AP® Physics B
2001 Sample Student Responses

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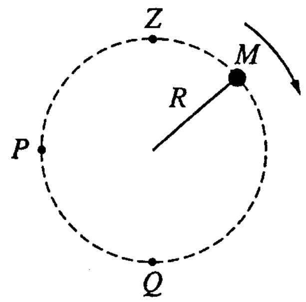
PHYSICS B
SECTION II
Time—90 minutes
7 Questions

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 green insert.

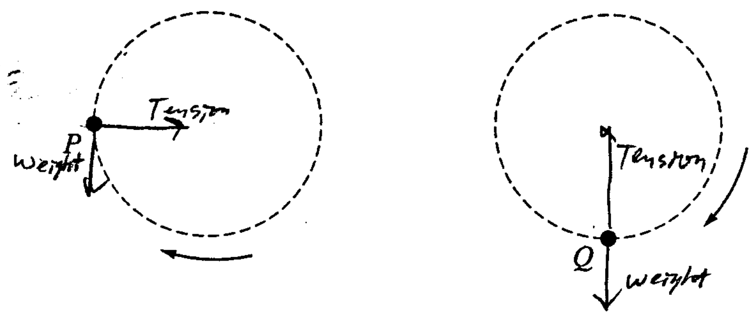


Side View

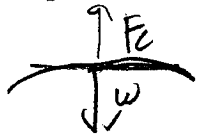
1. (15 points) "loan"

A ball of mass M is attached to a string of length R and negligible mass. The ball moves clockwise in a vertical circle, as shown above. When the ball is at point P, the string is horizontal. Point Q is at the bottom of the circle and point Z is at the top of the circle. Air resistance is negligible. Express all algebraic answers in terms of the given quantities and fundamental constants.

(a) On the figures below, draw and label all the forces exerted on the ball when it is at points P and Q, respectively.



(b) Derive an expression for v_{min}, the minimum speed the ball can have at point Z without leaving the circular path.



$$(m)a_c = \frac{(m)v^2}{r} \qquad F_c = \frac{mv^2}{r} \qquad F_c = W = Mg$$

$$(M)(g) = \frac{Mv^2}{r}$$

$$v = \sqrt{gr}$$

(c) The maximum tension the string can have without breaking is T_{max}. Derive an expression for v_{max}, the maximum speed the ball can have at point Q without breaking the string.

$$T_{max} - Mg = \frac{Mv^2}{r}$$

$$\frac{R(T_{max} - Mg)}{M} = v^2$$

$$v_{max} = \sqrt{\frac{r(T_{max} - Mg)}{M}}$$

(d) Suppose that the string breaks at the instant the ball is at point P. Describe the motion of the ball immediately after the string breaks.

it goes straight upward, accelerating @ $-9.8\ m/s^2$

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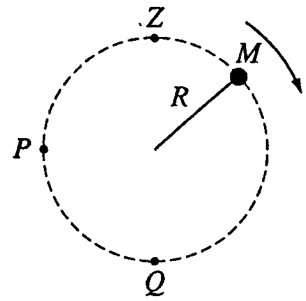
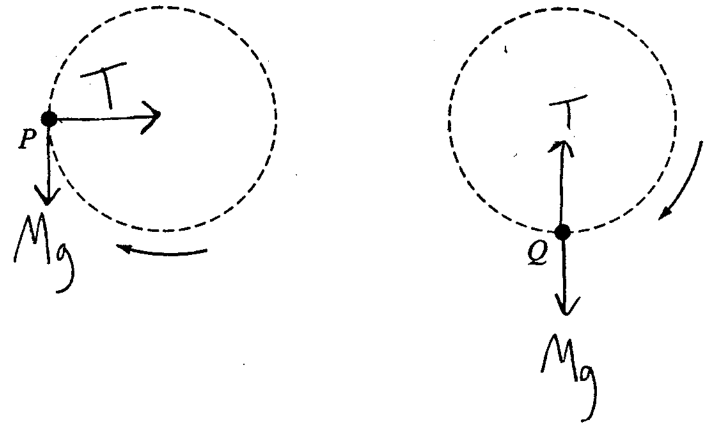


Side View

1. (15 points)

   A ball of mass M is attached to a string of length R and negligible mass. The ball moves clockwise in a vertical circle, as shown above. When the ball is at point P, the string is horizontal. Point Q is at the bottom of the circle and point Z is at the top of the circle. Air resistance is negligible. Express all algebraic answers in terms of the given quantities and fundamental constants.

   (a) On the figures below, draw and label all the forces exerted on the ball when it is at points P and Q, respectively.



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(b) Derive an expression for v_{min}, the minimum speed the ball can have at point Z without leaving the circular path.

$F = ma \quad a = \frac{v^2}{r}$

$F = \frac{mv^2}{r} \quad T + Mg = \frac{mv^2}{r}$

$mv^2 = (T + Mg)R$

$v^2 = \frac{RT + RMg}{m}$

$V_{min} = \sqrt{\frac{RT + RMg}{M}}$

(c) The maximum tension the string can have without breaking is T_{max}. Derive an expression for v_{max}, the maximum speed the ball can have at point Q without breaking the string.

$F = ma \quad a = \frac{v^2}{R}$

$F = \frac{mv^2}{r} \quad T_{max} - Mg = \frac{Mv^2}{R}$

$RT_{max} - RMg = Mv^2$

$v^2 = \frac{RT_{max} - RMg}{M}$

$V_{max} = \sqrt{\frac{RT_{max} - RMg}{M}}$

(d) Suppose that the string breaks at the instant the ball is at point P. Describe the motion of the ball immediately after the string breaks.

The ball will travel straight up with an initial velocity that is between V_{min} and V_{max}, and it's acceleration will be g $(9.8 \frac{m}{s^2})$ down, so eventually the ball will fall straight back down to Earth.

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