AP® Physics C: Mechanics
2003 Sample Student Responses

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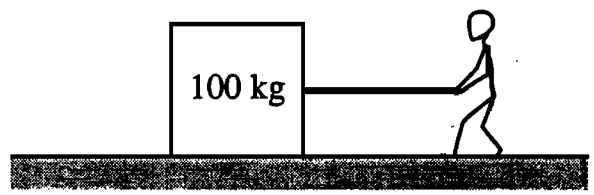
PHYSICS C

Section II, MECHANICS

Time—45 minutes

3 Questions

Directions: Answer all three questions. The suggested time is about 15 minutes for answering each of the questions, which are worth 15 points each. 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.



Mech. 1.

The 100 kg box shown above is being pulled along the x-axis by a student. The box slides across a rough surface, and its position x varies with time t according to the equation $x = 0.5t^3 + 2t$, where x is in meters and t is in seconds.

(a) Determine the speed of the box at time $t = 0$.

$v(t) = \frac{dx}{dt}$

$x = 0.5t^3 + 2t$

$\frac{dx}{dt} = 1.5t^2 + 2$

$v(t) = 1.5t^2 + 2$

$v(0) = 1.5(0)^2 + 2$

$v(0) = 2 m/s$

$v(0) = 2.0 m/s$

(b) Determine the following as functions of time t.

i. The kinetic energy of the box

$m = 100kg$ $K = \frac{1}{2}mv^2$

$v = 1.5t^2 + 2$ $K = \frac{1}{2}(100)(1.5t^2+2)^2$

$K = 50(1.5t^2+2)^2$

ii. The net force acting on the box

$a = \frac{dv}{dt} \Rightarrow 1.5t^2 + 2$

$a = 3t$

$F_{net} = ma$

$F = m(3t)$

$F = (100kg)(3t)$

$F = 300t$

iii. The power being delivered to the box

$P = F \cdot v$

$P = (300t)(1.5t^2+2)\cos(0°)$

$P = (300t)(1.5t^2+2)(1)$

$P = 450t^3 + 600t$

GO ON TO THE NEXT PAGE.

A2

(c) Calculate the net work done on the box in the interval $t = 0$ to $t = 2$ s.

$P = \frac{dW}{dt}$

$450t^3 + 600t = \frac{dW}{dt}$

$\int_0^2 450t^3 + 600t = \int \frac{dW}{dt}$

$450\frac{t^4}{4} + 600\frac{t^2}{2}\Big|_0^2 = W$

$\frac{450}{4}t^4 + 300t^2\Big|_0^2 = W$

$\left(\frac{450}{4}(2)^4 + 300(2)^2\right) - \left(\frac{450}{4}(0)^4 + 300(0)^2\right) = W$

$(1800 + 1200) - 0 = W$

$3000\text{ J} = W$

(d) Indicate below whether the work done on the box by the student in the interval $t = 0$ to $t = 2$ s would be greater than, less than, or equal to the answer in part (c).

✓ Greater than ___ Less than ___ Equal to

Justify your answer.

The student also does work against friction to move the box along the rough surface.

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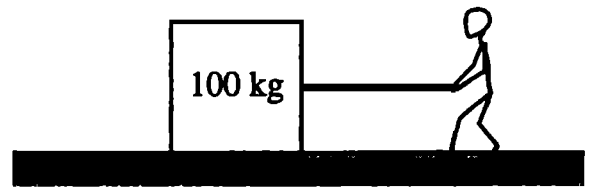

Mech. 1.

The 100 kg box shown above is being pulled along the x-axis by a student. The box slides across a rough surface, and its position x varies with time t according to the equation $x = 0.5t^3 + 2t$, where x is in meters and t is in seconds.

(a) Determine the speed of the box at time $t = 0$.

$v(t) = 1.5t^2 + 2$

$\boxed{v(0) = 2\ m/s}$

(b) Determine the following as functions of time t.

i. The kinetic energy of the box

$\Delta K = \frac{1}{2}mv^2 = \frac{1}{2}(100kg)(1.5t^2+2)$

$= 50kg(1.5t^2+2) = \boxed{(75t^2+100)\ J}$

ii. The net force acting on the box

$F_{net} = ma = m\left(\frac{dv}{dt}\right) = 100kg(3t) = \boxed{(300t)\ N}$

iii. The power being delivered to the box

$P = F \cdot v = 300t(1.5t^2+2)$

$\boxed{P = 450t^3 + 600t}$

GO ON TO THE NEXT PAGE.

(c) Calculate the net work done on the box in the interval $t = 0$ to $t = 2$ s.

$W = Fd = 300t(.5t^3 + 2t)$

$= 150t^4 + 600t^2$

$W_{net} = (150(2^4) + 600(2^2)) - 0$

$\boxed{W_{net} = 4800\ J}$

(d) Indicate below whether the work done on the box by the student in the interval $t = 0$ to $t = 2$ s would be greater than, less than, or equal to the answer in part (c).

√ Greater than ___ Less than ___ Equal to

Justify your answer.

The net work done on the box by the student would be greater than the answer in part (c) due to friction. The answer in part (c) is the net work including friction, which is subtracted from the work done by the student.