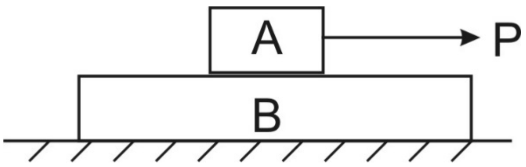
Dynamics 2 – Tutorial 3

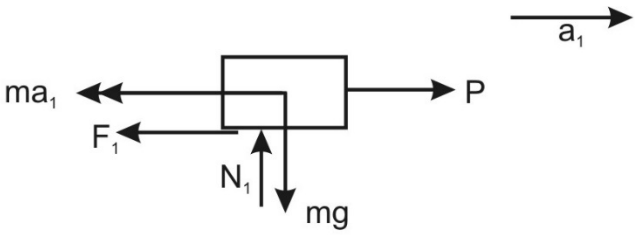
Dynamics of Particles and Newton's Laws

Outline Solutions

1.



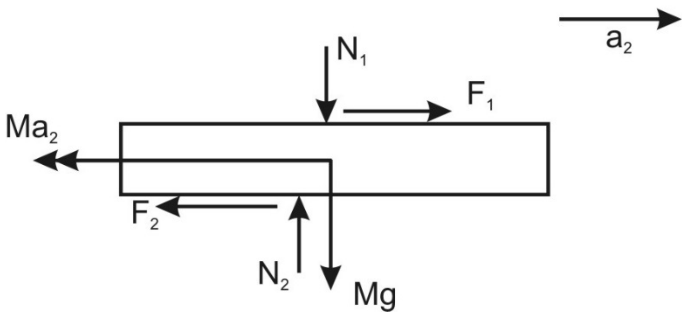
Let a_1 be accel of A
Let a_2 be the accel of B
m = 18 kg; M = 32 kg



FBD A:

$N_1 = mg = 176.58$ N
$F_1 = \mu_1 N_1 = 79.46$ N
$ma_1 = P - F_1$

$\Rightarrow \quad a_1 = 3.92 \text{ m/s}^2$



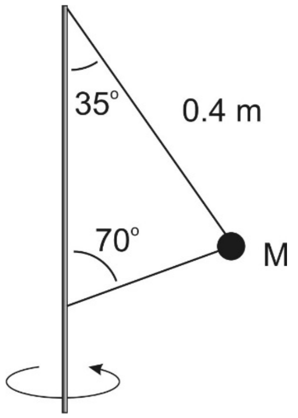
FBD B:

$N_2 - N_1 - Mg = 0$
$F_1 - F_2 - Ma_2 = 0$

Hence
$N_2 = 490.5$ N
$F_2 = \mu_2 N_2 = 73.57$ N

$$\Rightarrow \quad a_2 = \frac{F_1 - F_2}{M} = 0.184 \text{ m/s}^2$$

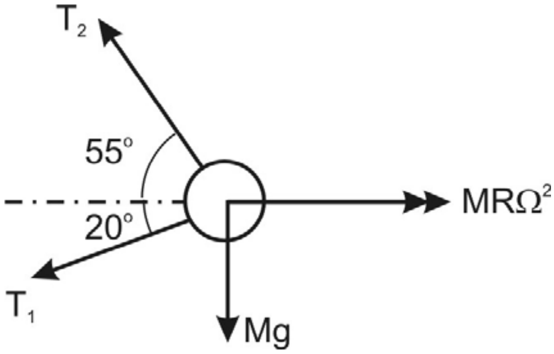
2.



M = 2.8 kg
R = 0.4 sin 35 = 0.229 m

Acceleration of M is
$R\Omega^2$ radially inwards.

Angular velocity
$\Omega = 120 \times 2\pi / 60 = 12.566$ rad/s

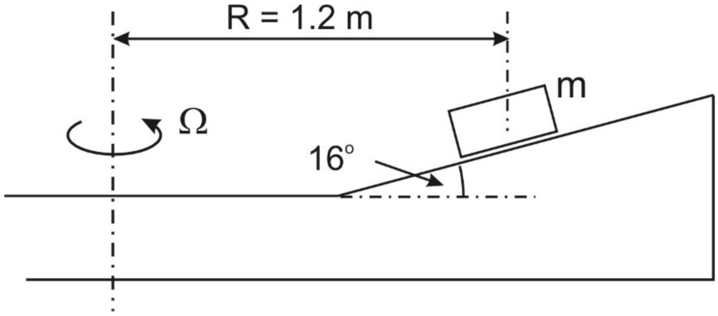


From FBD:

$T_2 \cos 55 + T_1 \cos 20 = MR\Omega^2$
$T_2 \sin 55 - T_1 \sin 20 - Mg = 0$

Get
$T_1 = 69.3$ N

$T_2 = 62.5$ N

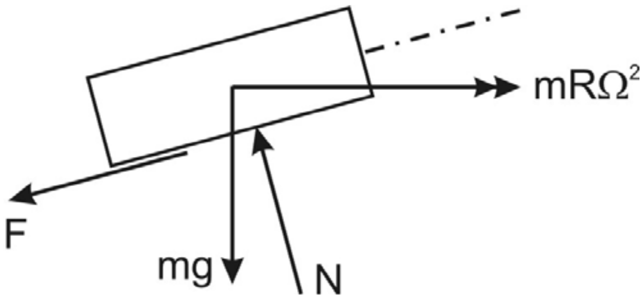


$m = ?$
$\mu = 0.35$

Acceleration of m is $R\Omega^2$ inwards (at point of slip)

Angular acceleration of platform is negligible.

FBD



R (|| slope) $\quad F + mg \sin 16 - mR\Omega^2 \cos 16 = 0$
R ($\perp$ slope) $\quad N - mg \cos 16 - mR\Omega^2 \sin 16 = 0$

But $F = \mu N$ at point of slip.

$$mR\Omega^2 \cos 16 - mg \sin 16 = \mu\,(mg \cos 16 + =mR\Omega^2 \sin 16) \qquad \text{[m cancels]}$$

Solve for Ω^2

$$R\Omega^2 (\cos 16 - \mu \sin 16) = g(\sin 16 + \mu \cos 16)$$

$$\Omega^2 = 5.786$$

$$\Rightarrow \qquad \Omega = 2.41 \text{ rad/s} = 23 \text{ Rev/min}$$

Newton's Second Law (N2) is

$$\sum \overline{F} = m\overline{a} \text{ or sum of forces} = \text{mass} \times \text{acceleration}$$

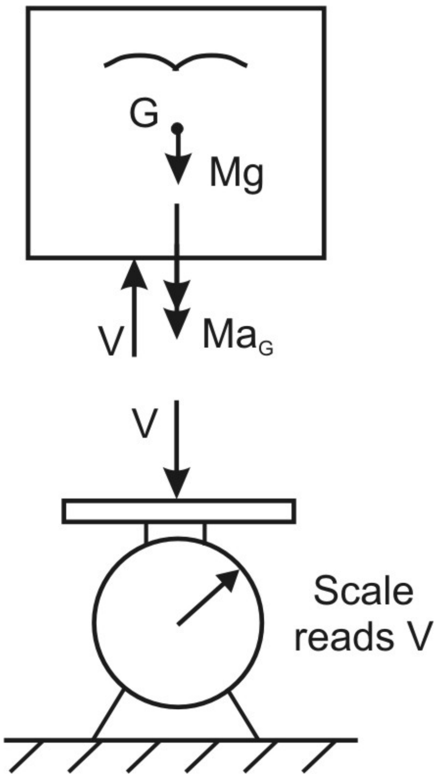
It applies to a mass particle.

Generalised Newton's Second Law (GN2):

Σ External Forces = (system total mass) × Accel of G

This applies to any constant mass system.

Part 1: Airtight box with canary inside is a system of constant mass within a boundary, hence, GN2 applies.



G is system centre of gravity.
M is system mass.
V is force on scales.
External System Forces are V and Mg.

Is G moving? Possible if bird is flying.

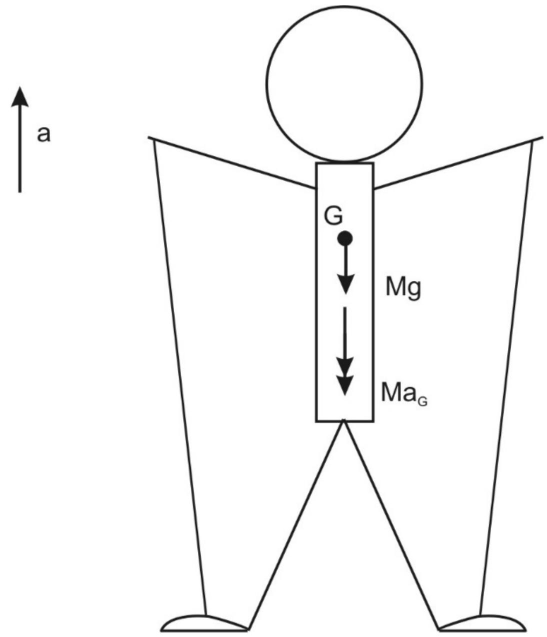
Let a_G be the accel of G. Then by GN2:

$$V - Mg - Ma_G = 0$$
$$V = Mg + Ma_G$$

So V **can fluctuate** due to system inertia force.

Part 2: By GN2 only external forces can accelerate the mass centre of a system.

System FBD:



Assume that you are off the ground, accelerating upwards by pulling on your laces.

Let a_G be the upwards acceleration.

The external forces are Mg only, there are no contact forces and lace forces are internal.

From FBD

$$Mg + Ma_G = 0$$

$$\Rightarrow \quad a_G = -g$$

Hence, free falling back to the floor is the only possible option.