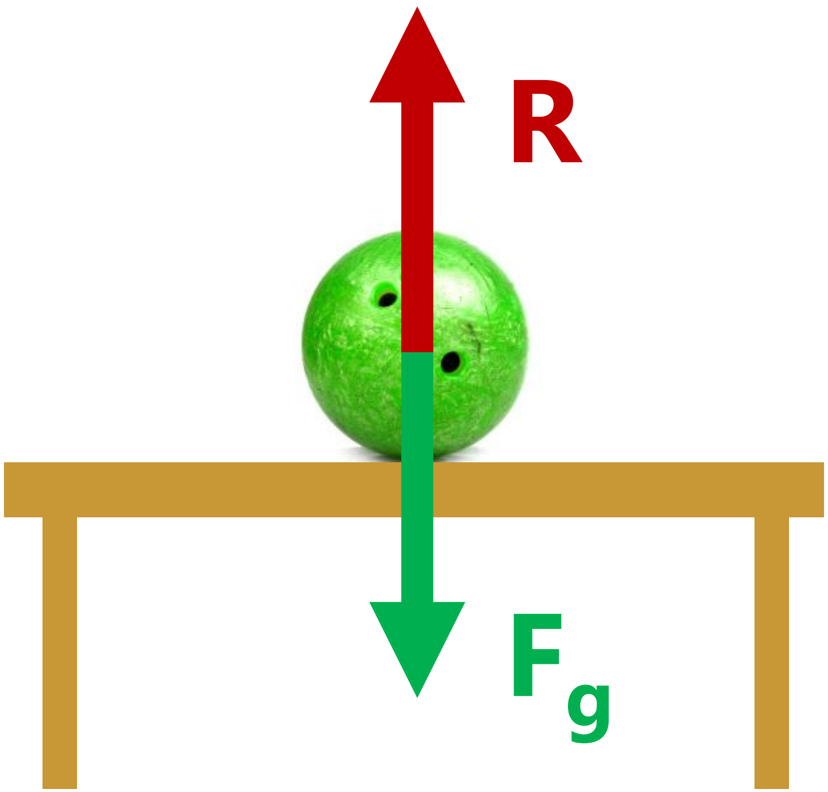
Vertical Circular Motion with a Surface

IB PHYSICS | CIRCULAR MOTION

IB Physics Data Booklet

Sub-topic 6.1 – Circular motion	
$v = \omega r$ $a = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$ $F = \frac{mv^2}{r} = m\omega^2 r$	v – linear velocity (m s^{-1}) ω – angular velocity (rad s^{-1}) r – radius (m) T – period (s) a – centripetal acceleration (m s^{-2}) F – centripetal force (N)

Remember Normal Reaction Force?



*Always perpendicular to the surface applying the force

Roller Coaster | Bottom

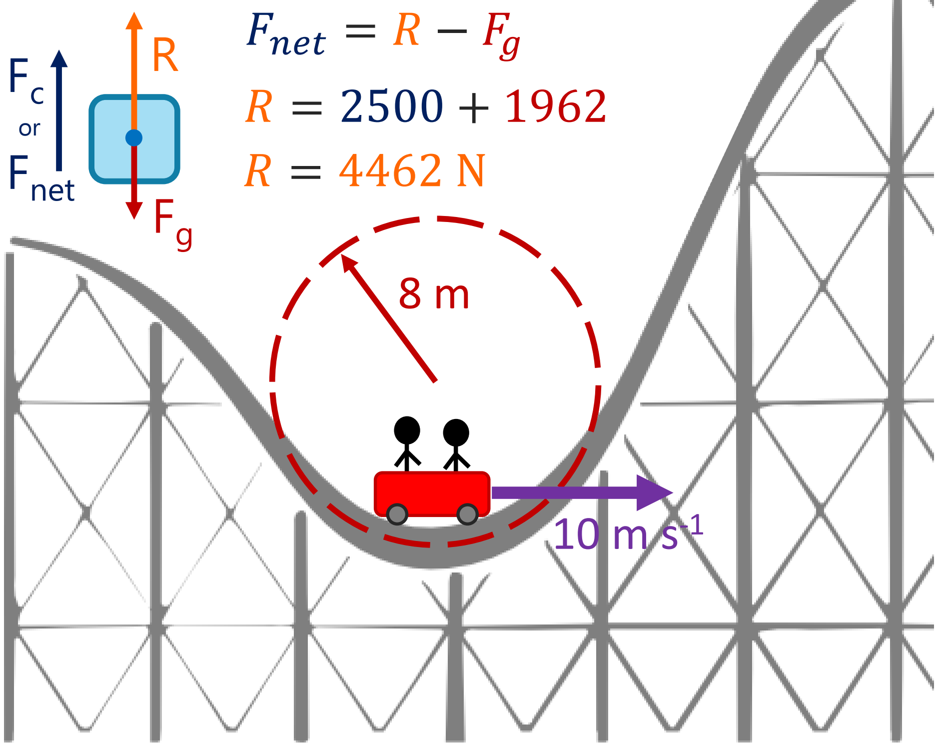
$$F_c = \frac{mv^2}{r} = \frac{(200)(10)^2}{8} = \mathbf{2500\ N}$$

$$F_g = mg = (200)(9.81) = \mathbf{1962\ N}$$

$$F_{net} = R - F_g$$

$$R = 2500 + 1962$$

$$R = 4462\ \text{N}$$

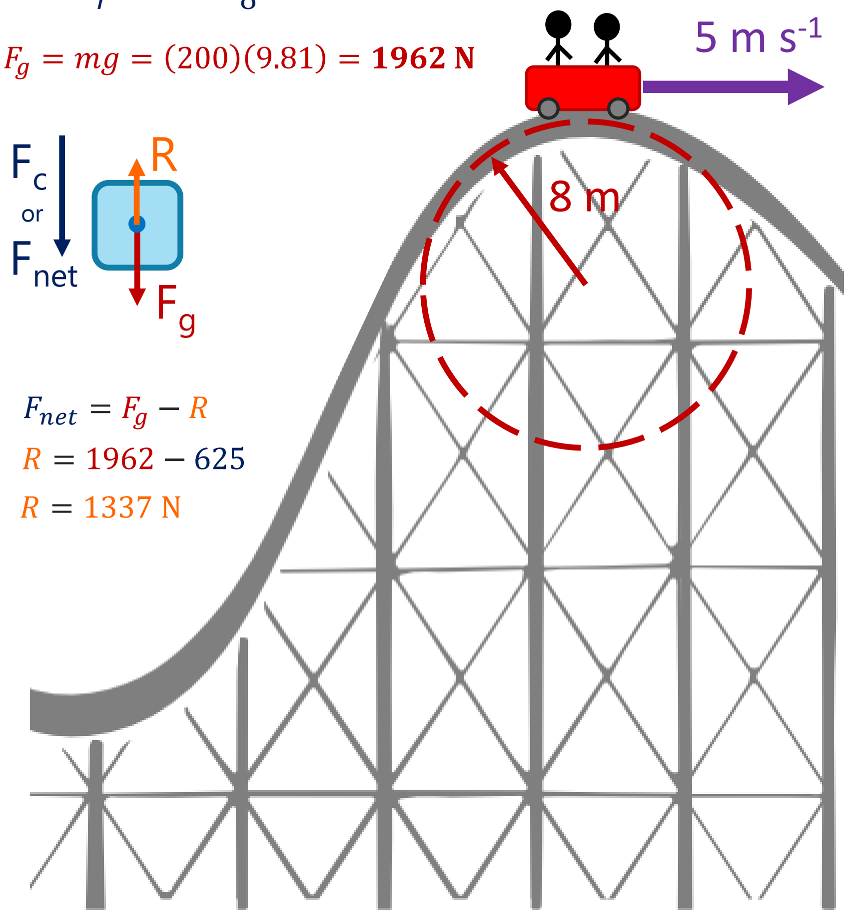


m	200 kg
v	$10\ m\ s^{-1}$
r	8 m
F_c	2500 N
F_{net}	2500 N
F_g	1962 N
R	4462 N

Roller Coaster | Top

$$F_c = \frac{mv^2}{r} = \frac{(200)(5)^2}{8} = \mathbf{625\ N}$$

$$F_g = mg = (200)(9.81) = \mathbf{1962\ N}$$



$$F_{net} = F_g - R$$

$$R = 1962 - 625$$

$$R = 1337\ \text{N}$$

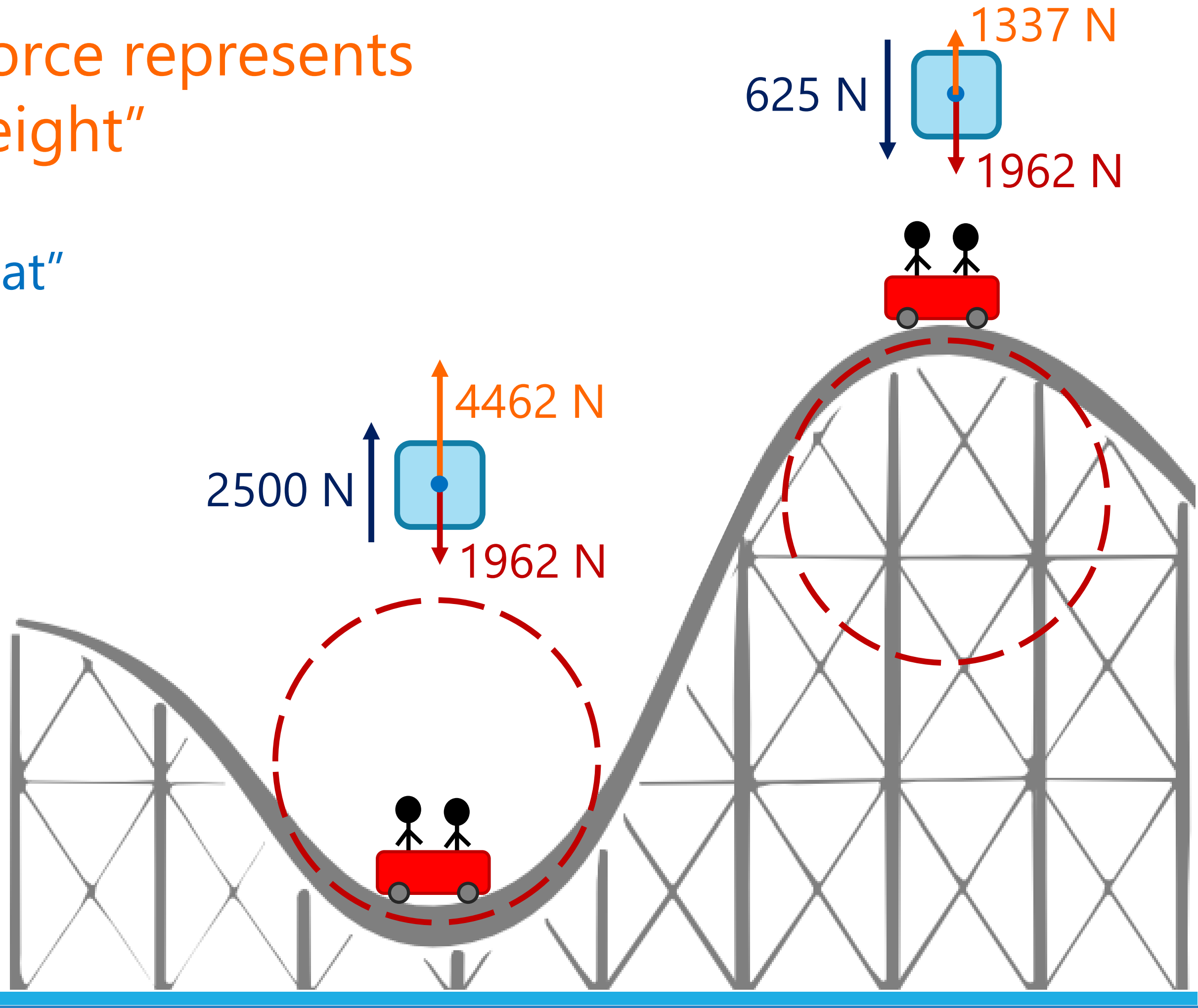
m	200 kg
v_t	5 m s^{-1}
r	8 m
F_c	625 N
F_{net}	625 N
F_g	1962 N
R	1337 N

Perceived Weight

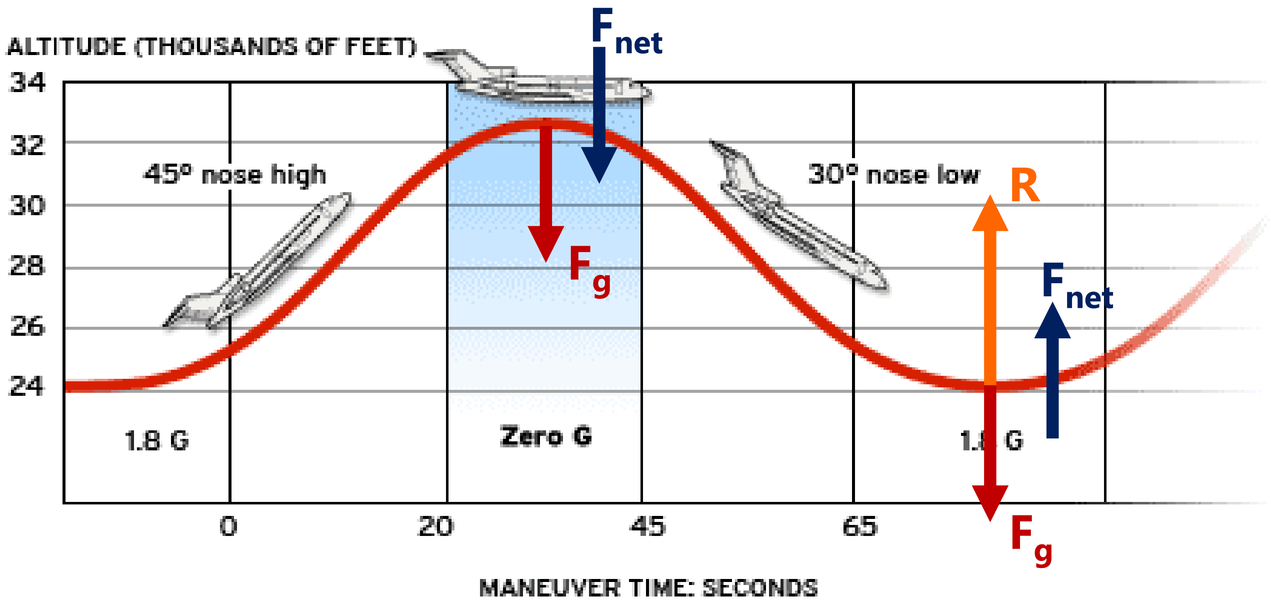
The normal reaction force represents a rider's "perceived weight"

$R > F_g$ | "Squished into seat"

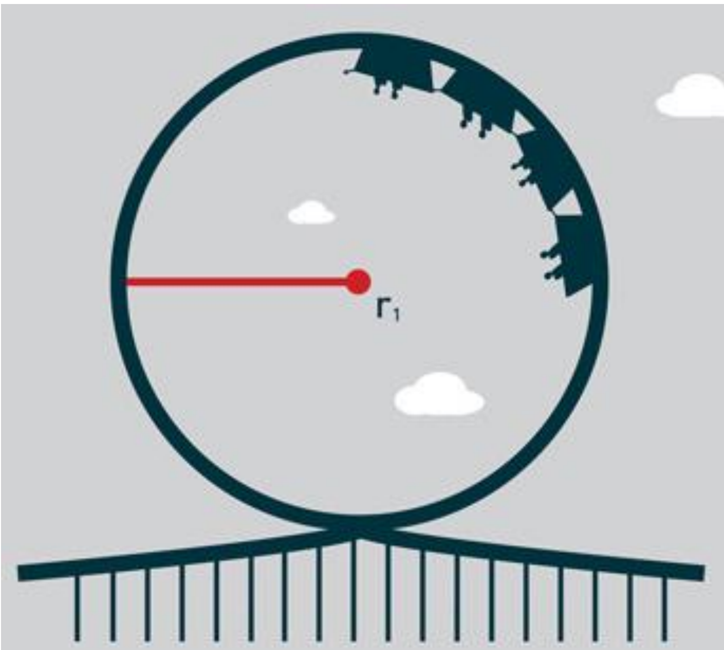
$R < F_g$ | "Weightless"



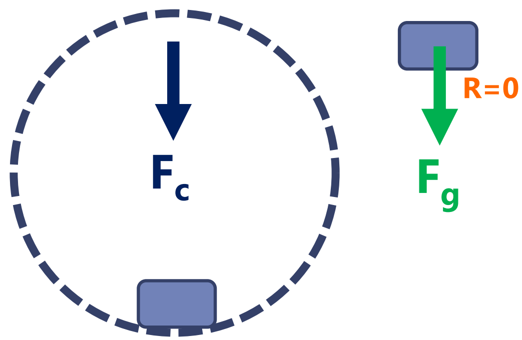
The ultimate "weightless" experience



Loop the Loop!



The velocity needs to be fast enough that the R is greater than 0 N



$$F_c = F_g$$

$$\frac{\cancel{m}v^2}{r} = \cancel{m}g$$

$$v = \sqrt{gr}$$

Minimum velocity required = $\sqrt{gr}$

Lesson Takeaways

- ❑ I can compare the forces on an object at different positions in vertical circular motion
- ❑ I can determine the magnitude and direction of the forces needed for the overall centripetal force
- ❑ I can qualitatively describe how normal reaction force changes in a vertical circle
- ❑ I can describe the experience of “weightlessness” in terms of normal reaction force