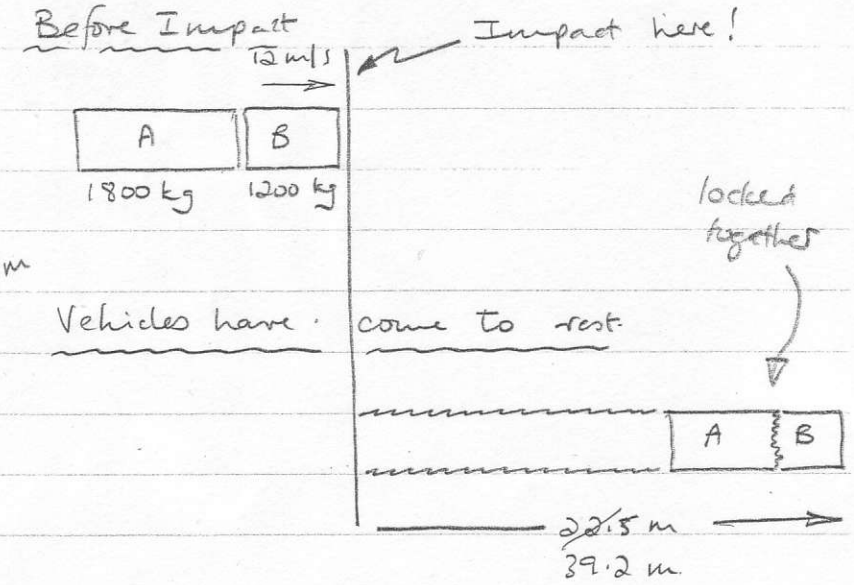
Momentum and Car Crashes



1. Car A crashes into the back of car B, and the two lock together + skid, and come to rest after travelling ~~22.5~~ 39.2 m. The friction force acting on the two skidding vehicles is 9000 N.

a) Calculate the work done by friction in bringing the 2 vehicles to rest (2)

(b) Calculate the speed of the interlocked vehicles just ~~before~~ after impact (2)

(c) Calculate the velocity of vehicle A just before impact (3)
(lay out your answer carefully!)

(d) What is the loss in k.E. of the 2 cars during impact, and where does the "lost" energy go? (3)

(e) Where does the k.E. of the cars go after impact (2)

(f) The drivers each have the same mass, State and explain which driver experiences the higher force during impact. (3)

(g) What is the acceleration of the locked vehicles after impact.? (2)

(h) Sketch graphs of velocity against time and of distance against time of the interlocked vehicles, from the time of impact until coming to rest. (6) (9)

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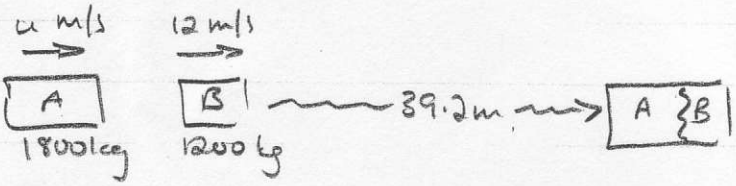
TLN 08.03 ✡ correction - skid distance is 39.2 m

Momentum & Car Crashes — Answers — A2 Physics

(a) work done by friction = $F_f s$ ① = $9000 \times 39.2 = 3.53 \times 10^5$ J ① /2



(b) KE of locked cars after crash = work done by friction .... so $\frac{1}{2}mv^2 = F_f s$ ①

$\frac{1}{2}(1800+1200)v^2 = 9000 \times 39.2$ ⇒ v after crash = 15.3 m/s ① /2

c) Momentum of the system of cars stays constant

so ... $p_A + p_B = p_{A+B}$ ① ... so $(1800 \times u) + (1200 \times 12) = 3000 \times 15.3$ ①

so u_A before impact = $(45,900 - 14,400)/1800$ = 17.5 m/s ① /3

d) KE loss = [KE before] − KE just after

$= \left[\left(\frac{1}{2} \times 1800 \times 17.5^2\right) + \left(\frac{1}{2} \times 1200 \times 12^2\right)\right] - \left(\frac{1}{2} \times 3000 \times 15.3^2\right)$ ①

$= [2.76 \times 10^5 + 8.64 \times 10^4] -$

$= 3.62 \times 10^5 - 3.51 \times 10^5 = 1.09 \times 10^4$ ① J energy lost

This "lost" energy is transferred to heat (mostly) in crumpled steel, ... + a teensy bit of sound + maybe light (sparks) /3

e) KE transferred ("lost") to heat ① in tyres ① + road (skid marks) /2

f) Driver A $\Delta v = 15.3 - 17.5 = -2.2$ m/s (retarded) Driver B $\Delta v = 15.3 - 12 = 3.3$ m/s ① (accelerated)

Driver B experiences bigger Δv in same time as driver A

Since $Ft = m\Delta v$ ① (Thank you Sir Isaac), driver B ① experiences higher force /3

g) Use $a = F/m$ ① $= 9000/3000 = 3\ ms^{-2}$ ① /2

h) Find time to come to rest

use $v = u + at$ ①

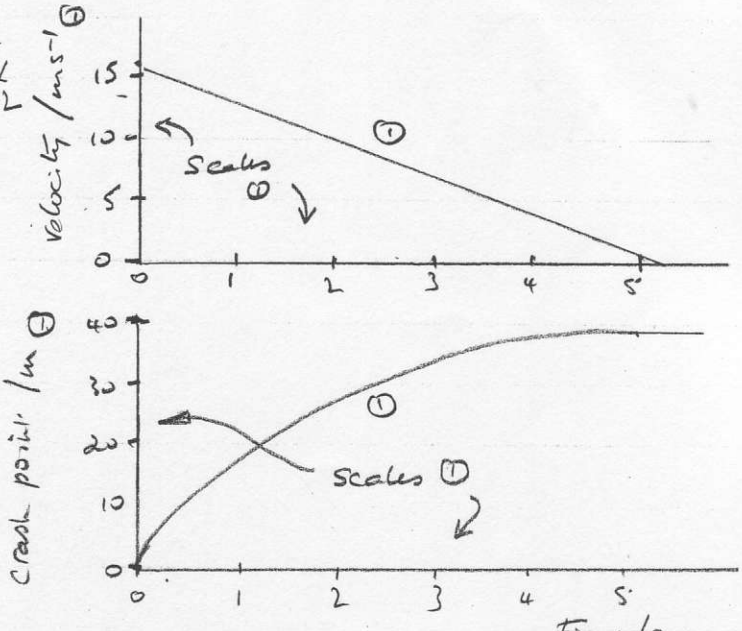
so $t = (v-u)/a$

$= 0 - 15.3/-3.0 = 5.1$ s. ①

Score... axes 3

scales 2

graphs 2 /9



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