# 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.

$p_0 = p$

$m_1 v_0 = (m+M) v_f$

$1000\text{kg}(12\text{m/s}) = (1000\text{kg} + M)\, 8\text{m/s}$

$M = 500\text{kg}$

~~when $v_f = 0$~~

at $t=0$, $v_f$ will be at the value where conservation of momentum can apply

$v$ 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 $t$.

$x = \int v$

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

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

$x(t) = \frac{8\ln(1+5t)}{5}$

**GO ON TO THE NEXT PAGE.**

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

$$\Sigma F = f = ma$$

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

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

↑ $-60000/(1+5t)^2$

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

$$I = \Delta p = p_f - p_i = (m+M)(v_f - v_i) = 1500\text{kg}\left(8/(1+5(2)) - 8/(1+5(0))\right) =$$

$$1500\text{kg}\left(8/11 - 8\right)\text{m/s} = \boxed{-10900\ \text{kg}\cdot\text{m/s}}$$

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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

$m = 1000\ kg$

$v_0 = 12\ m/s$

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

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

$mv_0 = mv + Mv$

$v = \lim_{t \to \infty} \frac{1}{1+5t}$

$= 8\ m/s$

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

(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 $t$.

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

$x = vt$

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

**GO ON TO THE NEXT PAGE.**

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

$F = ma$

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

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

$\{1000+500\}$

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

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

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

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

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

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

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

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

$J = -10{,}909$ N-s

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