2018 Enrolment The 2nd

Japan University Examination

Advanced Physics

Examination Date: May 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 13 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's No.	Name

Advanced physics

1

Please choose the appropriate formula, number or graph and put into the (1) to (10) in the following text I and text II one by one from the answer groups and write it with a number.

I

As shown in FIG. 1, the small ball P of mass m is hanged and kept stationery by the light spring with the spring constant k which is fixed at the top end to the ceiling. Assume that the position of P at this time is the starting point O, and take the x axis as vertically downward. Assume that the magnitude of the gravitational acceleration is g and the size of P as well as the resistance due to air acting on P are negligible.

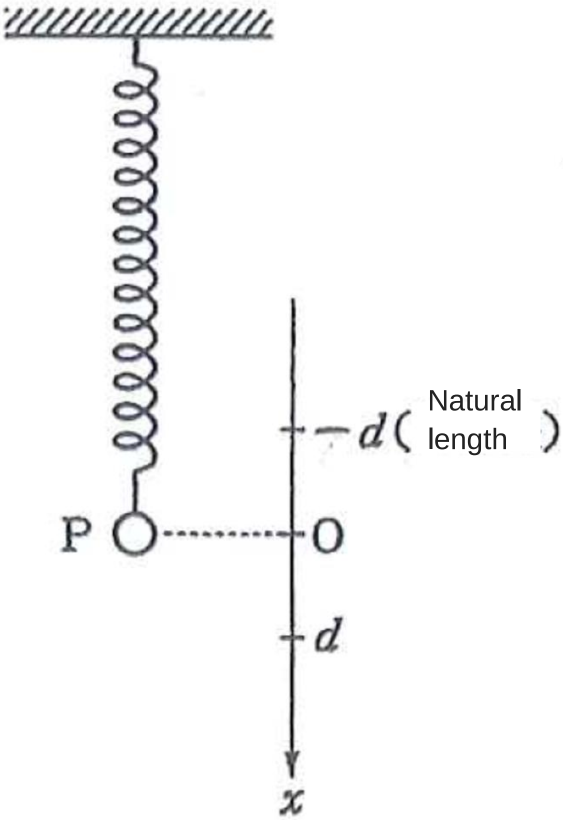


FIG. 1

While the small ball P is at the initial stationary position (starting point O), the elongation of the spring $d =$ (1) . Now, when P is gently released at the position where it is only lowered further as d ($x = d$), P will perform a simple vibration. Assume that the acceleration of P is a when P is in the vertical positive direction, the motion equation of P is expressed as,

$ma =$ (2)

From this it can be seen that P performs a simple vibration at the position of $x =$ (3) . In general, the acceleration a of such object that performs simple vibration is expressed by $a = -$ (4) using each frequency ω, and the period T of simple vibration is given as $T =$ (5) . Assume that $t = 0$ when P is released, the first time when P passes through the starting point O is at time $t_1 =$ (6) $\times T$, and at that time the speed v_1 of $v_1 =$ (7) .

Answer group for (1)

① $\frac{mg}{k}$ ② $\frac{k}{mg}$ ③ $\sqrt{\frac{k}{2mg}}$ ③ $\sqrt{\frac{2mg}{k}}$

Answer group for (2)

① $-kd$ ② $-k(d + x)$ ③ $mg + kx$
④ $mg - kx$ ⑤ $mg + k(d + x)$ ⑥ $mg - k(d + x)$

Answer group for (3)

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

Answer group for (4)

① ωx ② $\omega^2 x$ ③ $\frac{x}{\omega}$ ④ $\frac{x}{\omega^2}$

Answer group for (5)

① $\sqrt{\dfrac{k}{m}}$ ② $\sqrt{\dfrac{m}{k}}$ ③ $2\pi\sqrt{\dfrac{k}{m}}$ ④ $2\pi\sqrt{\dfrac{m}{k}}$

Answer group for (6)

① $\dfrac{1}{4}$ ② $\dfrac{1}{3}$ ③ $\dfrac{1}{2}$ ④ $\dfrac{3}{4}$ ⑤ 1

Answer group for (7)

① $d\sqrt{\dfrac{m}{k}}$ ② $d\sqrt{\dfrac{3m}{k}}$ ③ $2d\sqrt{\dfrac{m}{k}}$

④ $d\sqrt{\dfrac{k}{m}}$ ⑤ $d\sqrt{\dfrac{3k}{m}}$ ⑥ $2d\sqrt{\dfrac{k}{m}}$

II

Next, as shown in FIG. 2, use a rubber string instead of a spring to hang the small ball P (mass m) and stop it, then take the same axis as I. Rubber string shall have the same function as the spring of spring constant k when it stretches and no force is exerted on P when it is slack.

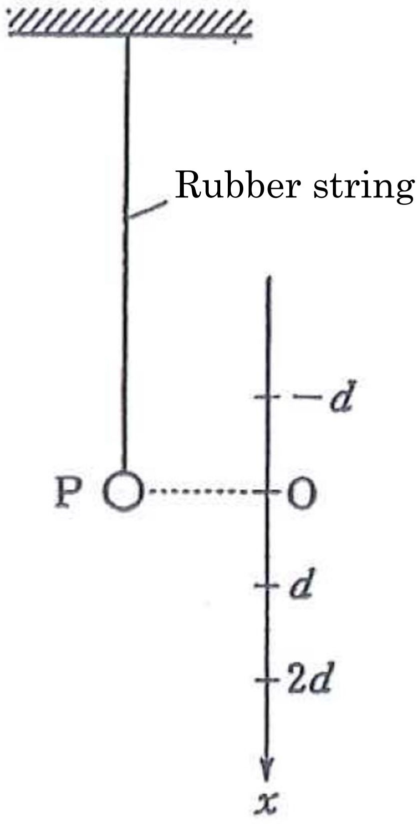


FIG. 2

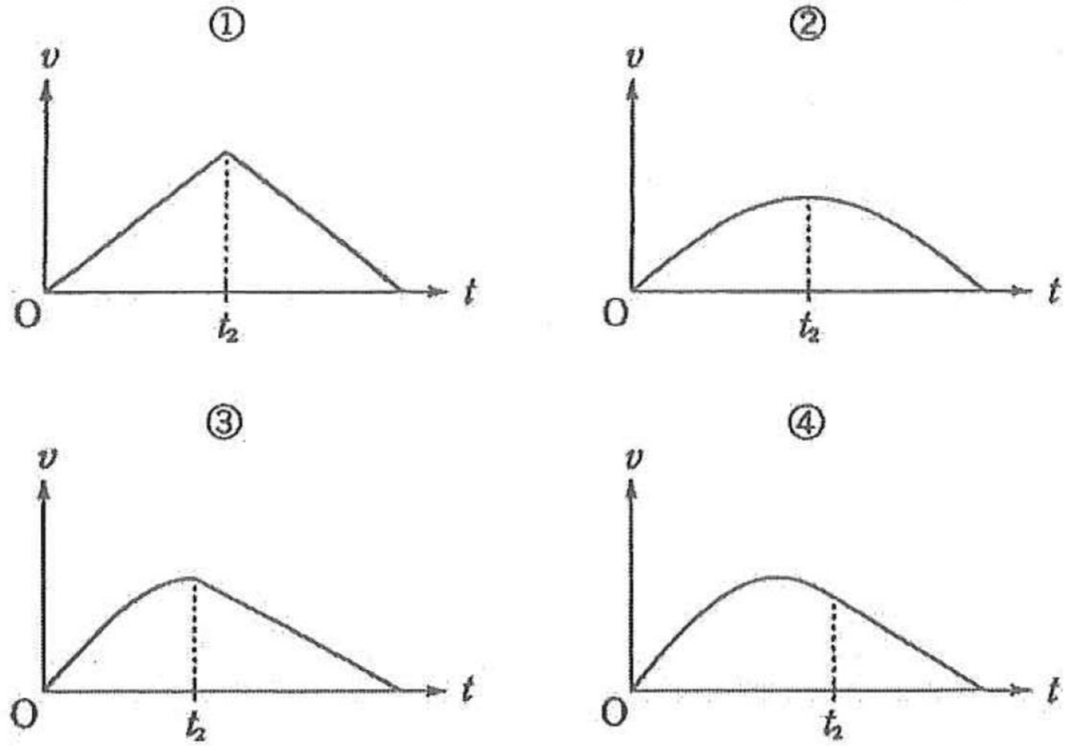
Now, gently release the small ball P at the position where it is only lowered further as $2d$ (x=$2d$) from its stationery point. The velocity $v_2$of P when it starts sagging is v_2 = [(8)]. Also, the velocity change of P from it is released until it reaches the highest point is shown in the graph taking the time t on the horizontal axis [(9)]. However, assume that t = 0 when P is released, and the time is t_2 = [(10)] when the rubber string starts sagging.

Answer group for [(8)]

① $d\sqrt{\frac{m}{k}}$　　② $d\sqrt{\frac{3m}{k}}$　　③ $2d\sqrt{\frac{m}{k}}$

④ $d\sqrt{\frac{k}{m}}$　　⑤ $d\sqrt{\frac{3k}{m}}$　　⑥ $2d\sqrt{\frac{k}{m}}$

Answer group for (9)



Answer group for (10)

① $\frac{\pi}{4}\sqrt{\frac{m}{k}}$ ② $\frac{\pi}{4}\sqrt{\frac{k}{m}}$ ③ $\frac{3\pi}{4}\sqrt{\frac{m}{k}}$ ④ $\frac{3\pi}{4}\sqrt{\frac{k}{m}}$ ⑤ $\frac{2\pi}{3}\sqrt{\frac{m}{k}}$ ⑥ $\frac{2\pi}{3}\sqrt{\frac{k}{m}}$

2

As shown in FIG. 3, a galvanometer G, a resistor with a resistance value of 5Ω, a 40cm-long resistance wire AB with a movable contact and a uniform resistance value of 8Ω are connected together to an 8V battery E with a negligible internal resistance to make a circuit. Terminals of the three units shown in FIG. 4 can be connected to the terminal X and terminal Y in the circuit. Please answer the following questions on the assumption that the resistance of the wire is negligible. However, please choose each answer from the answer groups and write it with a number.

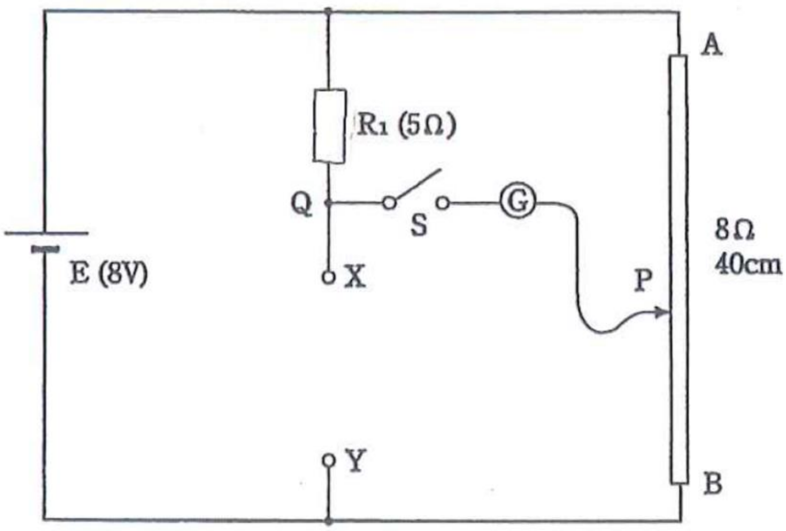


FIG. 3

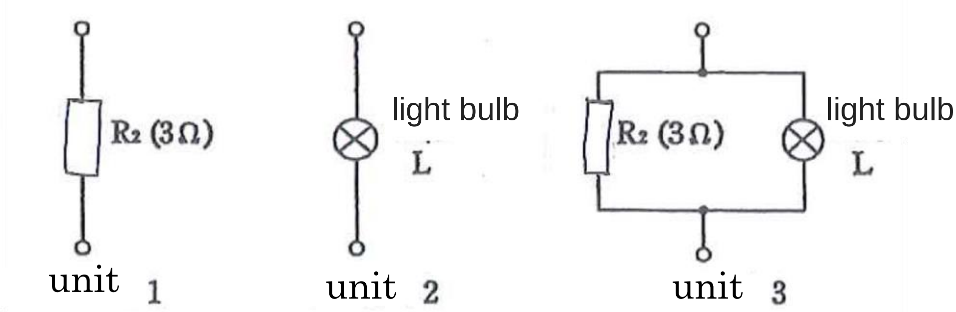


FIG. 4

Q1 Connect unit 1 which includes a 3Ω resistance between X and Y in the circuit while S is turned on.

(1) What is the strength of current R_1 flowing through the resistor?

① 0.5A ② 1A ③ 1.6A ④ 2.7A ⑤ 6.4A

(2) The position of the contact point P is set at the midpoint of the resistance wire AB. At this time, what is the potential difference between P and branch point Q?

① 0.5V ② 1V ③ 2V ④ 3V ⑤ 5V

(3) Adjust the position of contact P while S is turned off, the current flowing through G becomes 0. At this time, what is the distance between P and B?

① 10cm ② 15cm ③ 20cm ④ 25cm ⑤ 30cm

Q2 Turn on S again, connect the unit 2 which includes the current L with a voltage-current characteristic as shown in FIG. 5 instead of unit 1 between X and Y. Assume that the voltage across L is V [V] and the intensity of the current flowing through L is I [A].

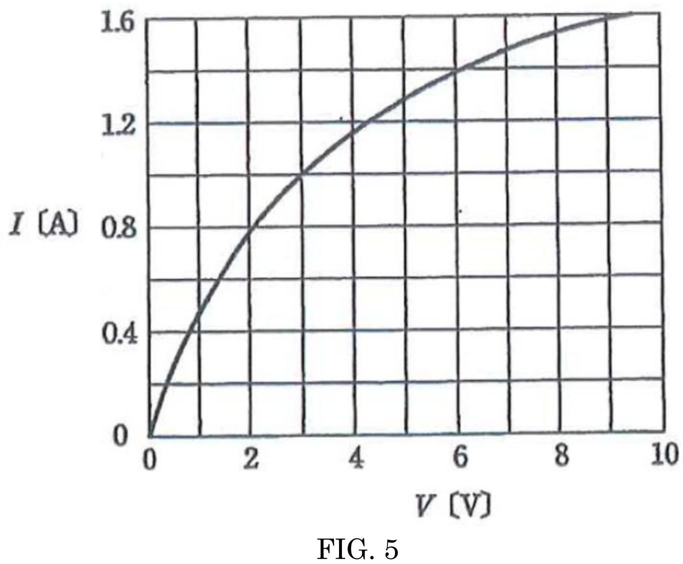


FIG. 5

(4) Please find the relational expression between *V* and *I*.

① $8 = 5I + V$ ② $8 = I + 5V$ ③ $8 = \frac{I}{5} + V$ ④ $8 = I + \frac{V}{5}$ ⑤ $V = 5I$

(5) Please find the value of *V*.

① 2V ② 3V ③ 5V ④ 6V ⑤ 8V

(6) Please find the power value of battery E.

① 1w ② 3w ③ 5w ④ 8w ⑤ 16w

Q3 Next, while S is turned on, instead of unit 2, the unit 3 which is consisting of R_2 and L connects between XY.

(7) Please find the strength value *I* of current flowing through *L*.

① 0.7A ② 0.8A ③ 1A ④ 1.4A ⑤ 1.5A

3

An equation is suitable for putting into (1) ~ (9) in the following text I and text II. Please choose numbers, texts, or figures one by one from each answer group and write down the number. However, assume that the refractive index of air is 1.

I

FIG. 6 shows a device for Young's interference experiment. Flat plate A, flat plate B and the screen are placed in parallel, and the slit S_1 and S_2 on flat plate B is equidistant from S_0 on flat plate A. The distance between S_1 and S_2 is d and d is small enough comparing to the distance L between flat plate B and the screen. Also, the intersection of the S_1S_2 and vertical bisector of flat plate A and is taken as the starting point O, and the axis is taken on the screen with the upward direction as positive.
When a monochromatic light of wavelength λ is applied from the left side of A, light and dark interference fringes can be observed on the screen. FIG. 7 shows the position of the light line.

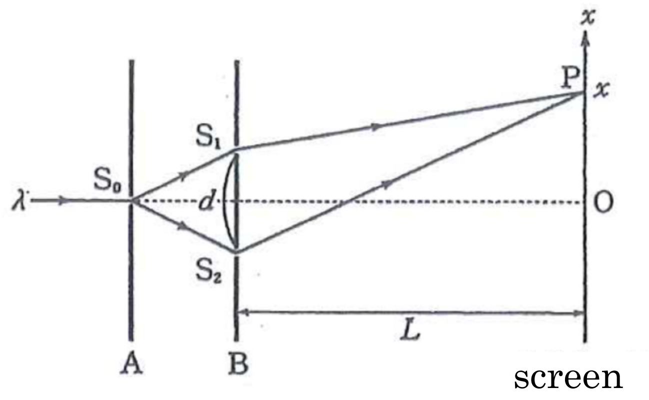


FIG. 6

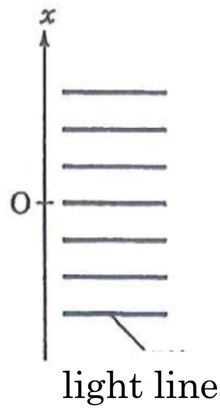


FIG. 7

The condition under which the bright line can be seen at the point P on the screen is expressed as S_2P-S_2P = (1), using the integer m. Since the path difference S_2P-S_2P can be approximated as $\frac{dx}{L}$ by using the position coordinate of point P, the position of the bright line with respect to the integer m x_m is expressed as x_m = (2) Thus, the interval between the bright lines Δx is expressed as Δx = (3) . When L=1.2 m, d=0.80 mm, Δx =0.93 mm, the wavelength of the monochromatic light is (4).

Answer group for (1)

① $\frac{m}{4}\lambda$ ② $\frac{m}{2}\lambda$ ③ $m\lambda$ ④ $\left(m+\frac{1}{4}\right)\lambda$ ⑤ $\left(m+\frac{1}{2}\right)\lambda$

Answer group for (2)

① $\frac{L\lambda}{4d}m$ ② $\frac{L\lambda}{2d}m$ ③ $\frac{L\lambda}{d}m$

④ $\frac{L\lambda}{d}\left(m+\frac{1}{4}\right)$ ⑤ $\frac{L\lambda}{d}\left(m+\frac{1}{2}\right)$

Answer group for (3)

① λ ② $\frac{d\lambda}{L}$ ③ $\frac{2d\lambda}{L}$ ④ $\frac{L\lambda}{d}$ ⑤ $\frac{L\lambda}{2d}$

Answer group for (4)

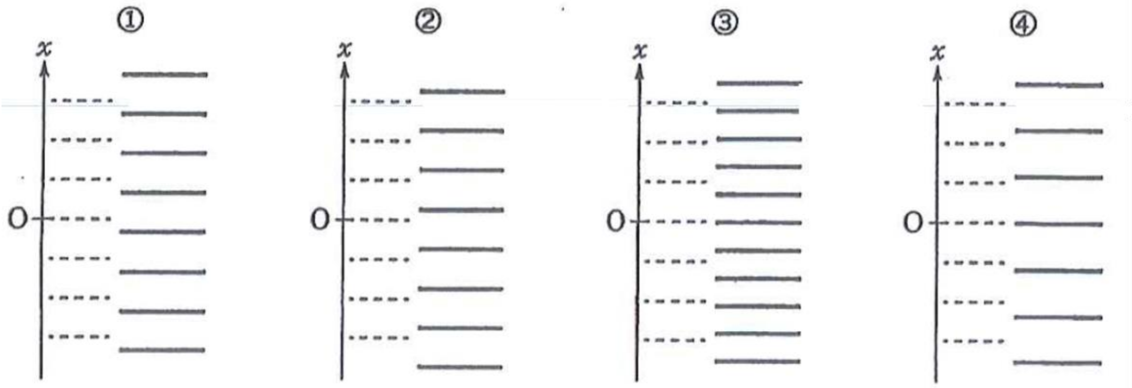
① $1.2\times10^{-7}m$ ② $1.2\times10^{-6}m$ ③ $3.1\times10^{-8}m$

④ $3.1\times10^{-7}m$ ② $6.2\times10^{-8}m$ ③ $6.2\times10^{-7}m$

If the monochromatic light that shines at the flat plate A is changed to that of a shorter wavelength, the bright line observed on the screen looks like [(5)].

Furthermore, move the flat plate A downward in the figure and slightly lower the S_0, interference fringe on the screen is like [(6)].

Answer group for [(5)] (However, the broken line shows the position of the bright line at the wavelength λ)



Answer group for [(6)]

① It will shift upward, but the distance will not change
② It will shift downward, but the distance will not change
③ It will shift upward, and the distance will become larger
④ It will shift downward, and the distance will become larger
⑤ It will shift upward, and the distance will become smaller
⑥ It will move downward, and the distance will become smaller

II

Next, as shown in FIG. 8, after returning S_0 to the vertical bisector of S_1S_2, in a state where monochromatic light of wavelength λ is applied to the flat plate A, place a film with heat t and refractive index $n(n > 1)$ on the right side of S_2.

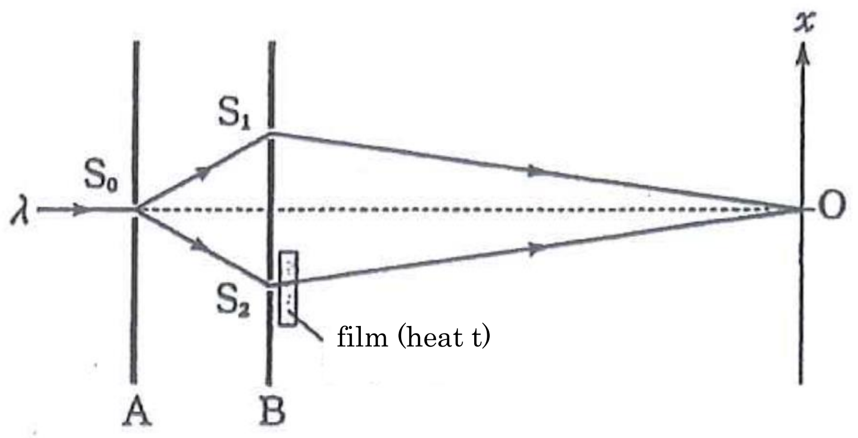


FIG. 8

Since the wavelength of the light traveling through the film is [(7)], the optical path difference (the difference of optical distance) [(8)] of light that passes through the S_1, S_2 and reaches the starting point O will occur. Depending on the heat of the film, when the origin O becomes a bright line, the interference fringes same as before the film is set can be observed, however, the minimum value of the thicknesses of the film that makes such a phenomenon occurs is [(9)].

Answer group for [(7)], [(9)]

① $n\lambda$ ② $\frac{\lambda}{n}$ ③ $n^2\lambda$ ④ $\frac{\lambda}{n^2}$

⑤ $(n-1)\lambda$ ⑥ $(n+1)\lambda$ ⑦ $\frac{\lambda}{n-1}$ ⑧ $\frac{\lambda}{n+1}$

Answer group for [(8)]

① nt ② $(n-1)t$ ③ $(n^2-1)t$

③ $\frac{n-1}{n}t$ ④ $\frac{n^2-1}{n}t$