Subject Code PHY 1 **Physics 1**
Module Code 1.0 **Kinematic Quantities**
Lesson Code 1.3 **Acceleration**
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 acceleration ● compute for average acceleration	1	
Hook 	You may have experienced the sudden jerky movements while riding public transportation. After a new passenger boards the jeep, all the passengers are thrust towards the back when the jeep moves again. When it suddenly stops from a late "*Kuya para*!", the passengers get thrust towards the front of the jeep. Which kinematics concepts are involved in these examples? These consequences are brought about by changes in velocity. We call the change of velocity as acceleration. Did you know that our universe is expanding? The galaxies are moving farther from each other. In fact, this expansion is accelerating! That means the speed at which the galaxies are moving away from each other is increasing! So far, we have learned about time, position, displacement, and velocity. In this learning guide, you will learn about the last main physical quantity involved in kinematics: acceleration.	1	
Ignite 	**Acceleration** is present whenever there is change in velocity. This change can either be a change in magnitude, or in speed, or a change in direction. It may occur during a short time interval, or a long one. Thus, an object does not have to be going fast to be accelerating – the only requirement is that its velocity is changing. **Average acceleration** is a vector that is defined as the change in the object's velocity (final velocity minus initial velocity) per unit of elapsed time, as shown in equation 1. The SI unit is meter per second squared (m/s^2).	12	

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

$$\vec{a} = \frac{\vec{v}-\vec{v}_0}{t-t_0} = \frac{\Delta\vec{v}}{\Delta t}$$

[eqn. 1]

Computing the average acceleration example:
A drag racer crosses the finish line, and the driver deploys a parachute and applies the brakes to slow down, as Figure 1 illustrates. The driver begins slowing down when $t_0 = 9.0$ s and the car's velocity is +28 m/s. When t = 12.0 s. the velocity has been reduced to +13 m/s. What is the average acceleration of the dragster? (Cutnell and Johnson, 2012)

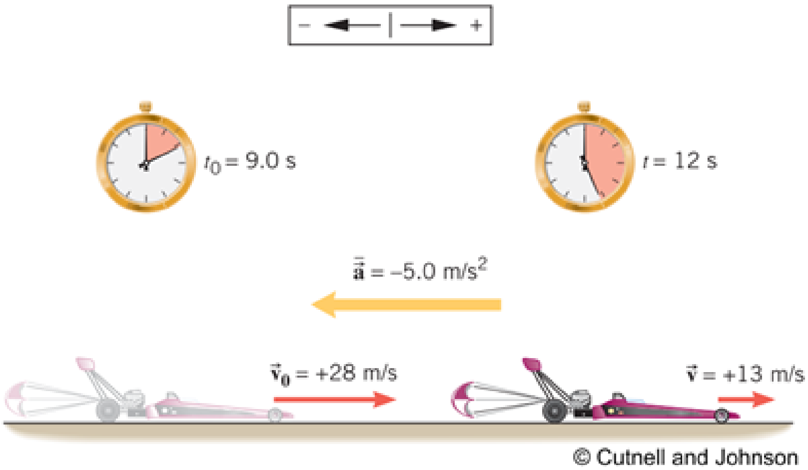

Figure 1. The direction of acceleration is opposite that of the velocity, so the velocity decreases (Cutnell and Johnson, 2012)

Solution: The average acceleration, according to equation 1, is

$$\vec{a} = \frac{\vec{v}-\vec{v}_0}{t-t_0} = \frac{13\,\frac{m}{s} - 28\,\frac{m}{s}}{12.0\,s - 9.0\,s} = \boxed{-5.0\,m/s^2}$$

Thus, the average acceleration in the 3.0 s while the dragster is slowing down is – 5.0 m/s². This means that every second, the velocity is decreasing by 5.0 m/s. The meaning of the negative sign will be explained in the next section.

Direction of acceleration
Average acceleration is a vector that points in the same direction as the change in velocity and thus follows the same convention as velocity: + and – signs indicate the two possible directions when the motion is along a straight line. The direction depends on two things:

- Is the object speeding up or slowing down?
- Is the object moving in the positive or negative direction

	in the chosen coordinate system? **Positive acceleration** implies that the acceleration is directed in the positive direction of the chosen coordinate system. Commonly, a positive acceleration is present for an object that is moving towards the *positive direction* and *speeding up*. However, a positive acceleration is also present for an object that is moving towards the *negative* direction if that object is *slowing down*. **Deceleration** is a term you may have heard before – it is often used as an opposite of acceleration. Indeed, deceleration always reduces speed because it occurs when the acceleration vector and the velocity vector points in opposite directions. **Negative acceleration**, on the other hand, means the acceleration is directed in the chosen negative direction. It may mean that the object is moving towards the positive direction but is slowing down, as in the example shown in Figure 1. It can also mean the object is speeding up while moving in the negative direction. Thus, deceleration and negative acceleration are not synonyms.		
Navigate	Now it is time for you to apply what you have learned. Write your answers (with complete solutions for word problems) on a clean sheet of paper. Follow your teacher's instructions regarding submission. This activity is non-graded. 1. At one instant of time, a car and a truck are traveling side by side in adjacent lanes of a highway. The car has a greater velocity than the truck has. Does the car necessarily have greater acceleration? (Cutnell and Johnson, 2012) 2. Two cars are moving in the same direction (the positive direction) on a straight road. The acceleration of each car also points in the positive direction. Car 1 has a greater acceleration than car 2 has. Which one of the following statements is true? (a) The velocity of car 1 is always greater than the velocity of car 2. (b) The velocity of car 2 is always greater than the velocity of car 2. (c) In the same time interval, the velocity of car 1 changes by a greater amount than the velocity of car 2 does. (d) In the same time interval, the velocity of car 2 changes by a	10	

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<td>greater amount than the velocity of car 1 does. (Cutnell and Johnson, 2012)

3. A sprinter explodes out of the starting block with an acceleration of +2.3 m/s^2, which she sustains for 1.2 s. Then, her acceleration drops to zero for the rest of the race. What is her velocity (a) at t = 1.2 s and (b) at the end of the race? (Cutnell and Johnson, 2012)</td>
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<td>In summary
● Acceleration is a vector which is defined as the rate at which the velocity is changing.
● The average acceleration is equal to the change in the velocity divided by the elapsed time as shown in the equation:
$$\vec{\bar{a}} = \frac{\vec{v}-\vec{v}_0}{t-t_0} = \frac{\Delta\vec{v}}{\Delta t}$$
If an object is slowing down, then its acceleration is in the opposite direction of its motion (Henderson, 2020).

To test your understanding of acceleration, answer the following and write your answers (with complete solutions for word problems) on a clean sheet of paper. Follow your teacher's instructions regarding submission. This activity is graded (scoring system is the subject teacher’s discretion.)

1. Imagine that you must explain the definition of acceleration to a grade-school student. Write your simplified explanation in 3 to 6 sentences.

2. The velocity of a train is 80.0 km/h due west. One and a half hour later its velocity is 65.0 km/h, due west. What is the train’s average acceleration? (Cutnell and Johnson, 2012)
(a) 10.0 km/h^2, due west (b) 43.3 km/h^2, due west
(c) 10.0 km/h^2, due east (d) 43.3 km/h^2, due east
(e) 53.3 km/h^2, due east</td>
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References:

1. Cutnell, John D. and Johnson, Kenneth W. (2012). *Physics 9th ed.* United States of America: John Wiley & Sons, Inc.
2. Henderson, Tom (2020, July 14). *The Physics Classroom*. Retrieved from https://www.physicsclassroom.com/class/1DKin/Lesson-1/Acceleration

Prepared by: Quantum Yuri B. Lubrica	Reviewed by: Joana Paulene L. Simangan
Position: SST III	Position: SST I
Campus: Cordillera Administrative Region Campus	Campus: Cordillera Administrative Region Campus