



AP[®] Physics C: Mechanics 2002 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.

A crash test car of mass 1,000 kg moving at constant speed of 12 m/s collides completely inelastically with an object of mass M at time $t = 0$. The object was initially at rest. The speed v in m/s of the car-object system after the collision is given as a function of time t in seconds by the expression

$$v = \frac{8}{1 + 5t}$$

(a) Calculate the mass M of the object.

$p_i = p_f$
 $m_i v_i = (m + M) v_f$
 $1000 \text{ kg} (12 \text{ m/s}) = (1000 \text{ kg} + M) 8 \text{ m/s}$
 $M = 500 \text{ kg}$

when $v_f = 0$
 at $t = 0$, v_f will be at the value where conservation of momentum can apply
 $v \text{ at } t = 0 = \frac{8}{1 + 5(0)} = \frac{8}{1} = 8 \text{ m/s}$

(b) Assuming an initial position of $x = 0$, determine an expression for the position of the car-object system after the collision as a function of time t .

$x = \int v$
 $x(t) = \int v(t) dt = \int \frac{8}{1 + 5t} dt = \frac{8 \ln(1 + 5t)}{5} + C$
 $0 = x(0) = \frac{8 \ln(1 + 5(0))}{5} + C = 0 + C = 0$
 $x(t) = \frac{8 \ln(1 + 5t)}{5}$

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- (c) Determine an expression for the resisting force on the car-object system after the collision as a function of time t .

$$\sum F = f = ma$$

$$a = \frac{dv}{dt} = \frac{dv(t)}{dt} = \frac{8(s)}{(1+5t)^2} = \frac{-40}{(1+5t)^2}$$

$$f = ma = 1500\text{kg} \left(\frac{40}{(1+5t)^2} \right) = \boxed{\frac{60000}{(1+5t)^2} \text{ N}}$$

- (d) Determine the impulse delivered to the car-object system from $t = 0$ to $t = 2.0$ s.

$$\begin{aligned} \vec{I} = \Delta p = p_f - p_i &= (m+M)(v_f - v_i) = 1500\text{kg} \left(\frac{8}{(1+5(2))} - \frac{8}{(1+5(0))} \right) = \\ &= 1500\text{kg} \left(\frac{8}{11} - 8 \right) \text{ m/s} = \boxed{-10900 \text{ kg}\cdot\text{m/s}} \end{aligned}$$

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Mech 1.

A crash test car of mass 1,000 kg moving at constant speed of 12 m/s collides completely inelastically with an object of mass M at time $t = 0$. The object was initially at rest. The speed v in m/s of the car-object system after the collision is given as a function of time t in seconds by the expression

$$v = \frac{8}{1 + 5t}$$

(a) Calculate the mass M of the object.

Car
 $m = 1000 \text{ kg}$
 $v_0 = 12 \text{ m/s}$

$$\vec{p}_1 = \vec{p}_2$$

$$mv_0 + 0 = (m + M)v$$

$$mv_0 = m v + M v$$

$$M = \frac{m(v_0 - v)}{v} = \frac{(1000 \text{ kg})(12 - 8) \text{ m/s}}{8 \text{ m/s}} = 500 \text{ kg}$$

$v = \lim_{t \rightarrow \infty} \frac{1}{1 + 5t} = 0$
 $v = 8 \text{ m/s}$

(b) Assuming an initial position of $x = 0$, determine an expression for the position of the car-object system after the collision as a function of time t .

$$x = x_0 + v_0 t + \frac{1}{2} a t^2$$

$$x = v t$$

$$= \frac{8t}{1 + 5t}$$

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(c) Determine an expression for the resisting force on the car-object system after the collision as a function of time t .

$$F = ma$$

$$= m \frac{dv}{dt}$$

$$F = (m+M) \frac{d}{dt} \left(\frac{8}{1+5t} \right)$$

{ 1000+500 }

$$= (m+M) \frac{-40}{(1+5t)^2}$$

$$F = - \frac{60,000}{(1+5t)^2}$$

$$f = 8(1+5t)^{-1}$$

$$f' = -8(1+5t)^{-2}$$

$$\rightarrow \frac{-40}{(1+5t)^2}$$

(d) Determine the impulse delivered to the car-object system from $t = 0$ to $t = 2.0$ s.

$$J = \Delta p = \int F dt$$

$$J = \int_0^2 \frac{-60,000}{(1+5t)^2} dt$$

$$J = -10,909 \text{ N}\cdot\text{s}$$

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