AP® Physics B
2002 Sample Student Responses

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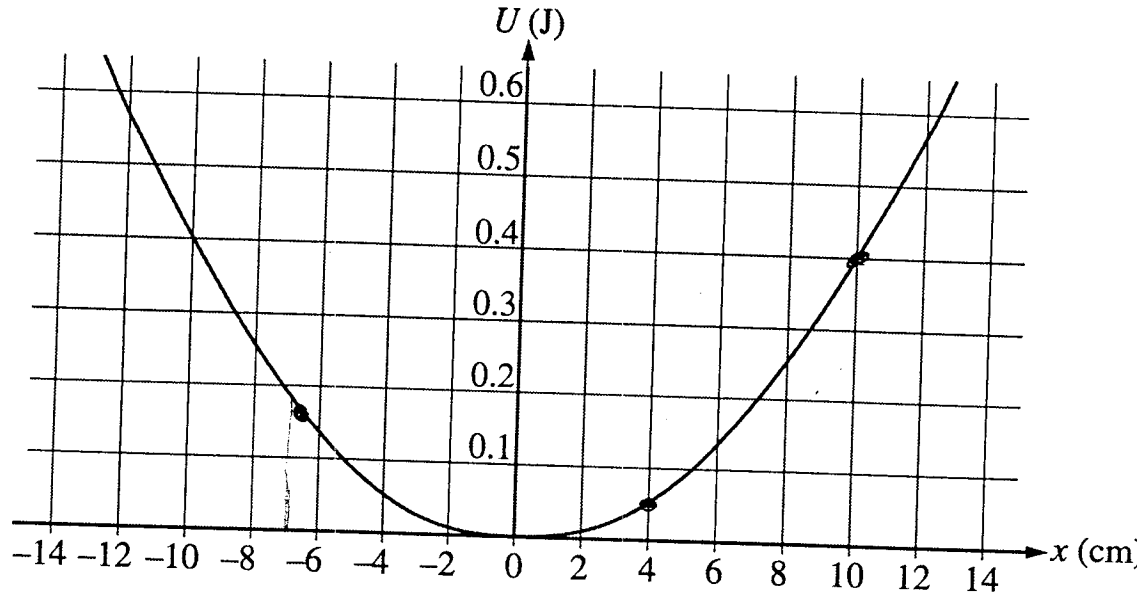

2. (15 points)

A 3.0 kg object subject to a restoring force F is undergoing simple harmonic motion with a small amplitude. The potential energy U of the object as a function of distance x from its equilibrium position is shown above. This particular object has a total energy E of 0.4 J.

(a) What is the object's potential energy when its displacement is +4 cm from its equilibrium position?

U=.5J

(b) What is the farthest the object moves along the x-axis in the positive direction? Explain your reasoning.

The farthest the object moves along the x-axis in the positive direction is 10cm. The object has a total energy of .4J, and therefore the potential energy can never be greater than .4J (at this point, the object is at its maximum displacement from the equilibrium position.)

(c) Determine the object's kinetic energy when its displacement is –7 cm.

$E_{Total} = .4J$

$.4J = U + K$

$.4 = .175 + K$

$K = .225\ J$

@ −7cm
U=.175J

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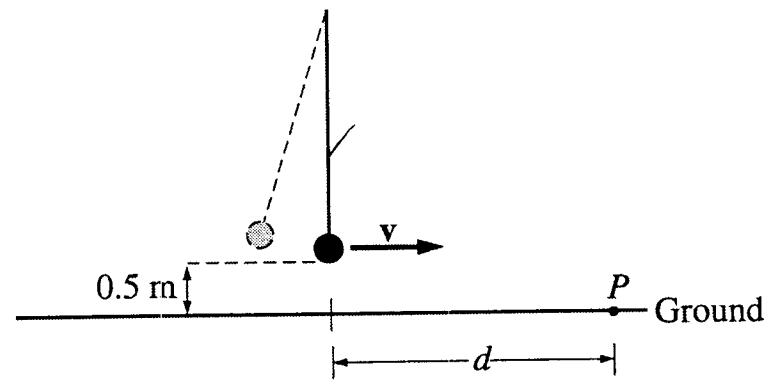
(d) What is the object's speed at $x = 0$?

@ $x = 0$, all energy is kinetic

$KE = \frac{1}{2} m v^2$ $\quad m = 3.0\ kg$

$4\ J = (\frac{1}{2})(3)(v^2)$

$v = .516\ m/s$



Note: Figure not drawn to scale.

(e) Suppose the object undergoes this motion because it is the bob of a simple pendulum as shown above. If the object breaks loose from the string at the instant the pendulum reaches its lowest point and hits the ground at point P shown, what is the horizontal distance d that it travels?

@ lowest point, the velocity = .516 m/s

horiz s = position

Horizon

$s =$

$v = .516\ m/s$

$t = .32s$

Vert

$s = -.5\ m$

$v =$

$v_0 = 0\ m/s$

$a = -9.8\ m/s^2$

$t =$

$s = vt$

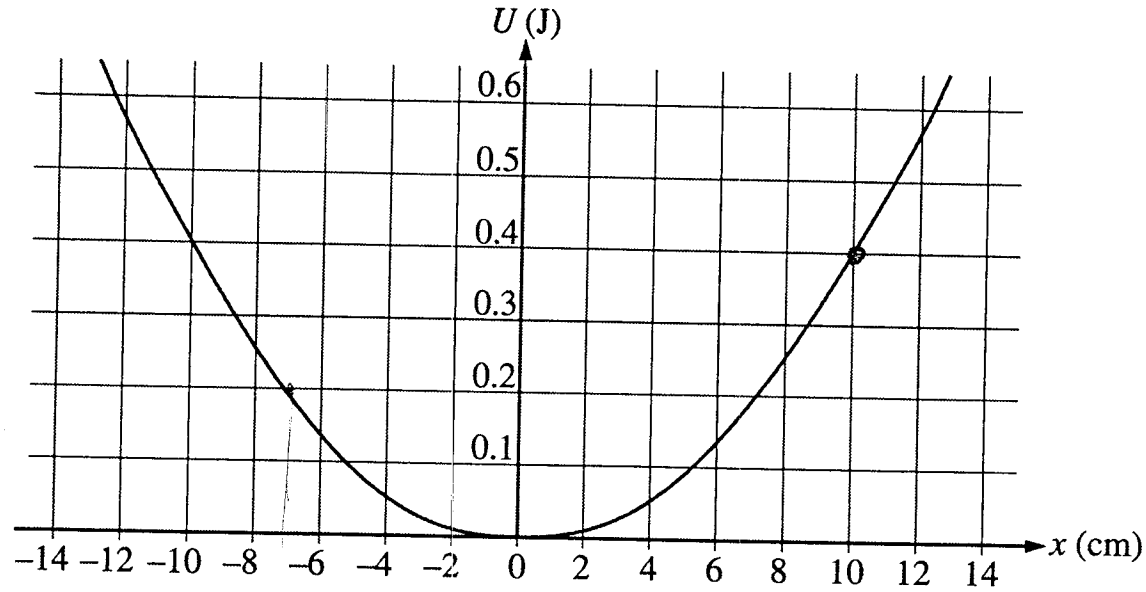
$s = (.516)(.32)$

$s = .165m = d$

$s = v_0 t + \frac{1}{2} a t^2$

$-.5 = 0 + \frac{1}{2}(-9.8)(t^2)$

$t = .32s$



2. (15 points)

A 3.0 kg object subject to a restoring force F is undergoing simple harmonic motion with a small amplitude. The potential energy U of the object as a function of distance x from its equilibrium position is shown above. This particular object has a total energy E of 0.4 J.

(a) What is the object's potential energy when its displacement is +4 cm from its equilibrium position?

$U + K = .4$ J

U @ $x=4 \approx$ .05 J

(b) What is the farthest the object moves along the x-axis in the positive direction? Explain your reasoning.

10 cm ; $U + K = .4$ J

Therefore when $K = 0$; the object is furthest away from equilibrium: $U = .4$ when $x = 10$ cm

(c) Determine the object's kinetic energy when its displacement is –7 cm.

$U + K = .4$ $\quad U \approx .2$ J when $x = -7$

$.2 + K = .4$

$K = .2$ J

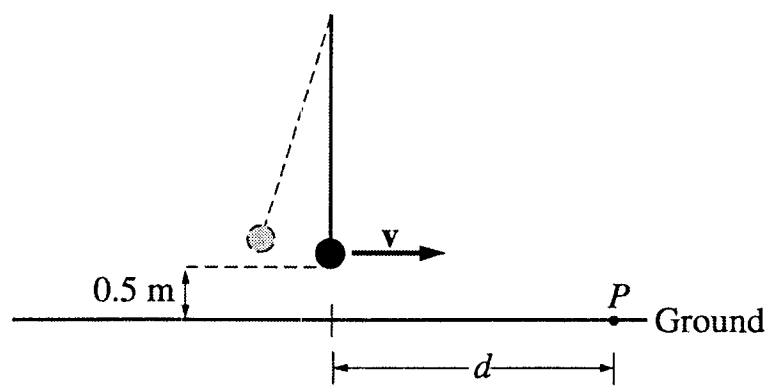
GO ON TO THE NEXT PAGE.

(d) What is the object's speed at $x = 0$?

$.4 = \frac{1}{2}(3)V^2$

$.267 = V^2$

$.516 \text{ m/s} = V$



Note: Figure not drawn to scale.

(e) Suppose the object undergoes this motion because it is the bob of a simple pendulum as shown above. If the object breaks loose from the string at the instant the pendulum reaches its lowest point and hits the ground at point P shown, what is the horizontal distance d that it travels?

X	Y
$V = \frac{s}{t}$	$s(t) = \frac{1}{2}at^2 + v_0t^0 + .5$
$.516 = \frac{s}{.319}$	$0 = -4.9t^2 + .5$
$.516(.319) = s$	$.5 = 4.9t^2$
$.165 \text{ m} = s$	$.102 = t^2$
	$.319 = t$

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