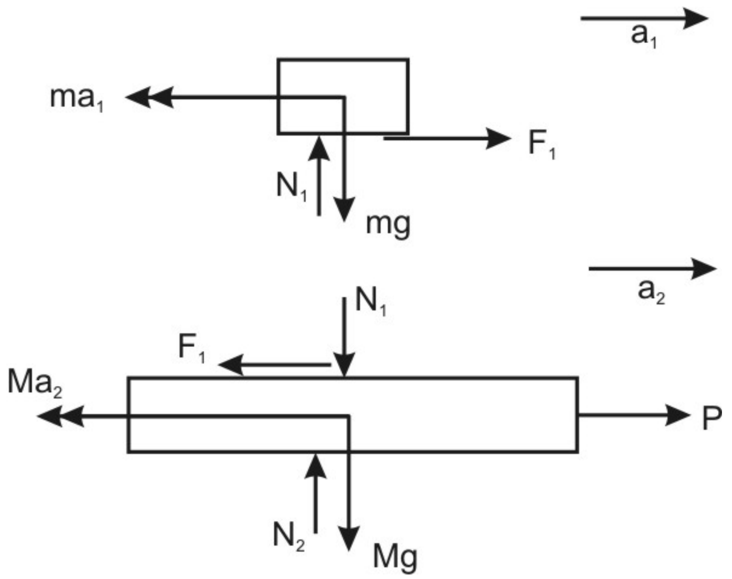
Dynamics 2 – Tutorial 2

Dynamics of a Single Particle and D'Alembert's Method

Outline Solutions

1.

Assume A is slipping on B. Let a_1 be the accel of A and a_2 be the accel of B (both to right). Draw FBDs.



From FBD for mass A

$$N_1 = mg$$

$$F_1 - ma_1 = 0$$

and for slipping: $F_1 = \mu N_1 = \mu mg$

Gives $F_1 = 4.081$ Newtons

$$\Rightarrow \quad a_1 = \frac{F_1}{m} = 2.551 \text{ m/s}^2$$

From FBD for mass B:

$$P - F_1 - Ma_2 = 0$$

a_2 is only unknown in this

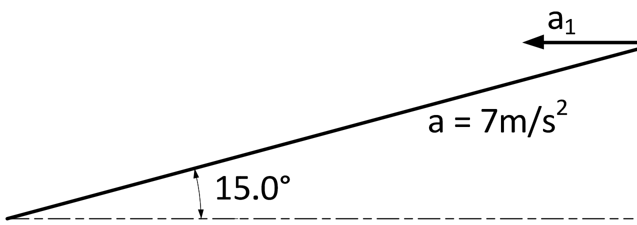
$$\Rightarrow \quad a_2 = 9.743 \text{ m/s}^2$$

2.

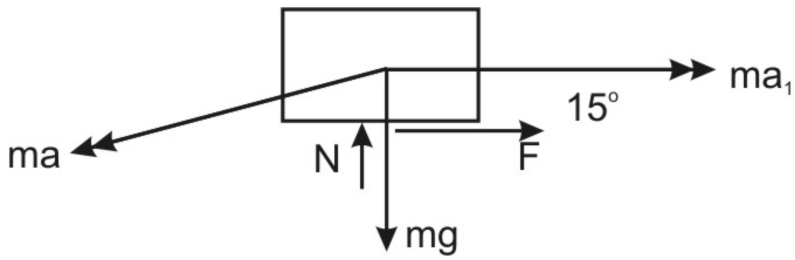
Assume the mass m will slide; then its acceleration is different to *a*
However, we can define its absolute acceleration as:

accel (absolute) = (accel of platform) + (accel of m *relative* to the platform)

The last term must be horizontal. Let a_1 be the relative acceleration of m on the platform (assumed backwards).



The total acceleration of m is the sum of the two acceleration components a and a_1, as shown. Hence we can draw two separate inertia forces on the FBD and then solve for a_1:



$$N = mg + ma \sin 15$$
$$ma_1 + F - ma \cos 15 = 0$$

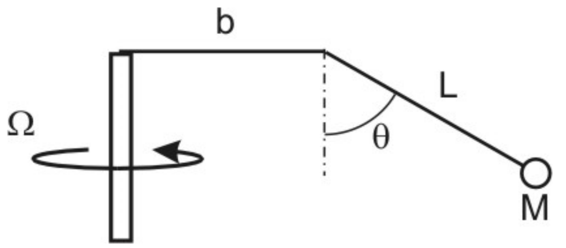
Also $F = \mu N$ for slipping

$$\Rightarrow \quad a_1 = 2.69 \text{ m/s}^2$$

Time to fall off is time to go 1.2m relative to platform so use $s = \frac{1}{2} a_1 t^2$

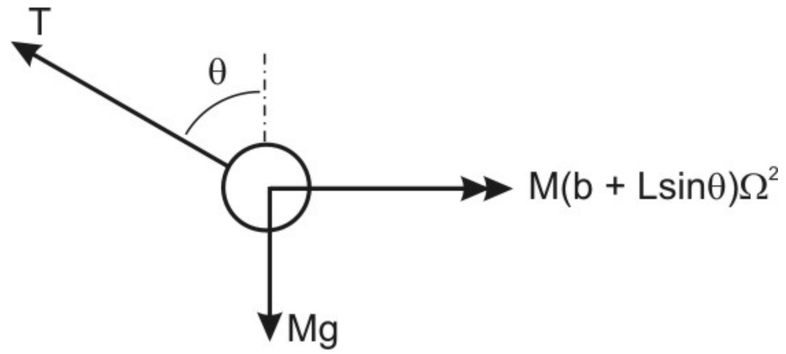
$$t = \sqrt{2\frac{s}{a_1}} = 0.94 \text{ s}$$

3.



M = 75 kg
b = 2.5 m
L = 4 m
Ω =?
θ = 60°

FBD of mass



↑ $$T\cos\theta - Mg = 0 \tag{1}$$
→ $$T\sin\theta - M(b + L\sin\theta)\Omega^2 = 0 \tag{2}$$

Find Ω^2

(1) gives

T cos60 = 75(9.81) = 735.75

⇒ T = 1471.5 N

In (2)

1471.5 sin60 = 75(2.5 + 4 sin60) Ω^2

⇒ Ω^2 = 2.849

Ω = 1.688 rad/s = 16.12 RPM

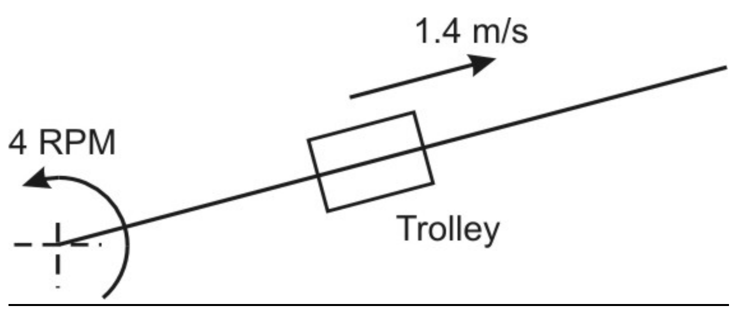
The effective "weight" of the customer M will be the force applied by the seat to M, which will be the tension T = 1471.5

Now $$\frac{T}{Mg} = \frac{1471.5}{735.75} = 2.0$$

So the customer feels an "effective" gravity field of 2g

4.

Tower crane jib (plan view)



r = 10 m
$\ddot{r} = 0$
$\dot{r} = +1.4$ m/s
$\dot{\theta} = \Omega = 4 \times \dfrac{2\pi}{60}$ =0.419 rad/s
$\dot{\theta}$ is +ve

Acceleration components of trolley:

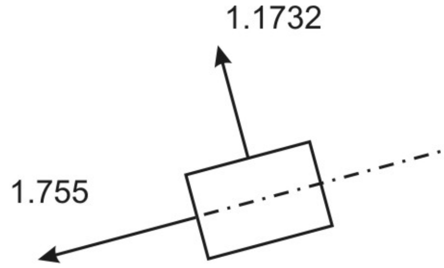
Radially outwards:

$$\ddot{r} - r\dot{\theta}^2 = 0 - (10)(0.419^2) = -1.755 \text{ m/s}^2$$

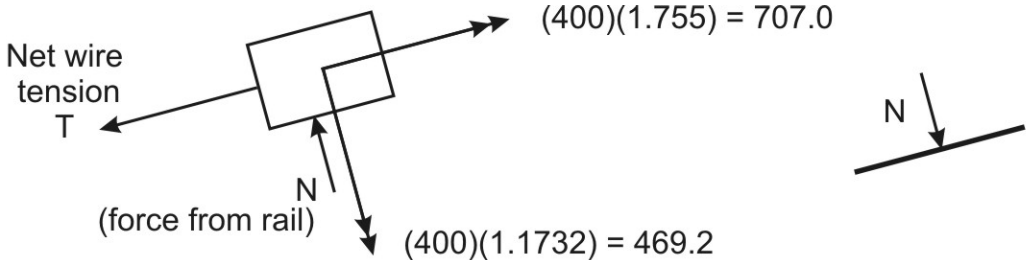
Tangentially (anti-clock)

$$r\ddot{\theta} + 2\dot{r}\dot{\theta} = (10)(0) + 2(1.4)(0.419) = 0 + 1.1732 \text{ m/s}^2$$

(Last term is the <u>Corioles Accel</u> = $2\dot{r}\dot{\theta}$)



Hence FBD of trolley with Inertia Forces:



$\Rightarrow$ T = 707.0 N
N = 469.2 N

N acts clockwise on rail by N3 viewed from above and T must be inwards