Introduction to Mechanics (0J2)
Example Sheet 3 – solutions

1. (i) From A to B $s = 320$, $t = 80$, $u = 0$ so using $s = ut + \frac{1}{2}at^2$

$$320 = 0 \times 80 + \frac{1}{2}\,a(80)^2$$

Hence

$$a = \frac{640}{80^2} = 0.1\text{m s}^{-2} \qquad \text{(2 marks)}$$

(ii) Using $v = u + at$ gives $v = 0 + 0.1 \times 80 = 8$ ms^{-1}. (1 mark)

(iii) If the mass is 450 kg and the acceleration is 0.1 ms^{-2} then the total force must be $F = ma = 450 \times 0.1 = 45$ newtons. If the lift force is L newtons then the total force is $L - mg$ so

$$45 = L - 450 \times 9.81 = L - 4414.5$$

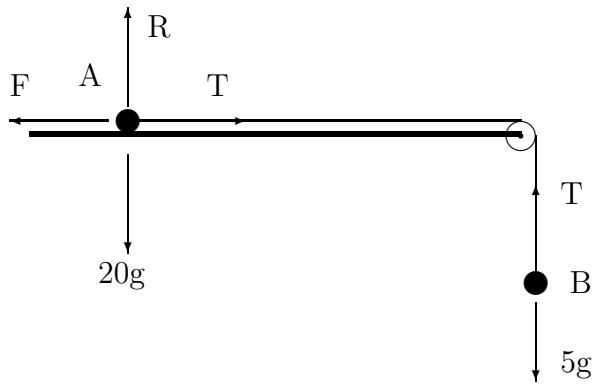
Therefore $L = 4459.5$ N. (3 marks)

(iv) From B to C there is no acceleration so the total force must be zero.

$\therefore \quad 0 = L - 4414.5 \quad \Rightarrow \quad L = 4414.5\text{N}$ (2 marks)

(v) Work done by this lift force is $W = L \times$ distance
$= 4414.5 \times 80 = 353,160$ J $= 353.16$kJ. (2 marks)

2. Drawing in the forces with normal reaction R, friction F and tension T gives



(a) No motion of A in the vertical direction, so total force is zero and resolving vertically for A: $R = 20g = 196.2$ newtons.

Coefficient of friction is 0.15 so $F = 0.15 \times 20g = 3g = 29.43$ newtons.
(3 marks)

(b) Let the acceleration be a. Total horizontal force on A is $T - F$.
Using Newton's 2nd law gives $T - F = 20a$ so

$$T - 3g = 20a. \qquad (1)$$

Using Newton's 2nd law for B gives

$$5g - T = 5a. \qquad (2)$$

(1) + (2) gives $5g - 3g = 25a$ so $a = 0.08g$.
Using $g = 9.81$, $a = 0.7848$ ms^{-2}. (4 marks)

(c) From (1) $T = 3g + 20a = 3g + 1.6g = 4.6g = 45.13$ N. (1 mark)

(d) Using $s = ut + \frac{1}{2}at^2$ gives $s = 0 + \frac{1}{2}0.7848(9) = 3.53$ m. (2 marks)

3. (a) $u_1 = 6$, $u_2 = 0$, $v_1 = 0$, v_2 unknown. Conservation of momentum gives

$$2 \times 6 + 0 \;=\; 0 + 3 \times v_2 \quad \Rightarrow \quad v_2 \;=\; 4 \text{ ms}^{-1} \qquad \text{(2 marks)}$$

(b) $u_1 = 6$, $u_2 = 0$, $v_1 = -v$, $v_2 = 4v$. Conservation of momentum gives

$$2 \times 6 + 0 \;=\; 2 \times (-v) + 3 \times (4v)$$

$$\Rightarrow \quad 10v \;=\; 12 \quad \Rightarrow \quad v \;=\; 1.2\text{ms}^{-1} \qquad \text{(3 marks)}$$

(c) $(v_2 - v_1) \;=\; -e(u_2 - u_1)$, where e is the coefficient of restitution

$$\therefore \quad 4v - (-v) \;=\; -e(0 - 6) \quad \Rightarrow \quad e \;=\; \frac{5v}{6} \;=\; 1 \qquad \text{(2 marks)}$$

$$\text{KE before} \;=\; \frac{1}{2} \times 2 \times 6^2 + 0 \;=\; 36 \text{ joules}$$

$$\text{KE after} \;=\; \frac{1}{2} \times 2 \times (1.2)^2 + \frac{1}{2} \times 3 \times (4.8)^2$$

$$=\; 1.44 + 34.56 \;=\; 36 \text{ joules}$$

so there is no loss of energy. (3 marks)
(Full marks can also be obtained by noting that the collision is perfectly elastic so the energy loss will be zero.)