AP® Physics B
2003 Sample Student Responses
Form B

These materials were produced by Educational Testing Service® (ETS®), which develops and administers the examinations of the Advanced Placement Program for the College Board. The College Board and Educational Testing Service (ETS) are dedicated to the principle of equal opportunity, and their programs, services, and employment policies are guided by that principle.

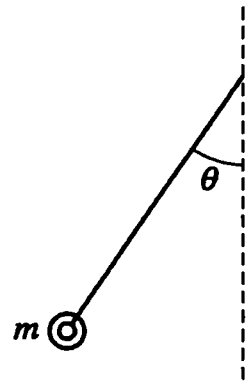
The College Board is a national nonprofit membership association whose mission is to prepare, inspire, and connect students to college and opportunity. Founded in 1900, the association is composed of more than 4,300 schools, colleges, universities, and other educational organizations. Each year, the College Board serves over three million students and their parents, 22,000 high schools, and 3,500 colleges through major programs and services in college admissions, guidance, assessment, financial aid, enrollment, and teaching and learning. Among its best-known programs are the SAT®, the PSAT/NMSQT®, and the Advanced Placement Program® (AP®). The College Board is committed to the principles of equity and excellence, and that commitment is embodied in all of its programs, services, activities, and concerns.

For further information, visit www.collegeboard.com

For the College Board's online home for AP professionals, visit AP Central at apcentral.collegeboard.com.

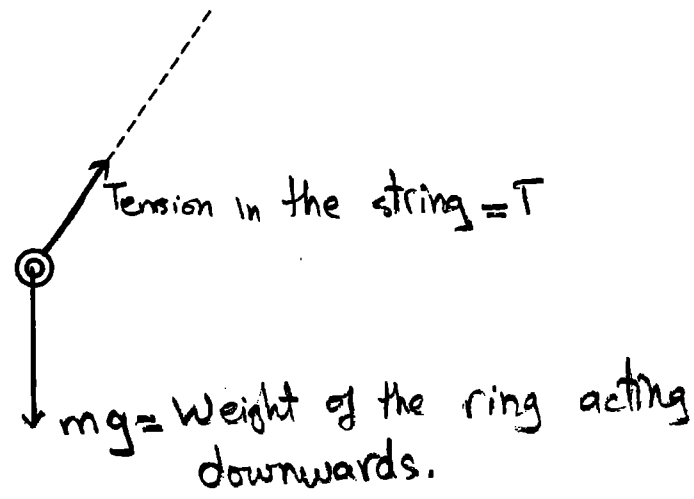
PHYSICS B
SECTION II
Time—90 minutes
7 Questions

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.



GO ON TO THE NEXT PAGE.

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.

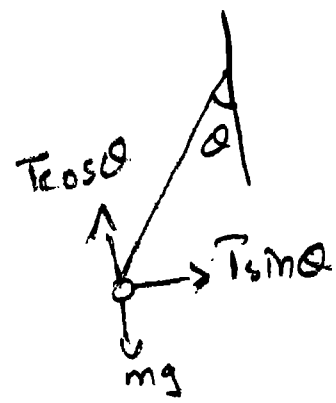
$u=0,\ v=65,\ t=30,\ x=?$

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

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

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

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



$T\cos\theta = mg - ①$

$T\sin\theta = ma - ②$

divide ② by ①

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

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

(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, $h=0$

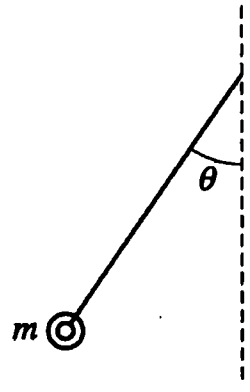
$\Rightarrow$ mechanical energy $=\frac{1}{2}mv^2$

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

GO ON TO THE NEXT PAGE.

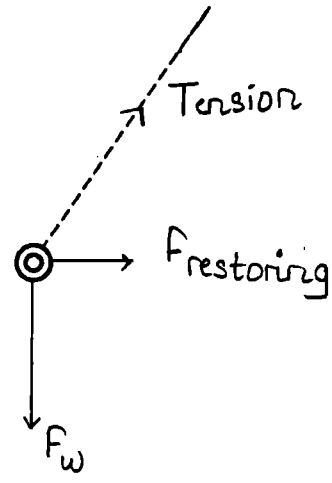
PHYSICS B
SECTION II
Time—90 minutes
7 Questions

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.



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.

$v_f = v_i + at$

$65 = 0 + a(30)$

$\frac{65}{30} = a$

$\Rightarrow a = 2.16\ ms^{-2}$

$S = v_i t + \frac{1}{2}at^2$

$S = 0 + \frac{1}{2} \times 2.16 \times (30)^2$

$S = \frac{2.16 \times 900}{2}$

$S = 972\ m$

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

$F_{net} = m \times a$

$\Rightarrow F_{restoring} = m \times a$

$mg\sin\theta = ma$

$g\sin\theta = a$

$\sin\theta = \frac{a}{g}$

$\Rightarrow \theta = \sin^{-1}\left(\frac{a}{g}\right)$

$\theta = \sin^{-1}\left(\frac{2.16}{9.8}\right)$

$\theta = \sin^{-1}(0.2204)$

$\theta = 12.73°$

(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 ~~ai~~ 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.

GO ON TO THE NEXT PAGE.