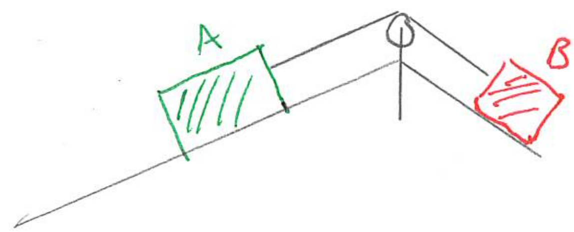
Mon: Warm Up 8

Tues: Discussion / quiz

Ex: 230, 231, 233, 235, 239, 242, 244

Interacting objects

The strategy for analyzing motion of interacting objects is:



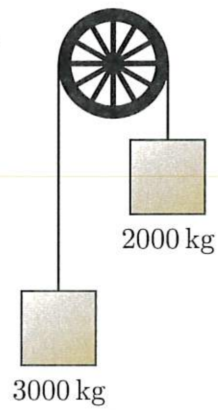
- Apply Newton's Second Law to object A
  - ↳ Gives expressions involving $T, a_A, m_A, g \ldots$
- Apply Newton's Second Law to object B
  - ↳ Gives expressions involving $T, a_B, m_B, g, \ldots$
- relate accelerations of two objects
  - maybe $a_{Ax} = a_{Bx}$
  - or $a_{Ax} = -a_{Bx}$

→ Combine algebraic expressions to solve for relevant variables

Group Exercise 5.

1 Counterbalanced elevator

A 3000 kg elevator is connected to a 2000 kg block by a rope that runs over a pulley. Determine the acceleration of the elevator. *(131Sp2025)*



Make $A \rightsquigarrow 3000\,kg$

$B \rightsquigarrow 2000\,kg$

For A:

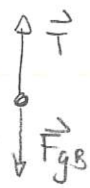
$\sum F_{iy} = M_A a_{Ay}$

$\Rightarrow T - M_A g = M_A a_{Ay}$

$\Rightarrow T - 3000\,kg \times 9.8\,m/s^2 = 3000\,kg\ a_{Ay}$

$\Rightarrow T - 29400\,N = 3000\,kg\, a_{Ay}$

For B



$\sum F_{iy} = M_B a_{By}$

$\Rightarrow T - M_B g = M_B a_{By}$

$\Rightarrow T - 2000\,kg \times 9.8\,m/s^2 = 2000\,kg\ a_{By}$

$\Rightarrow T - 19600\,N = 2000\,kg\ a_{By}$

Connect accelerations: $a_{Ay} = -a \qquad a_{By} = a$

$\Rightarrow$

$T - 29400\,N = -3000\,kg\ a \quad \Rightarrow T = 29400\,N - 3000\,kg\, a$

$T - 19600\,N = 2000\,kg\ a \quad \Rightarrow T = 19600\,N + 2000\,kg\, a$

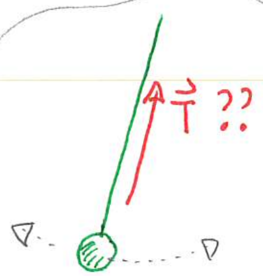
Set equal $\quad 29400\,N - 3000\,kg\, a = 19600\,N + 2000\,kg\, a$

$\Rightarrow 9800\,N = 5000\,kg\, a$

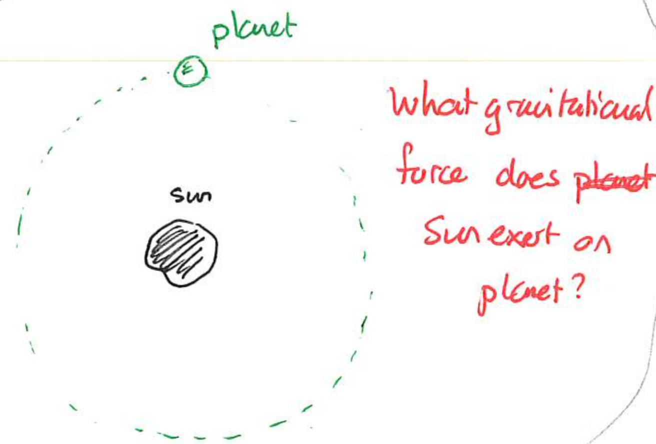
$$\Rightarrow a = \frac{9800\,N}{5000\,kg} \Rightarrow a = 1.96\,m/s^2$$

Circular motion

Newton's laws can be applied to objects that move in circles. There are no substantial modifications - only adaptation to the kinematics of circular motion. We can ask

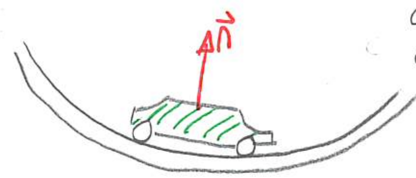


For a pendulum that swings with a particular speed, what is the tension



We need to review the kinematics of circular motion.

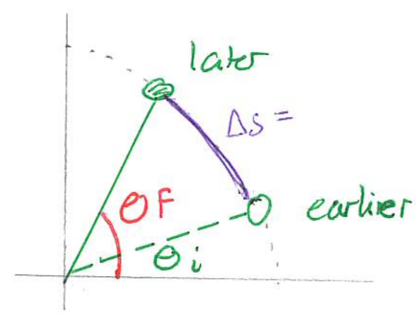
We will use angular variables to help describe this



What normal force does surface exert

First the position is described by

* choose a co-ordinate system with origin at center
* angular position, θ, is angle measured counterclockwise from +x



Note 2π radians $= 360°$

Then angular displacement is $\Delta\theta = \theta F - \theta i$

This is related to the arclength distance $\Delta s = r\Delta\theta$

We describe the rate of change of angular position via:

Angular velocity ~ rate of change of angular position

The definition is

The angular velocity of an object is

$$\omega := \lim_{\Delta t \to 0} \frac{\Delta \theta}{\Delta t} = \frac{d\theta}{dt}$$

units: rad/s

"omega"

Quiz1 60% – 90%

Then a simple derivation gives:

If an object moves in a circle with radius r the its speed is

$$v = \omega r$$

where ω is its angular velocity

Quiz2 80%

The acceleration of an object moving in a circle depends on whether its speed is constant.

Consider an object that moves in a circle of radius r with constant speed v. The object's acceleration is

$$a = v^2/r$$

or equivalently

$$a = \omega^2 r$$