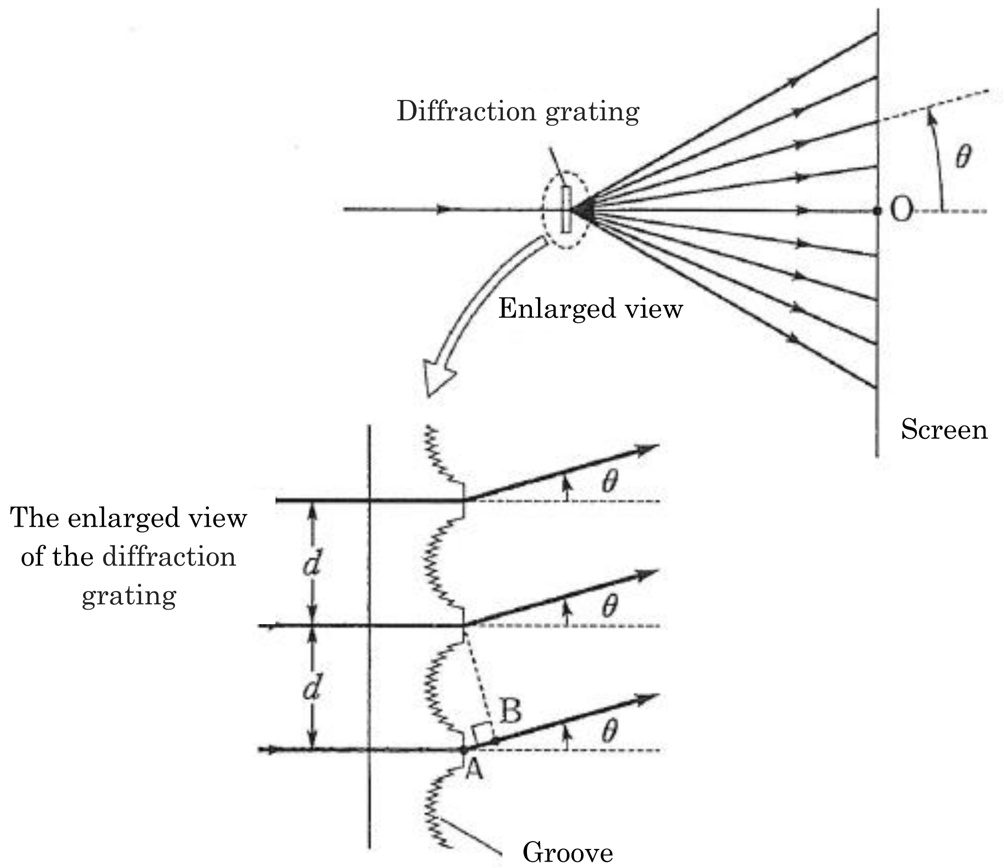


Figure 3

Question 1 Please choose the appropriate terms or formulas from (A) to (D) in the next article one by one from the options and write the number as well.

Because the light is absorbed or irregularly reflected in the groove of the diffraction grating, the flat part between the grooves works as a slit. According to the principle (A) ,as light passes through the slit, a spherical wave called (B) occurs from each point on the slit, and the light diffracts to proceed. The light diffracted from each slit (C) and strengthens in several certain directions, and bright spots appear on the screen. Hereinafter, this strengthened light is called "diffracted light", and in the direction in which the diffracted light appears, the angle θ ($-90° < \theta < 90°$) is measured counterclockwise from the incident direction.

The difference of path AB between the lights traveling in the direction of the positive angle θ through the adjacent slits is $dsin\theta$. In general, the conditional formula of the diffracted light giving the direction where the diffracted light appears, including the case of which the angle θ is negative, is expressed as below, as m to be an integer.

$$dsin\theta = \text{(D)} \times \lambda$$

① Diffract(S)	② Refract(S)	③ Reflect(S)
④ Interfere(S)	⑤ Huygens	⑥ Young
⑦ Longitudinal Wave	⑧ Elementary wave	⑨ Stationary Wave
⑩ m	⑪ $m+\frac{1}{4}$	⑫ $m+\frac{1}{2}$

Question 2 A similar experiment was conducted using a diffraction grating with a smaller lattice constant d without changing the wavelength λ of monochromatic light. What happens to the appearing direction of the diffracted light?

① Nothing changes.
② In Figure 3, all the diffracted lights move upward.
③ In Figure 3, all the diffracted lights move downward.
④ In Figure 3, the diffracted lights above point O move upward and the diffracted lights below O move downward.
⑤ In Figure 3, the diffracted lights above point O move downward and the diffracted lights below O move upward.

Question 3 In the experiment using the monochromatic light of wavelength $\lambda_1 = 6.0 \times 10^{-7}$m, the diffracted light of $m = 4$ which the condition found in Question 1 appears in the direction of $\theta = 30°$. In the diffraction grating, about how many grooves are carved per 1 cm?

① 1.4×10^3 ② 2.1×10^3 ③ 3.6×10^3 ④ 5.5×10^3 ⑤ 1.1×10^4

Next, as shown in Figure 4, on the other side without grooves of the diffraction grating which is used in Question 3, the monochromatic light of wavelength λ_2 is made incident obliquely downward at an angle of incidence of 30°. The incident light is refracted, travels through the glass, diffracts from the slit, and returns to the air again.

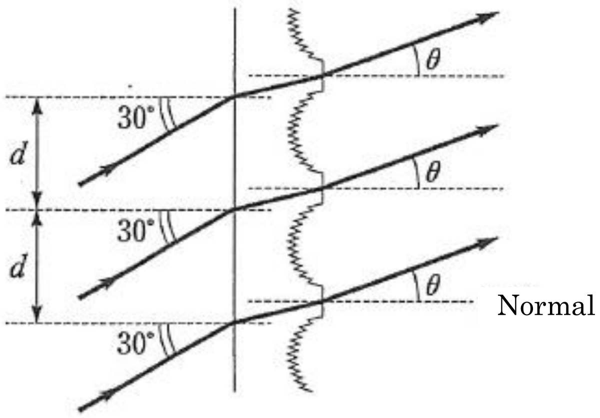


Figure 4

Question 4 Considering the fact that the optical path lengths in the glass are equal, how is the conditional formula of the diffracted light giving the direction where the diffracted light appears expressed? Assume m' is an integer, and the direction where the diffracted light appears is expressed by the angle θ ($-90^\circ < \theta < 90^\circ$) which is measured counterclockwise from the normal direction.

① $d\,(\sin 30^\circ - \sin\theta) = m'\lambda_2$ ② $d\,(\sin 30^\circ - \cos\theta) = m'\lambda_2$

③ $d\,(\cos 30^\circ - \cos\theta) = m'\lambda_2$ ④ $d\,(\cos 30^\circ - \sin\theta) = m'\lambda_2$

⑤ $d\,(\tan 30^\circ - \tan\theta) = m'\lambda_2$

Question 5 Compared with Question 3 in which monochromatic light of wavelength λ_1 is vertically incident, the position of the bright spots which occur on the screen by the diffracted light are correspondent with the positions of several bright spots. A bright spot also occurs at the position of m=2 in Question 3. In response to this, please find the value of the wavelength λ_2 ($\times 10^{-7}$m). And although λ_1 and λ_2 are different, they are both in the visible light region, and the wavelength region of visible light is around 3.8×10^{-7}m ～ 7.7×10^{-7}m.

① 3.8 ② 4.0 ③ 5.0 ④ 6.5 ⑤ 7.2