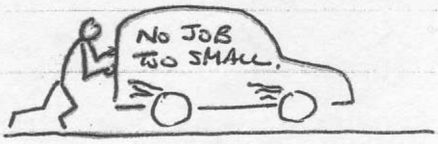
Problems on Momentum

A Physics
Momentum

All these little problems can be solved using Isaac Newtons great momentum equation $F = \text{rate of change of momentum} = \frac{mv - mu}{t}$.

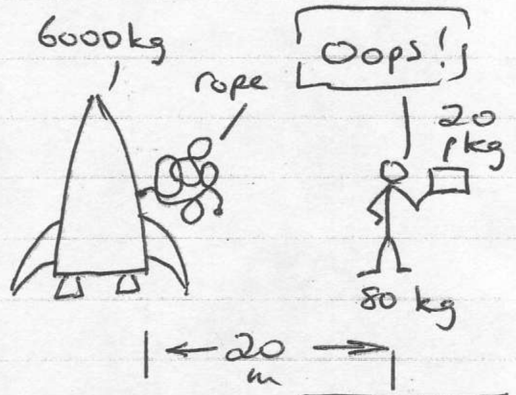
1. **Man and Van**



The driver pushes his broken van, mass 700 kg, with the brakes off (ie. no friction)
He pushes... with a 100 N force for 20 s
with a 60 N force for another 10 s.

(a) Sketch a graph of force vs. time. ← axes, labels + simple scales!
(b) Calculate the final velocity of the van
Harder (c) Sketch a graph of velocity vs. time.

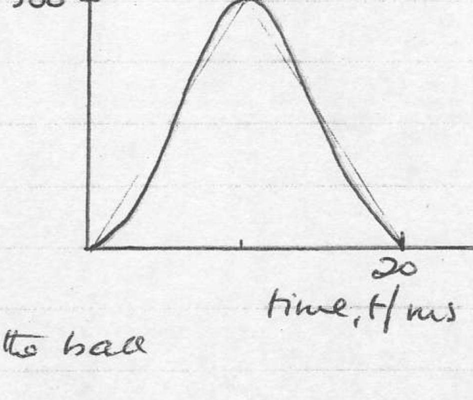
2. **Fred the Forgetful Astronaut** is 20 m from his space ship when he discovers he has not tied himself to the rope. He estimates he can throw the toolbox with a velocity of 2 m/s. Everything is initially stationary in space.*



* why is this statement technically meaningless?

(a) Explain how Fred can get back to the ship
(b) Calculate his maximum velocity
(c) Calculate his time to return to the space ship.
(d) Fred hits the ship (good aim!). Calculate the resulting velocity of astronaut + ship.

3. The graph shows how the force on a tennis ball, mass 80g, varies during the serve.



(a) Estimate the area under the graph.
(b) Calculate the speed of the ball off the racket. Why is this only an estimate?
(c) What is the maximum acceleration of the ball and when does this occur?

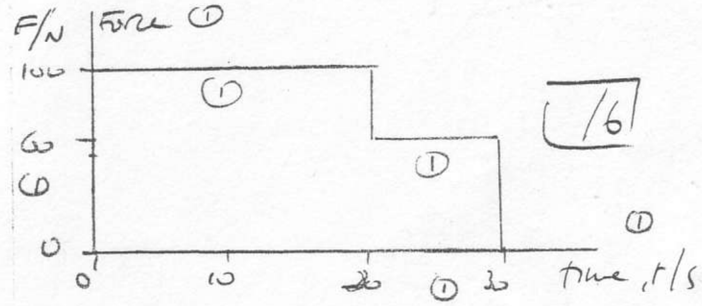
Thx .98.

Momentum Problems — ANSWERS

A Physics
Momentum

1. Man + van

(a)



/6

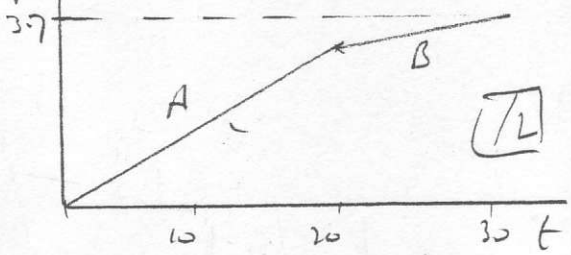
(b) $Ft = mv - mu = \Delta p$

Area under graph (1) $= (100 \times 20) + (60 \times 10)$

$= 2000 + 600$

$= mv$ (1)

So $v = 2600/700 = 3.7$ m/s /2



/2

(c) A – larger F ∴ larger a

B – smaller F ... etc.

2. (a) Throw toolbox away from ship, he recoils towards ship /(1)

(b) p (fred + tools system) = 0 so $m_F v_F + m_T v_T = 0$ (1)

so $v_F = (20 \times 2)/80 = \underline{0.5 \text{ m/s}}$ /2

(c) $s = vt \rightarrow t = s/v = 20/0.5 = 40$ s. /2

(d) $p_F + p_{ship} = p_{F+ship}$ (1)

$(80 \times 0.5) + 0 = 6080 \times v_{F+S}$ (1)

so v (fred + ship) $= 40/6080 = \underline{6.6 \times 10^{-3}}$ (1) m/s /3

$\boxed{3}$ (a) area ≈ ½ base × height (1) (approx triangle)

$= \frac{1}{2} \times 20 \times 10^{-3}$ (1) $\times 300 = 3$ (1) Ns /3

(b) Impulse, Ft = change in momentum = area under graph (1)

so $3 = mv - \underbrace{mu}_{=0}$ (1)

so velocity $v = 3/80 \times 10^{-3} = \underline{37.5}$ (1) m/s (≈ 90 mph) /3

(c) a_{max} occurs at F_{max} at time $t = 10$ ms (1)

$a_{max} = F_{max}/m$ (1) $= 300/80 \times 10^{-3} = 3750$ (1) m/s² /3

Q.1 /10   Q.2 /8   Q.3 /9

TLN
1.98