



AP[®] Physics B 2003 Sample Student Responses Form B

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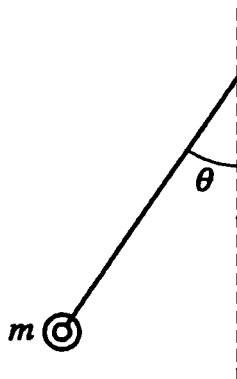
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PHYSICS B
SECTION II
Time—90 minutes
7 Questions

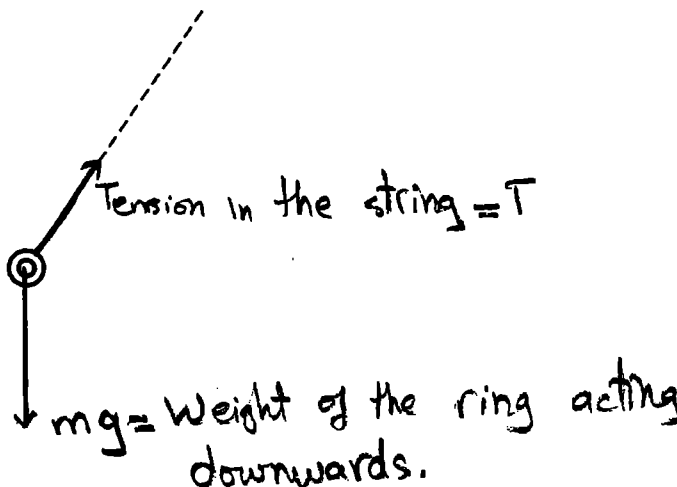
Directions: Answer all seven questions, which are weighted according to the points indicated. The suggested time is about 15 minutes for answering each of questions 1-4, and about 10 minutes for answering each of questions 5-7. The parts within a question may not have equal weight. Show all your work in this booklet in the spaces provided after each part, NOT in the lavender insert.



1. (15 points)

An airplane accelerates uniformly from rest. A physicist passenger holds up a thin string of negligible mass to which she has tied her ring, which has a mass m . She notices that as the plane accelerates down the runway, the string makes an angle θ with the vertical as shown above.

(a) In the space below, draw a free-body diagram of the ring, showing and labeling all the forces present.



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The plane reaches a takeoff speed of 65 m/s after accelerating for a total of 30 s.

(b) Determine the minimum length of the runway needed.

$$u=0, v=65, t=30, x=?$$

$$a = \frac{v-u}{t} = \frac{65-0}{30} = \frac{13}{6} \text{ m/s}^2$$

$$2ax = v^2 - u^2$$

$$x = \frac{65^2}{2(\frac{13}{6})} = 975 \text{ m}$$

(c) Determine the angle θ that the string makes with the vertical during the acceleration of the plane before it leaves the ground.

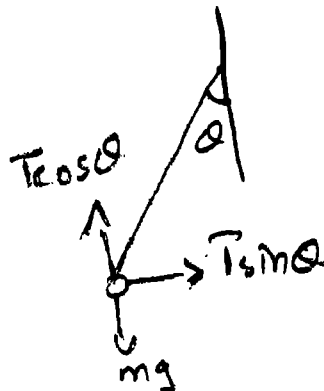
$$T \cos \theta = mg \quad \text{--- ①}$$

$$T \sin \theta = ma \quad \text{--- ②}$$

divide ② by ①

$$\frac{T \sin \theta}{T \cos \theta} = \frac{ma}{mg}$$

$$\Rightarrow \tan \theta = \frac{a}{g} \quad \Rightarrow \theta = \tan^{-1} \left(\frac{13/6}{9.8} \right) = 12.47^\circ \text{ (to 2 decimal places)}$$



(d) What additional information would be needed in order to estimate the mechanical energy of the airplane at the instant of takeoff? Explain your answer.

Total mechanical energy = kinetic energy + potential energy

$$= \frac{1}{2}mv^2 + mgh$$

At the instant of take off, $h=0$

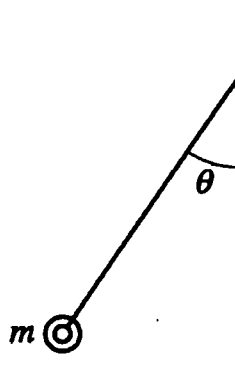
$$\Rightarrow \text{mechanical energy} = \frac{1}{2}mv^2$$

\therefore the mass of the airplane is required to calculate the mechanical energy at the instant of take off.

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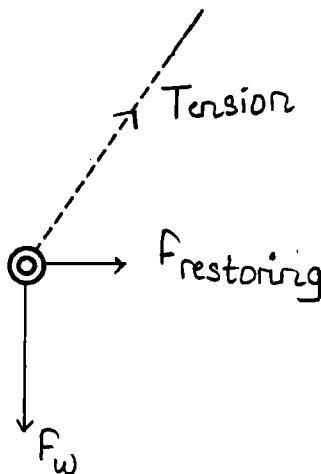
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1. (15 points)

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(a) In the space below, draw a free-body diagram of the ring, showing and labeling all the forces present.



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The plane reaches a takeoff speed of 65 m/s after accelerating for a total of 30 s.

(b) Determine the minimum length of the runway needed.

$$v_f = v_i + at$$
$$65 = 0 + a(30)$$
$$\frac{65}{30} = a$$
$$\Rightarrow a = 2.16 \text{ ms}^{-2}$$

$$S = v_i t + \frac{1}{2} at^2$$
$$S = 0 + \frac{1}{2} \times 2.16 \times (30)^2$$
$$S = \frac{2.16 \times 900}{2}$$
$$S = 972 \text{ m}$$

(c) Determine the angle θ that the string makes with the vertical during the acceleration of the plane before it leaves the ground.

$$F_{\text{net}} = m \times a$$
$$\Rightarrow F_{\text{restoring}} = m \times a$$
$$mg \sin \theta = ma$$
$$g \sin \theta = a$$
$$\sin \theta = \frac{a}{g}$$
$$\Rightarrow \theta = \sin^{-1} \left(\frac{a}{g} \right)$$
$$\theta = \sin^{-1} \left(\frac{2.16}{9.8} \right)$$
$$\theta = \sin^{-1} (0.2204)$$
$$\theta = 12.73^\circ$$

(d) What additional information would be needed in order to estimate the mechanical energy of the airplane at the instant of takeoff? Explain your answer.

Mechanical Energy is the sum of the potential and kinetic energies at any particular instant. At the instant of take off the height above the ground can be assumed to be zero. Thus the entire mechanical energy of the plane is due to its kinetic energy. Since we already know the final velocity, the mass of the airplane would be needed to calculate the mechanical energy.

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