8 Newton's Laws of Motion

8.1 Force and Acceleration

1. a) $a = \frac{v-u}{t} = 0.24 ms^{-2}$

b) $F = ma$
$= 800 \times 0.24 = 190N$

c) weight $= mg$
$= 800 \times 9.8 = 7840N$ Ratio $= \frac{190}{7840} =$
$= 0.024$

2. a) $a = \frac{v-u}{t} = \frac{-60}{25} = 2.4 ms^{-2}$

b) $F = ma = 5000 \times 2.4 = 12,000N$

3. a) $F = m\left(\frac{v-u}{t}\right) = 1200 \times \left(\frac{6-0}{20}\right) = 360N$

b) $a = \frac{F}{m} = \frac{360}{(1200+200)} = 0.257 ms^{-2}$

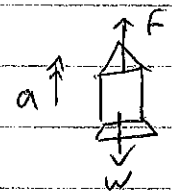
$a = \frac{v-u}{t} \rightarrow t = \frac{v-u}{a} = \frac{6-0}{0.257} = 23.3$ seconds

4. a) $a = ?$ $u = 120$ $v = 0$ $s = 0.055m$

$v^2 = u^2 + 2as \rightarrow a = \frac{u^2}{2s} = \frac{120^2}{(2 \times 0.055)} = 130,909 ms^{-2}$

b) $F = ma = 0.002 \times 130,909$
$= 262N$

8.2 Using $F = ma$



1. a) $W = mg = 550 \times 9.81 = 5396N$

b) $F = ma = 550 \times 4.2 = 2310$
Total thrust $= W + F = 5396 + 2310 = 7706N$

2. a) from trailer point of view:
$F = ma = m\left(\frac{v-u}{t}\right) = 400 \times \left(\frac{9}{60}\right)$
$= 60N$

b) $F = (1400+400) \times \left(\frac{9}{60}\right)$
$= 270N$

8.2 Cont'd...

3. a) Stationary, $T = Mg = 1200 \times 9.81 = 11,800N$

b) $T = Mg = 11,800N$ → stationary and constant speed, No resultant force

c)

$T - Mg = Ma$

$T = Ma + Mg = (1200 \times 0.4) + (1200 \times 9.81)$

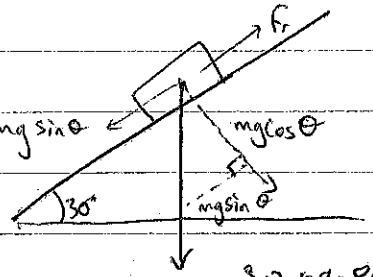
$= 12,300N$

[same situation]

d) $T - mg = ma$ → $T = mg + ma$

$= (1200 \times 9.81) + (1200 \times 0.6) = 12,300N$

4.



$mg = 3.2 \times 9.81$

$= 31.4N$

a) $s = ut + \frac{1}{2}at^2$

$a = \frac{2s}{t^2} = \frac{2 \times 2}{2^2} = 1 ms^{-2}$

b) Equating forces parallel to slope

$Mg \sin 30° - Ma = F_R$

$15.7 - (1 \times 3.2) = F$

Frictional force $= 12.5N$

8.3 Terminal Speed

1. a) (i) $v = \frac{s}{t} = \frac{0.2}{0.5} = 0.04 ms^{-1}$

ii) $F_g = Mg = 0.15 \times 9.8$

$= 1.47N$

b) Smaller surface area means it experiences less drag, so ~~if it has the same mass~~ it will fall faster.

2. Less air resistance / drag due to reduced surface area, meaning a higher speed.

3. a) $a = \frac{F}{M} = \frac{4400}{32000} = 0.138 ms^{-2}$

b) $u = 0$, $v = 12$, $a = 0.138$, $s = ?$

$v^2 = u^2 + 2as$ → $s = \frac{v^2}{2a}$, $s = \frac{12^2}{(2 \times 0.138)} = 522m$

4. Downhill, vehicle has a component of its weight acting in the same direction as travel, increasing the resultant force and a

8.4 On the road

1. a) i) $s = vt = 18 \times 0.4 = 7.2m$

ii) $v^2 = u^2 + 2as$ (0, 18, -4.8)

$\frac{-u^2}{2a} = s \rightarrow s = \frac{-18^2}{(2 \times -4.8)} = 33.7m$

b) Total stopping distance = 7.2 + 33.7 = 40.9m

Pedestrian is 45m away, so 45 - 40.9 = 4.1m

2. a) $u = 18$ $v = 0$, $s = 24$, $a = ?$

$v^2 = u^2 + 2as \rightarrow a = -u^2/2s = \frac{-18^2}{(2 \times 24)} = 6.75m$

b) $F = ma = 1000 \times 6.75 = 6750N$

3. a) Braking distance is the distance covered by a vehicle in the time taken to stop it

b) Brakes applied → leads to a resultant force on the car in the opposite direction to travel, meaning a deceleration ($-F = m \times (-a)$)

4. a) $F_f = 0.6 \times mg$

$= 0.6 \times (1200 \times 9.8)$

$= 7063.2N$

$a = F/m$

$= 7063.2 / 1200$

$= 5.9 ms^{-2}$

b) $s = u^2/2a = \frac{30^2}{(2 \times 5.9)} = 76.3m$

8.5 Vehicle Safety

1. a) $a = \frac{v-u}{t} = \frac{19-15}{0.2} = 20 ms^{-2}$ or $2g$

b) $F = ma = 1200 \times 20 = 24,000N$

2. a) $u = 20$, $v = 0$, $s = 0.8$, $t = ?$ $s = \frac{1}{2}(u+v)t$

b) $a = \frac{v-u}{t} = \frac{20}{0.08} = 250 ms^{-1}$ $\hookrightarrow t = \frac{2s}{(u+v)} = \frac{(2 \times 0.8)}{(20+0)} = 0.08s$

$F = ma = 1500 \times 250 = 375000N$

3. a) $a = \frac{v-u}{t} = \frac{3-0}{0.4} = 7.5 ms^{-2}$

b) $F = ma = 900 \times 7.5 = 6750N$

4. a) $v^2 = u^2 + 2as \rightarrow a = \frac{-u^2}{2s}$

$s = \frac{-25^2}{2 \times (4.5) + 0.5} = 62.5 \sim 6.4g$

b) $F = ma$

$= 68 \times 62.5$

$= 4250N$