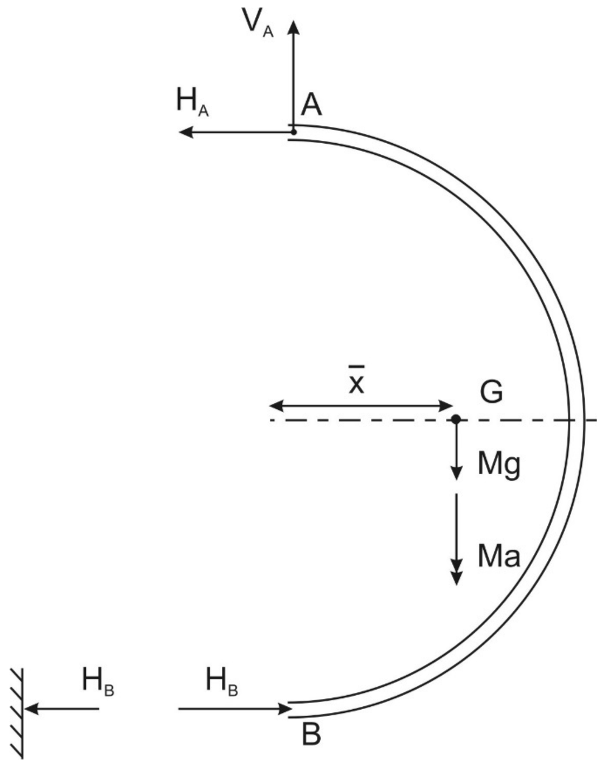
Dynamics 2 – Tutorial 4

Pure Translation of Bodies and Location of G

Outline Solutions

1.



Mass M = 45kg
R = 0.8m
Accel. = 15m/s^2 upwards (same as wall)

Pure Translation case

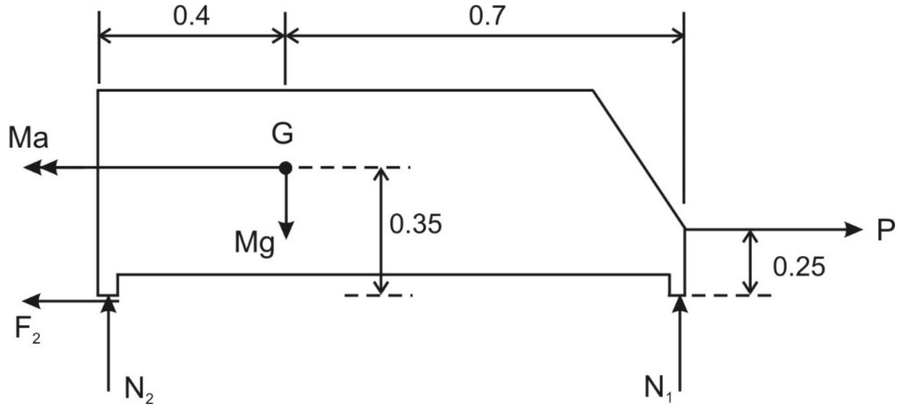
FBD of ring includes weight and inertia force acting downwards through G
(x = $\dfrac{2R}{\pi}$ for bar or shell bent into a semicircle)

By Moments about A get:

$$2RH_B - (Mg + Ma)\bar{x} = 0$$

$\Rightarrow$ H_B = 355 N

2.



a = acceleration to right

$\mu = 0.35$
$M = 24$ kg
$P = 95$ N

From FBD (including Inertia Force through G)

$$P - Ma - F_2 = 0 \quad (1)$$
$$N_1 + N_2 = Mg \quad (2)$$

For sliding

$$F_2 = \mu N_2 \quad (3)$$

4 unknowns (N_1, N_2, F_2, a) so need another equation.

Take moments – about, e.g., front contact point)

$$1.1 \times N_2 + 0.25 \times P - 0.7 \times Mg - 0.35 \times Ma = 0 \quad (4)$$

$$\Rightarrow \quad N_2 = 7.6364a + 128.33$$

Hence

$$F_2 = 2.673a + 44.88$$

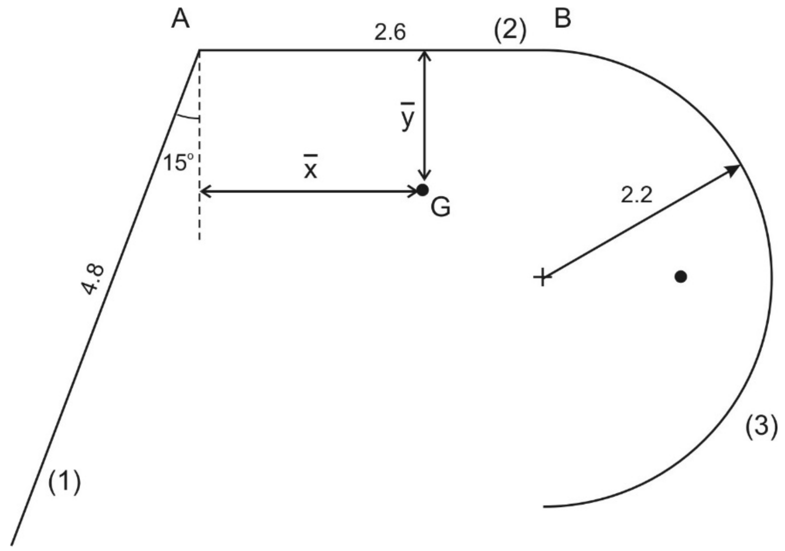
Put in (1)

$$95 - 24a - 2.673a - 44.88 = 0$$

$$\Rightarrow \quad a = 1.88 \text{ m/s}^2$$

And $F_2 = 49.9$ N
$N_2 = 142.58$ N
$N_1 = 92.86$ N

3.



Mass = 480 kg

G for semi-circle is at $\frac{2R}{\pi}$ from centre of circle

Take A as reference origin for G location.

Need to locate G horizontally from A. Need $\bar{x}$ (but don't need $\bar{y}$ to do the question). Note that the mass of each part is proportional to length. In tabular form:

Part	Length	x_G	Length × x_G	y_G	Length × y_G
1	4.8	−0.6212	−2.9817	2.3182	11.1275
2	2.6	1.3	3.38	0	0
3	6.91	4.0006	27.6441	2.2	15.202
$\sum$	14.31		28.0423		26.3295

For the assembly G

$$\bar{x} = \frac{28.0423}{14.31} = 1.96 \text{ m}$$

$$\bar{y} = \frac{26.3295}{14.31} = 1.840 \text{ m}$$

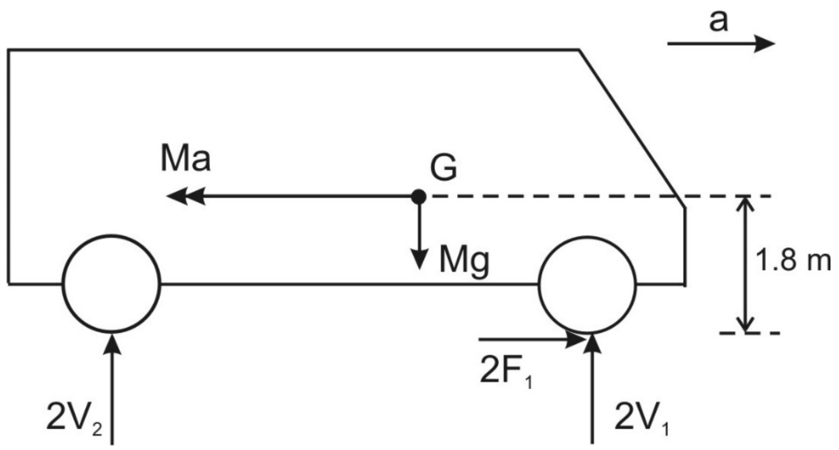
i.e., attach crane wire at 1.96 m to right of A

Crane tension

$$T = M(g + a) = 10.469 \text{ kN}$$

4.
(a) Let a be acceleration of van (with front wheel drive). M = 2500, a = 2.8m/s^2 initially.

FBD (external forces plus Inertia Force through G)



Force equation:

$$2F_1 = Ma$$
$$2V_1 + 2V_2 = Mg$$

And Moment Equation about rear wheel:

$$2V_1(2.2) + Ma(1.8) – Mg(1.8) = 0$$

$$\Rightarrow \quad 4.4V_1 + 4500a – 44145 = 0$$

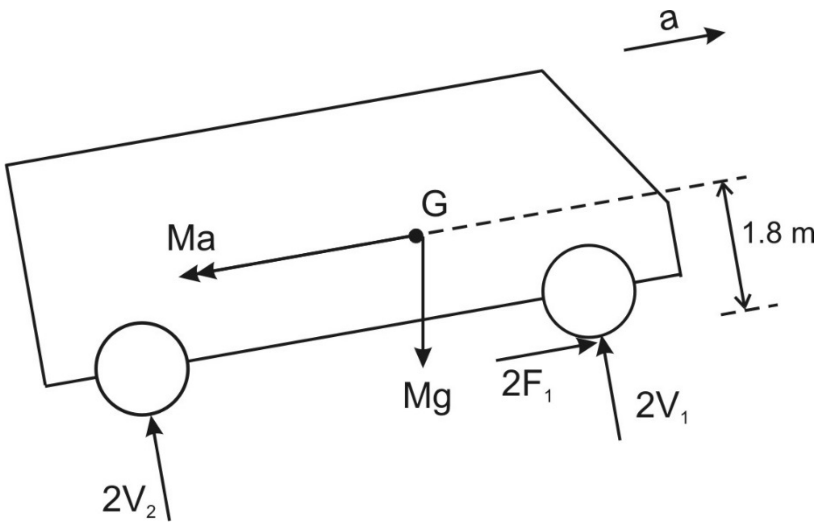
Gives:

$$V_1 = 10033 – 1023a = 7169 \text{ N}$$
$$V_2 = ½Mg – V_1 = 12262 – (10033 – 1023a)$$

$$\Rightarrow \quad V_2 = 2229 + 1023a = 5093 \text{ N}$$

$$F_1 = ½Ma = 1250a = 3500 \text{ N}$$

(b) Let a = accel up the incline. $\theta = 5°$, M = 2500 kg



From FBD:

$$2V_1 + 2V_2 = Mg\cos\theta \qquad (1)$$

$$2F_1 = Ma + Mg\sin\theta \qquad (2)$$

Taking moments about rear wheel contact point:

$$2V_1(L) + (Ma)h + (Mg\sin\theta)h - (Mg\cos\theta)\,d = 0 \qquad (3)$$

where: h is 1.8 m, L = 2.2 m and d = 1.8 m

a is an unknown but moment equation gives:

$$V_1 = 9120 - 1023a$$

At limit of wheel spin onset:

$$F_1 = 0.55V_1 \qquad (4,\ \text{given})$$

Hence

$$F_1 = 5016 - 562.5a$$

Put in (2)

$$10032 - 1125a = 2500a + 2137.5$$

$$\Rightarrow \qquad a = 2.18\ \text{m/s}^2$$