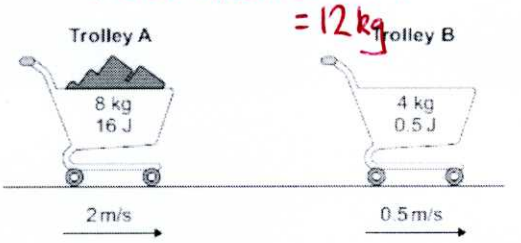
Multi-Step Calculations for Paper 2

Some of these questions are challenging and are designed to make you really think.

Gravitational field strength = 9.8 N/kg

1 Use the data provided in the diagram to calculate the resultant velocity of the trolleys after they collide and stick together.

total mass = 8+4 = 12kg



a) If they are both initially moving as in the diagram.

initial p = mv = (8×2) + (4×0.5) = 18 kgm/s

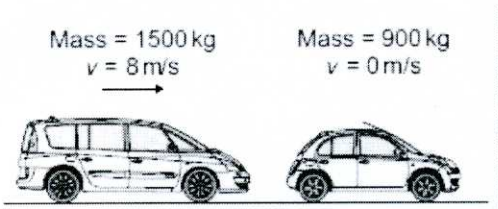
final p = 18 kgm/s = mv = 12kg × v ∴ v = 18/12 = 1.5m/s

b) If the velocity of Trolley B is reversed to be -0.5 m/s

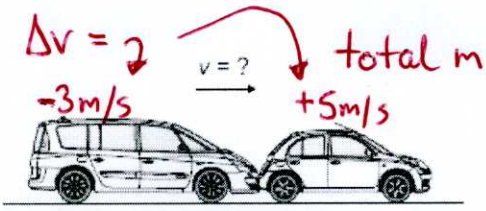
initial p = (8×2) + (4×-0.5) = 14 kgm/s

final p = 14 kgm/s = mv ∴ v = 14/12 = 1.17 m/s

2 The diagram shows two cars, just before and just after a collision.



Before collision



After collision

total m = 1500+900 = 2400 kg

a) Calculate the velocity of the two joined cars immediately after the collision.

Initial p = mv = 1500 × 8 = 12000 kgm/s = final p

v = p/m = 12000/2400 = 5m/s

b) The impact lasted for 0.02s. Calculate the magnitude of the forces involved the collision.

F = mΔv/Δt = 1500 × 3/0.02 = 225000 N

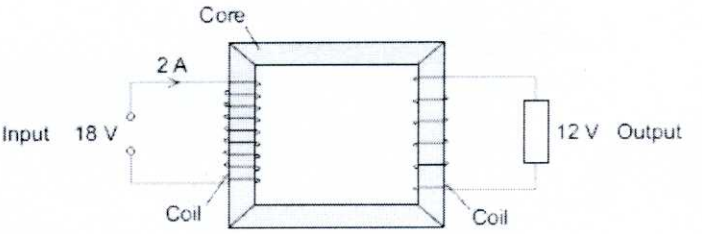
or for second car 900 × 5/0.02 = 225000 N

c) Calculate the acceleration experienced by each of the cars during the collision.

i) The larger car a = F/m = 225000/1500 = 150 m/s²

ii) The smaller car a = F/m = 225000/900 = 250 m/s²

3 a) The primary coil of the transformer contains 1200 turns. Calculate the number of turns in the secondary coil.



$V_p/V_s = n_p/n_s$

$18/12 = 1200/n_s$

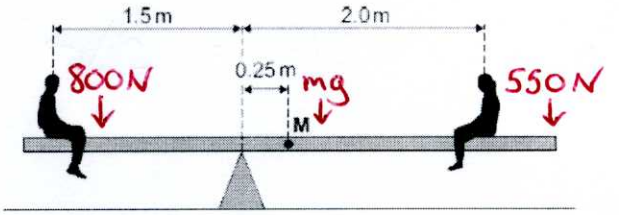
$\therefore n_s = 1200 \times 12/18 = 800$ turns

b) The current in the secondary coil was measured to be 2.8 A
Calculate the efficiency of the transformer.

$P = VI$ $\quad P_{IN} = 18 \times 2 = 36W$ $\quad P_{OUT} = 12 \times 2.8 = 33.6$

$Eff = OUT/IN = 33.6/36 = 0.93$

4 Two students sit on a see saw. One sits 1.5m from the pivot with a weight of 800 N and the other 2.0 m from the pivot with a weight of 550 N. To make the see saw balance a bag of sand is placed at point M. Calculate the mass of the bag of sand.



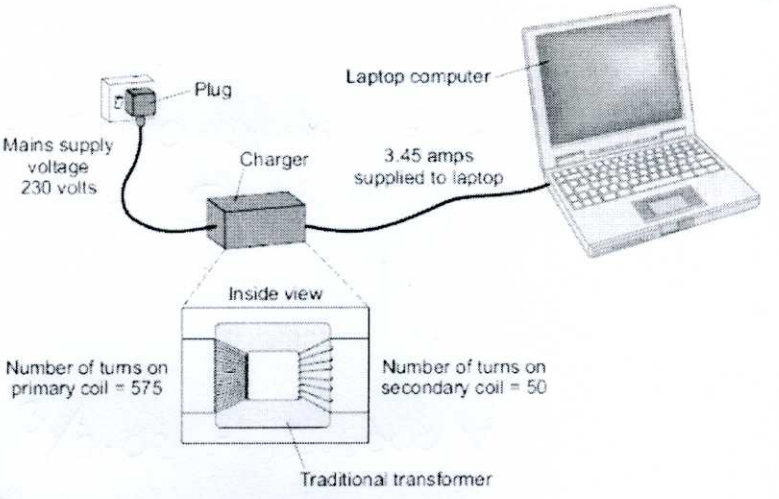
$M = Fd$

$1.5 \times 800 = 0.25\,mg + 2 \times 550$

$1200 = 0.25\,mg + 1100$ $\quad m = W/g$

$0.25\,mg = 100 \quad \therefore mg = 100/0.25 = 400N \quad \therefore m = \frac{400}{9.8} = 40.8\,kg$

5 a) Calculate the voltage across the secondary coil of the transformer.



$V_p/V_s = n_p/n_s$

$V_s = V_p\, n_s/n_p$

$= 230 \times 50/575$

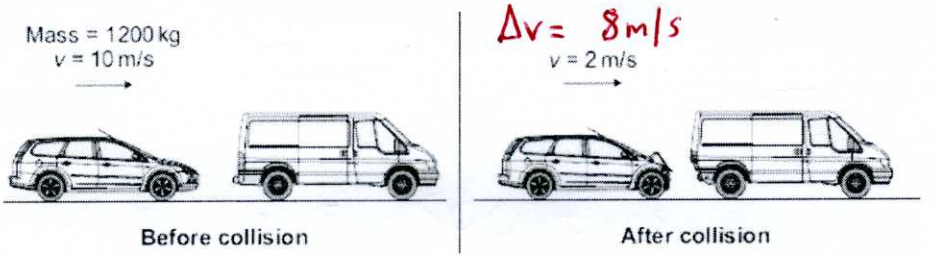
$= 20V$

b) Calculate the current in the primary coil.

$V_p I_p = V_s I_s \quad \therefore \quad 230 \times I_p = 20 \times 3.45$

$I_p = 20 \times 3.45/230 = 0.3\,A$

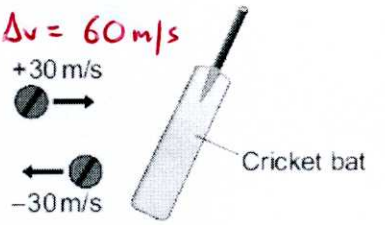
6 The diagram shows a car and a van, just before and just after a collision. The force of the impact was estimated to be 500 kN from the damage caused to the car. Calculate the duration of the impact.



$F = \frac{m\Delta v}{\Delta t} = \frac{1200 \times 8}{\Delta t} = 500\,000\ N$

$\therefore \Delta t = \frac{1200 \times 8}{500000} = 0.0192\ s$

7 The cricket ball in the diagram has a mass of 0.16 kg and is in contact with the ball for 0.0012 s. Calculate the magnitude of the force of the bat and ball on each other during the impact.

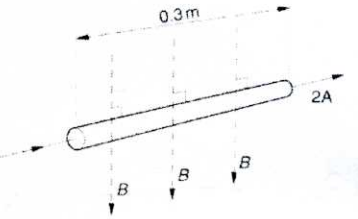


$F = m\Delta v/\Delta t$

$= 0.16 \times 60/0.0012$

$= 8000\ N$

8 A wire of length 0.3m carries a current of 2A. It is placed in a magnetic field which is uniform over the length of the wire. The force on the length of wire is 0.05 N. Calculate the magnetic flux density B.



$F = BIL \therefore B = F/IL = 0.05/2 \times 0.3 = 0.083\ T$

9 A rocket sits on its the launch pad. It contains a fuel tank filled with fuel of density of 670 kg/m^3 The pressure at the bottom of the tank is 25kPa. Calculate height of the fuel tank.

$p = h\rho g \therefore h = P/\rho g = 25000/670 \times 9.8$

$= 3.81\ m$

10 An earthquake was detected by a seismometer. The P-waves were found to have a period of 0.5s and a wavelength 2.5km. The S-waves were found to have a period of 2s and a wavelength of 6km. The P-waves arrived 40s before the S-waves. Calculate the distance to the Earthquake.

For P $f = 1/T = 1/0.5 = 2\ Hz$, For S $f = 1/T = 1/2 = 0.5\ Hz$

For P $v = f\lambda = 2 \times 2.5 = 5\ km/s$, For S $v = f\lambda = 0.5 \times 6 = 3\ km/s$

So P are 2km/s faster. To arrive 40s ahead then

$s = vt = 2\ km/s \times 40s = 80\ km$