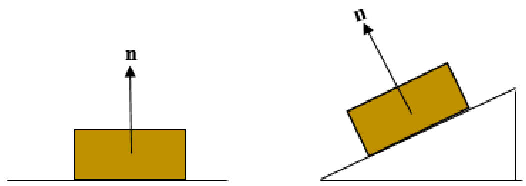
Subject Code PHY1 **Physics 1**
Module Code 7.0 **Applications of Newton's Laws of Motion**
Lesson Code 7.1 **Normal Force (Part 1)**
Time Frame 30 minutes

Components	Tasks	TA[1] (min)	ATA[2] (min)
Target	By the end of this learning guide, the student should be able to: ● define normal force ● represent forces in diagrams using appropriately labeled vectors ● apply Newton's laws of motion to determine normal force	1	
Hook	Have you ever experienced riding on a Ferris wheel? Aside from feeling nervous (maybe not true for some), did you feel lighter while you are at the top of the Ferris wheel? Can you recall your feelings of weightlessness and heaviness when you rode a roller coaster? Have you tried riding on the EKstreme Tower of Enchanted Kingdom Amusement Park? How was the feeling? Did you feel weightless? In this lesson, we will be studying the physics behind these feelings of weightlessness and heaviness.  The EKstreme Tower of Enchanted Kingdom *Image from https://www.wheninmanila.com/10-things-to-cross-off-enchanted-kingdom-bucket-list/*	2	
Ignite	Normal force (**n**) is the force exerted by an object on another object in contact with it. The normal force is directed towards the object on which it is exerted upon and is perpendicular to	13	

[1] Time allocation suggested by the teacher.
[2] Actual time allocation spent by the student (for information purposes only).

the surface of contact. As shown in Figure 1(a), the floor exerts an upward normal force on the object while in Figure 1(b), the normal force on the object is tilted upwards and perpendicular to the surface of the incline.



(a) (b)

***Figure 1**. Direction of Normal force of an object mounted on (a) a horizontal, and (b) an inclined surface*

The normal force vanishes once the object is no longer in contact with the surface.

The magnitude of the normal force may vary depending on the situation. To determine the magnitude of the normal force acting on an object, identify the other forces that are acting on that object, specifically those along the same line of action as the normal force, and apply Newton's second law of motion ($\Sigma\mathbf{F} = m\mathbf{a}$).

Let us consider the case of an object, of mass m, on a horizontal surface.

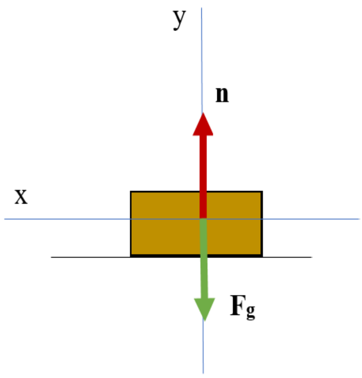


***Figure 2**. Free-body Diagram of the Forces Acting on an Object Resting on a Horizontal Surface*

Aside from the normal force, there is a gravitational force acting on the object along the y-axis. Normal force is directed upward (positive) while the gravitational force is directed downward (negative).

Since the object is stationary, its acceleration is equal to zero ($\mathbf{a} = 0$). From Newton's second law of motion:

$\Sigma\mathbf{F} = m\mathbf{a}$

$n + (-F_g) = m(0)$

Solving now for the magnitude of the normal force, we get

$\boxed{n = F_g = mg}$

The normal force on the object is equal to the weight of the object.

What happens when another mass is added on top of the object?

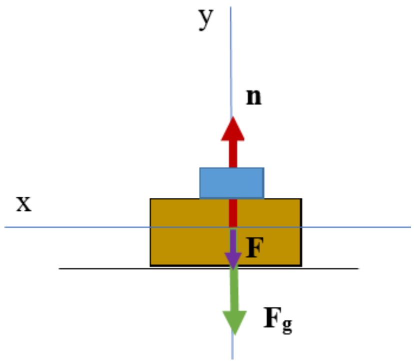


***Figure 3**. Free-body Diagram of the Forces Acting on an Object Resting on a Horizontal Surface with a Block of Wood on Top*

We can see from Figure 3 that there are now three forces acting on the object, the normal force **n** exerted by the surface (upward), the gravitational force $\mathbf{F_g}$ (downward), and the normal force **F** exerted by the upper mass (downward).
Using Newton's second law of motion to solve for the normal force:

$\Sigma\mathbf{F} = m\mathbf{a}$

The object is not moving. Hence, **a** = 0.

$\Sigma\mathbf{F} = m(0)$

$n + (-F_g) + (-F) = 0$

$\boxed{n = F_g + F}$

How do we determine the force **F** exerted by the upper mass (mass m_t) on the object?
There are only two forces acting on the upper mass: it's weight (m_tg) and the upward normal force exerted by the object. The upward normal force exerted by the object is the reaction to the downward normal force exerted by the upper mass on the object. Hence, this has the same magnitude as **F**.
Applying Newton's second law on the upper mass

$\Sigma\mathbf{F} = m_t\mathbf{a}$

$F + (-m_tg) = m_t(0)$

$F = m_tg$

Therefore, the normal force on the object can be written as

$n = F_g + m_tg$

$\boxed{n = mg + m_tg}$

The normal force on the object is equivalent to the combined weight of the object and the upper mass.

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<td>Navigate</td>
<td>It is now time to check your understanding by doing the activity below. Follow your teacher's instructions regarding submission.

1. Draw arrows to show the direction of the normal force and the gravitational force acting on the rider while he is on the different positions in the loop as shown in the figure below. Label normal force with n and gravitational force with $\mathbf{F}_g$.

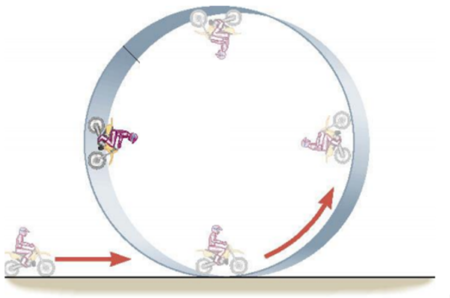
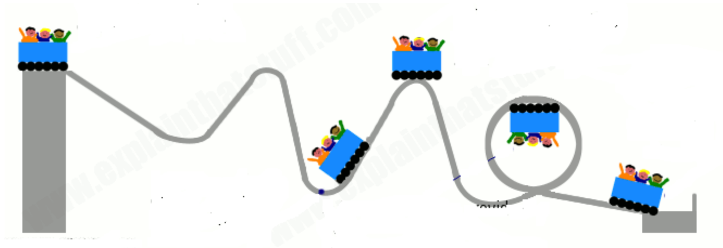


Image modified from https://www.tecumseh.k12.oh.us/Downloads/Physics_PowerPoint_9_3.pdf

2. A 3.00-kg physics book is resting on top of the table. What is the magnitude of the normal force exerted by the table on the book?

3. Draw arrows to show the direction of the normal force and the gravitational force acting on the roller coaster cart while it is on the positions shown in the figure below.



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<td>Knot</td>
<td>In summary,
Normal force is a contact force exerted by a surface on an object that is in contact with it. It is always perpendicular to the surface and directed towards the object. The magnitude of the normal force can be calculated using Newton's second law of motion ($\Sigma\mathbf{F} = m\mathbf{a}$).</td>
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References:

1. Serway, R., & Beichner, R. (2000). *Physics for Scientists and Engineers with Modern Physics (5th edition).* Saunders College Publishing.
2. Giancoli, Douglas C. (2007). *Physics: Principles with Applications (6th edition).* Pearson Education, Inc.

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