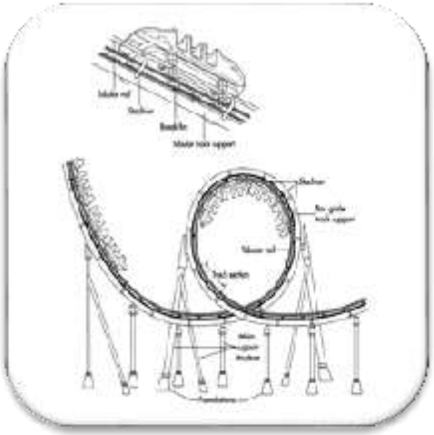
# A2 Physics Unit 4
# 1 Forces & Momentum


## KS5 AS PHYSICS 2450

Mr D Powell

# Chapter Map

## 1.1 Momentum and impulse

**Specification link-up 3.4.1: Momentum concepts**

How do we calculate momentum?

What is the connection between Newton's first and second laws of motion and momentum?

What is an impulse, and how is it calculated from a force v. time graph?

## 1.2 Impact forces

**Specification link-up 3.4.1: Momentum concepts**

What happens to the impact force (and why?) if the duration of impact is reduced?

How do we calculate $\Delta(mv)$ for a moving object which stops or reverses?

What happens to the momentum of a ball when it bounces off a wall?

## 1.3 Conservation of momentum

**Specification link-up 3.4.1: Momentum concepts**

Is momentum ever lost in a collision?

What do we mean by *conservation of momentum*?

What condition must be satisfied if the momentum of a system is conserved?

## 1.4 Elastic and inelastic collisions

**Specification link-up 3.4.1: Momentum concepts**

What is the difference between an elastic collision and an inelastic collision?

What is conserved in a perfectly elastic collision?

Are any real collisions ever perfectly elastic?

## 1.5 Explosions

**Specification link-up 3.4.1: Momentum concepts**

What energy changes takes place in an explosion?

What can we always say about the total momentum of a system that has exploded?

What are the consequences when, after the explosion, only two bodies move apart?

# 1.1 Momentum & Impulse

How do we calculate momentum?

What is the connection between Newton's first and second laws of motion and momentum?

Derive the impulse formulae by combining Newton's first and second laws.

What is an impulse, and how is it calculated from a force v. time graph?

Use the idea of Impulse $F = m\Delta v/t$ to predict graphs of $m\Delta v$ for various situations.

# Investigating Simple Concepts of Momentum

**Aims**

1. Simply explore ideas of p
2. Be able to explain how velocity and mass have an effect on p
3. Derive the impulse formulae by combining Newton's first and second laws.
4. Use the idea of Impulse $F = m\Delta v/t$ to predict graphs of $m\Delta v$

**Method**

1. Take several coins or objects of similar mass and size and some of different size and mass.

2. Think about a series of collisions which might assist you in thinking about p and also Ft. Sketch them out and detail all the quantities that you feel are poignant. Conduct the collisions and write out a conclusion which includes a predicted Ft graph.

# Tasks to Complete

Aims

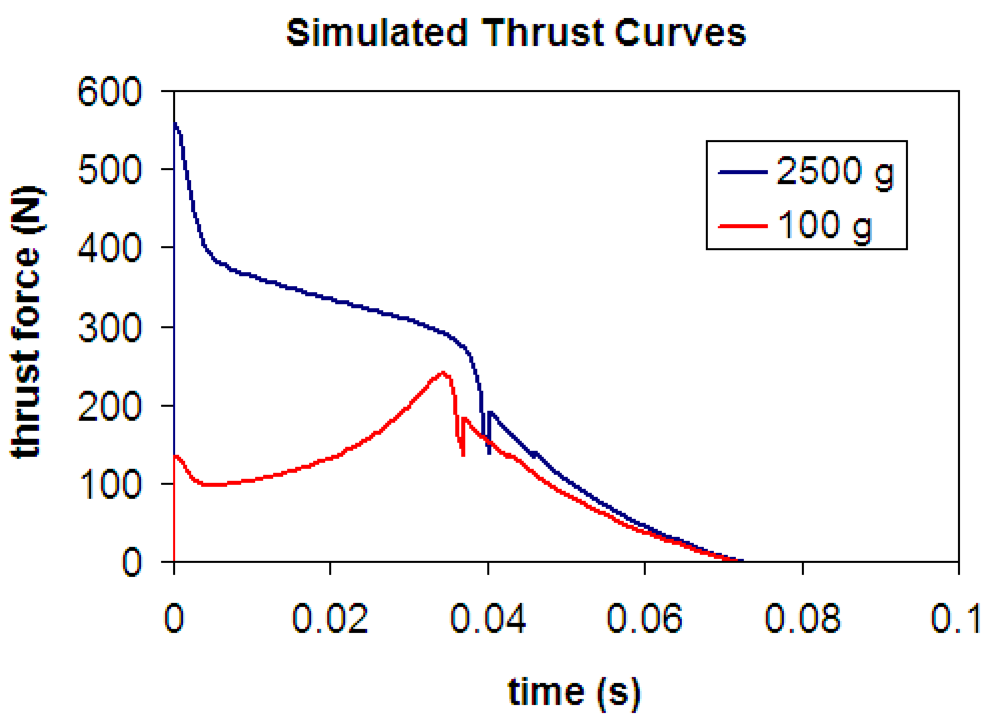
- Simply explore ideas of p
- Be able to explain how velocity and mass have an effect on p
- Derive the impulse formulae by combining Newton's first and second laws.
- Use the idea of Impulse $F = m\Delta v/t$ to predict graphs of $m\Delta v$

1) Complete a set of summary notes on the topic as shown in the book pages 4-7. Include definitions of laws and diagrams. Also include some simple examples i.e. Ft graphs which build up to a more complex idea. (20 mins)

2) Complete each summary question by copying it out neatly, define all quantities, define any units & formulae, clear answer. (25mins)

3) Submit questions and notes for inspection by Thursday PM with write up from experiment all as one piece of work.

# Force – Time Graphs



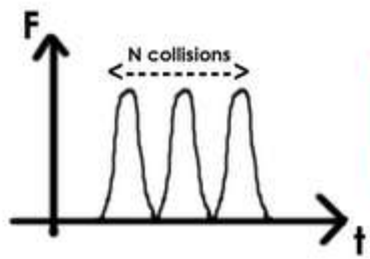

$$F = \frac{dp}{dt}$$

$$\int F\,dt = \int dp$$ << separable variable!

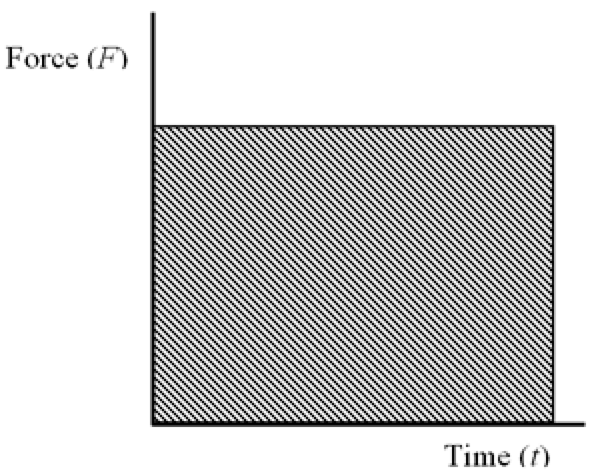
Hence

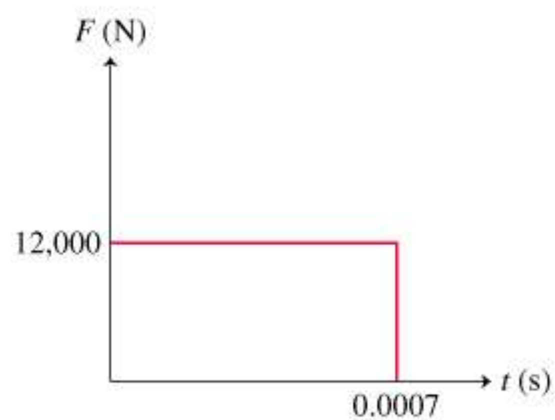
$$p = \int F\,dt$$

a.k.a area under F-t graph




$$\langle F \rangle = \Delta p \times \frac{N}{\Delta t}$$

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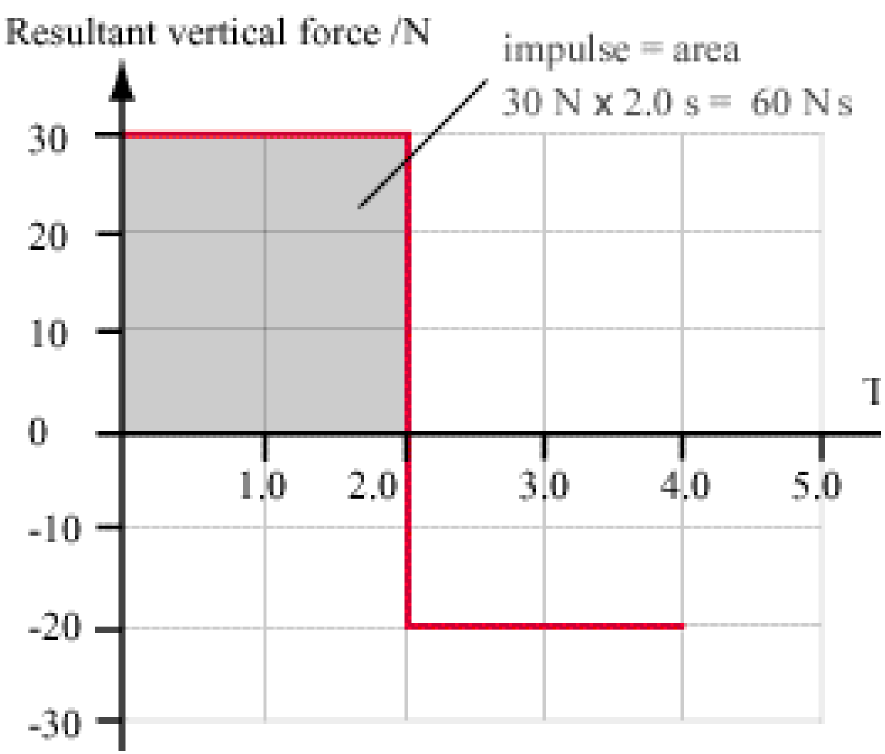
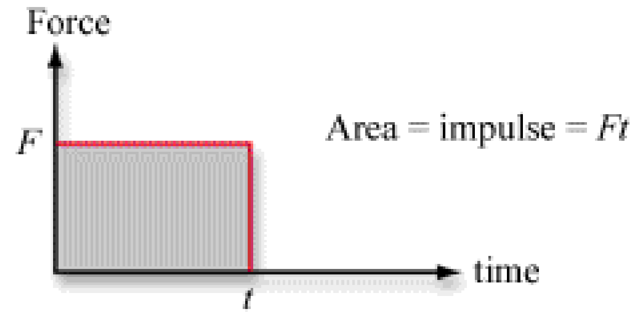
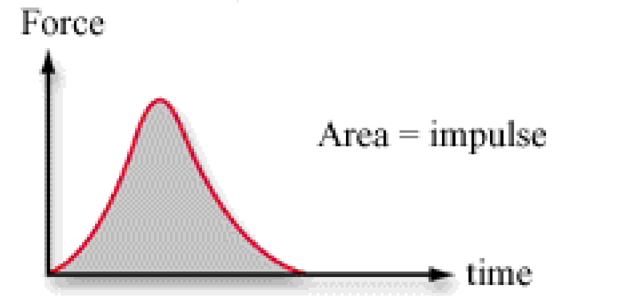
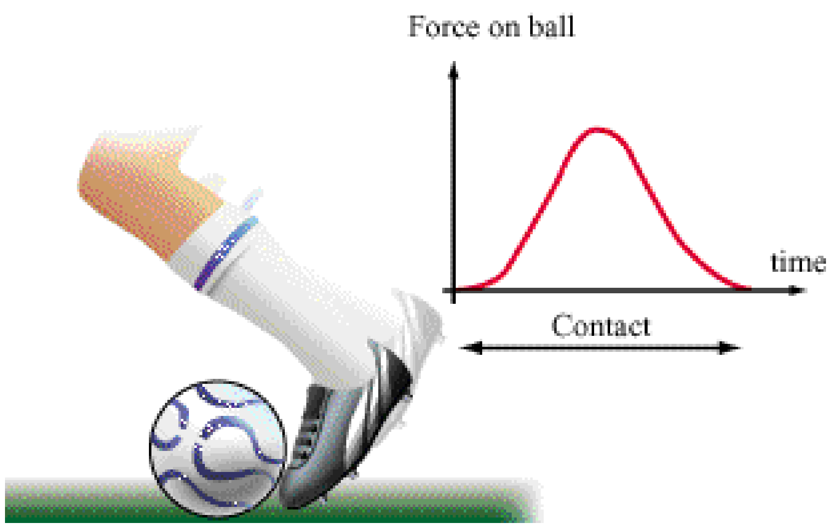
# More Examples...



# Momentum 1.1

1) a

I) $4 \times 10^{-25} kg \times 3 \times 10^{6} ms^{-1} = 12 \times 10^{-18} kgms^{-1}$

II) $4.2 \times 10^{-4} kg \times 120 ms^{-1} = 0.05 kgms^{-1}$

III) $0.56 kg \times 25 ms^{-1} = 14 kgms^{-1}$

b)

I) $\frac{mv}{v} = \frac{96 kgms^{-1}}{16 ms^{-1}} = 6 kg$

II) $\frac{mv}{m} = \frac{128 kgms^{-1}}{6.4 kg} = 20 ms^{-1}$

2) $m = 24{,}000 kg$ $F = -6000$

$u = 15 ms^{-1}$

$v = 0$

a) momentum $p = mu$

$p = 24{,}000 kg \times 15 ms^{-1}$

$= 3.6 \times 10^{5} kgms^{-1}$

b) $Ft = mv - mu$ $(v = 0)$

$Ft = -mu$

$t = \frac{-mu}{F}$

$= \frac{-3.6 \times 10^{5} kgms^{-1}}{-6000 N}$

$= 60 s$

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3) a)

m = 45,000kg

u = 0

v = 120 ms$^{-1}$

F = 120 × 10$^3$ N

p = mv

= 45,000 kg × 120 ms$^{-1}$

= 5.4 × 10$^6$ kg ms$^{-1}$

b) Ft = mv − mu (u = 0)

$t = \frac{mv}{F}$

$t = \frac{5.4 \times 10^6 \text{ kgms}^{-1}}{120 \times 10^3 \text{ N}}$

t = 45 s

4)

m = 600kg  t = 20s

u = 15 ms$^{-1}$  F = 400N

v =

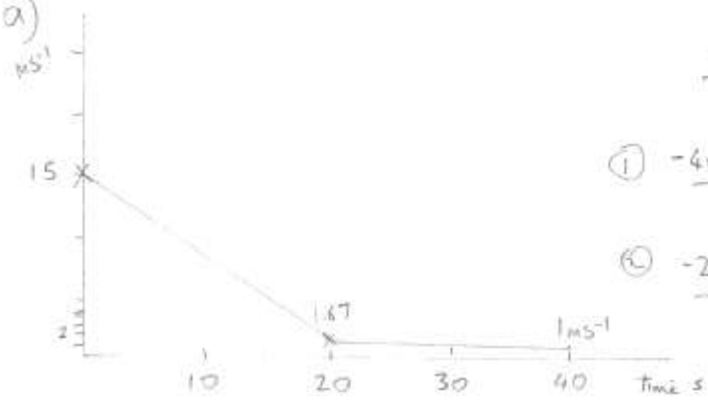
2nd part

F = 20N  u =

t = 20s  v =

mass = 600kg

a)



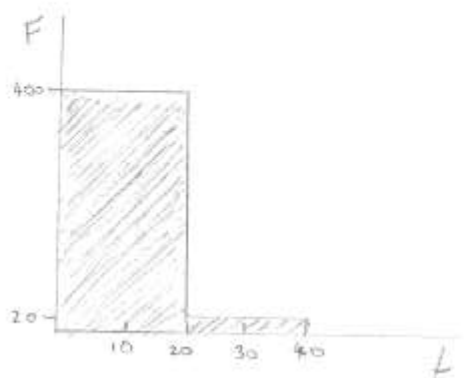

Ft = mv − mu

$\frac{Ft + mu}{m} = v$

① $\frac{-400 \times 20 + 600 \times 15}{600} = 1.67 \text{ ms}^{-1}$

② $\frac{-20 \times 20 + 600 \times 1.666}{600} = 1 \text{ ms}^{-1}$

a) see above vt graph & ⟶




i) p = 600kg × 15ms$^{-1}$ = 9000 kgms$^{-1}$

ii) $\Delta mv = F_1 t_1 + F_2(t_2 - t_1)$

= 400N × 20s + 20N × 20s

= −8400 kgms$^{-1}$ (negative as v is reducing)

III) see calc next to a) & v-t graph two stages