MODULE 2. **MECHANICS**

Part I. THE SCIENCE OF MECHANICS

Task 1. Find the meaning and pronunciation of the highlighted words in a dictionary and learn them:

Mechanics is a branch of physics that **concerns** the motions of objects and their **response** to forces. Modern descriptions of such behavior begin with a careful definition of such quantities as **displacement** (distance moved), time, **velocity**, **acceleration**, mass, and force. Until about 400 years ago, however, motion was explained from a very different point of view. For example, following the ideas of Greek philosopher and scientist Aristotle, scientists reasoned that a cannonball falls down because its natural position is in the earth. The sun, the moon, and the stars travel in circles around the earth because it is the nature of heavenly objects to travel in perfect circles.

The Italian physicist and astronomer Galileo brought together the ideas of other great thinkers of his time and began to analyze motion in terms of distance traveled from some starting position and the time that it took. He showed that the speed of falling objects increases steadily during the time of their fall. This acceleration is the same for heavy objects as for light ones, provided air **friction** (air resistance) is **discounted**. The English mathematician and physicist Sir Isaac Newton **improved** this analysis by defining force and mass and relating these to acceleration. For objects traveling at speeds close to the speed of light, Newton's laws were **superseded** by Albert Einstein's theory of relativity. For atomic and subatomic particles, Newton's laws were superseded by quantum theory. For everyday phenomena, however, Newton's three laws of motion remain the **cornerstone** of dynamics, which is the study of what is motion.

Task 2. Answer the following questions on the text:

1. What branch of physics concerns the motions of objects and their response to forces?
2. What are the quantities that require careful definition?
3. How did ancient people explain motion?
4. What was the impact of Galileo on the field of physics?

5. Does the speed of the falling object increase steadily during the time of its fall?
6. Is it possible to discount air resistance while calculating acceleration?
7. How did Isaac Newton improve the analysis of acceleration?
8. Whose theory superseded Newton's laws?
9. What is the cornerstone for the study of motion?

Task 3. Decide whether the following statements are true or false according to the text. Prove your answers using the information from the text.

1. Mechanics concerns acceleration of objects and their response to mass.
2. Greek philosopher reasoned that a cannonball falls down because its mass is lighter than the earth's.
3. The sun, the moon and the stars travel in circles around the earth because of their nature.
4. Galileo showed that the acceleration of falling objects decreases steadily during the time of their fall.
5. Newton improved the analysis by defining acceleration, mass and relating these to force.

Task 4. Find an odd word:

1. *number (n),* zero, amount, quantity, volume, sum;
2. *reduce (v),* condense, contract, increase, decrease, diminish;
3. *conclude(v),* deduce, close, start, complete, determine;
4. *progress (v),* advance, improve, proceed, regress;
5. *increase (v),* extend, grow, decrease, multiply;
6. *opposition (n),* contradiction, contrast, denial, resistance, attraction.

Task 5. Match the word on the left with the correct definition on the right:

1. concern	a) take place of sth that is less efficient, less modern;
2. displacement	b) measure of rate of change in position of sth with respect to time, involving speed and direction;
3. acceleration	c) smb or sth that is fundamentaly important to sth;
4. cannonball	d) rate of increase in the velocity of sth;
5. friction	e) resistance encountered by an object moving relative to another object with which it is in contact;
6. supersede	f) be about a particular topic;
7. discount	g) amount of an object movement measured in a particular direction;
8. velocity	h) decide that sth can be disregarded as unimportant;
9. cornestone	i) make sth happen or exist;
10. cause	j) heavy metal or stone ball.

Part II. KINETICS

Task 6. Find the meaning and pronunciation of the highlighted words in a dictionary and learn them:

Kinetics is the description of motion without regard to what **causes** the motion. Velocity is **defined** as the distance traveled divided by the time interval. Velocity may be **measured** in such units as kilometers per hour, miles per hour, or meters per second. Acceleration is defined as the time rate of change of velocity: the change of velocity divided by the time interval during the change. Acceleration may be measured in such units as meters per second or feet per second. Regarding the size or weight of the moving object, no mathematical problems are presented, if the object is very small compared with the distances **involved**. If the object is large, it contains one point, called the center of mass, the motion of which can be described as characteristic of the whole object. If the object is **rotating**, it is frequently convenient to describe its rotation about an **axis** that goes through the center of mass.

To fully describe the motion of an object, the direction of the displacement must be given. Velocity, for example, has both **magnitude** (a scalar quantity measured, for example, in meters per second) and direction (measured, for example, in degrees of arc from a reference point). The magnitude of velocity is called speed.

Several special types of motion are easily described. First, velocity may be constant. In the simplest case, the velocity might be zero; position would not change during the time interval. With constant velocity, the average velocity is equal to the velocity at any particular time. In the second special type of motion, acceleration is constant. Because the velocity is changing, instantaneous velocity, or the velocity at a given instant must be defined. Falling objects accelerate in response to the force exerted on them by Earth's gravity. Different objects accelerate at the same rate, regardless of their mass.

Circular motion is another simple type of motion. If an object has constant speed but an acceleration always at right **angles** to its velocity, it will travel in a circle. The required acceleration is directed toward the center of the circle and is called **centripetal acceleration.**

Another simple type of motion that is frequently observed occurs when a bad is **thrown** at an angle into the air. Because of gravitation, the ball **undergoes** a constant downward acceleration that first slows its original upward speed and then increases its downward speed as it falls back to earth. Meanwhile the horizontal component of the original velocity remains constant (ignoring air resistance), making the ball travel at a constant speed in the horizontal direction until it hits the earth. The vertical and horizontal components of the motion are independent and they can be analyzed separately. The resulting path of the ball is in the shape of a parabola.

Task 7. Answer the following questions on the text:

1. What is kinetics?
2. How is the time rate of change of position defined in kinetics?
3. What is acceleration and how is it measured?
4. In what way is it convenient to describe the rotating object?
5. What must be given to fully describe the motion of an object?
6. What is speed?
7. What special type of motion is easily described?

Task 8. a) Find an odd word:

1. *movement (n),* move, motion, mobility, stillness;
2. *motivate (v),* cause, impulse, stimulate, tranquilize, impel;
3. *part (n),* bit, section, component, aggregate, fragment, member;
4. *divide (v),* detach, unite, separate, split, dissolve, disconnect;
5. *round (adj),* circular, orbicular, rectangular, spherical, convex.

b) Match the word on the left with the correct definition on the right:

1. define	a) turn like a wheel around an axis or a fixed point;
2. measure	b) space between two diverging lines;
3. involve	c) experience or endure smth;
4. rotate	d) acting, moving, or pulling toward a center or axis;
5. angle	e) imaging straight line around an object, such as the earth, etc;
6. instant	f) result of the multiplication of two or more quantities;
7. undergo	g) present or current;
8. centripetal	h) particular system used to determine the dimensions, area;
9. axis	i) contain or include as a necessary element of sth;
10. product	j) state or describe sth clealy.

Task 9. Fill in the table with the missing parts of speech (if they exist) and translate them into Ukrainian:

Noun	Adjective	Verb
supersedence		
discount		
		velocitize
	concerned	
		study
		branch
	natural	
		separate
	analyzed	
direction		
		travel
	horizontal	
circle		
		back

Task 10. Translate the following sentences into English:

1. Механіка є галуззю фізики, що вивчає рух об’єктів.
2. У механіці використовують такі поняття, як сила, прискорення, час, маса та швидкість.
3. Стародавні вчені вважали, що Сонце і Місяць обертаються навколо Землі.
4. Галілей почав вираховувати швидкість, беручи до уваги відстань, пройдену від певного початкового положення і час витрачений на це.
5. Галілей довів, що швидкість об’єкта, що падає постійно, зростає протягом падіння.
6. Ньютон вдосконалив аналіз, визначивши силу і масу щодо прискорення.
7. Закони Ньютона стосовно об’єктів, що рухаються зі швидкістю близькою до швидкості світла, були вдосконалені у теорії відносності Альберта Ейнштейна.
8. Три закони Ньютона залишаються основними для розуміння динаміки.
9. Кінетика вивчає рух, не беручи до уваги те, що спричиняє рух.
10. Швидкість – це пройдена відстань, поділена на проміжок часу.
11. Прискорення визначається як коефіцієнт зміни періоду часу швидкості.
12. У центрі великого об’єкта знаходиться точка, що називається центром ваги, рух якої можна визначити як рух цілого об’єкта.
13. Якщо об’єкт обертається, то можна визначати його обертовий момент за допомогою осей, що проходять через центр маси.
14. Якщо швидкість дорівнює нулю, розташування об’єкта не зміниться протягом часового проміжку.
15. Збільшення швидкості називається прискоренням.
16. Важливим висновком, що випливає з цього рівняння, є залежність відстані, помноженої на час у квадраті.
17. Якщо об’єкт має постійну швидкість, але прискорення надається постійно з правого боку, то він буде рухатися по колу.

Part III. FORCE AND MASS

Task 11. Find the meaning and pronunciation of the highlighted words in a dictionary and learn them:

To understand why and how objects accelerate, force and mass must be defined. At the **intuitive** level, a force is just a **push** or a **pull**. It can be measured in terms of either of two effects. A force can either distort something, such as a **spring**, or accelerate an object. The first **effect** can be used in the calibration of a spring scale, which can in turn be used to measure the amplitude of a force: the greater the force, *F*, the greater the stretch, *x*. For many springs, over a limited range, the stretch is proportional to the force:

$$F = kx$$

where *k* is a constant that depends on the nature of the spring material and its dimensions.

Components of Velocity. Neglecting air resistance, a ball thrown into the air at an angle will travel in a parabolic path. The velocity of the ball (V) has independent vertical (V) and horizontal (H) components. The horizontal component stays the same the entire time the ball is in the air, while the vertical component, the only component **affected** by gravity, changes continuously while the ball is **aloft**.

Force, in physics is **determined** as any action or influence that accelerates an object. Force is a vector, which means that it has both direction and magnitude. When several forces act on an object, the forces can be combined to give a net force. The **net force** acting on an object, the object's mass, and the acceleration of the object are all related to each other by Newton's second law of motion, named after English physicist and mathematician Newton.

Mass in physics is stated as an amount of matter that a body contains, and a measure of the inertial property of that body, that is, of its resistance to change of motion. Mass is different from weight, which is a measure of the attraction of the earth for a given mass. Inertial mass and gravitational mass are identical. Weight, although proportional to mass, varies with the position of a given mass relative to the earth. Thus, **equal** masses at the same location in a gravitational field will have equal

weights. A mass in **interstellar** space may have zero weight. A fundamental principle of classical physics is the law of conservation of mass, which states that matter cannot be created or **destroyed**. This law **holds true** in chemical reactions but is modified in cases where atoms **disintegrate** and matter is converted to energy or energy is converted to matter.

Task 12. Answer the following questions:

1. Why must force and mass be defined?
2. What is force at the intuitive level?
3. In what way can the force be measured?
4. What can the effect of distortion be used for?
5. What is proportional to the force for springs over a limited range?
6. How will the ball, thrown into the air at an angle, travel?
7. What do independent vertical and horizontal components state?
8. How is force determined in physics?
9. How are net force, the object's mass and the acceleration related to each other?
10. Is mass different from weight?

Task 13. Decide whether the following statements are true or false according to the texts from Part I and III. Prove your answers using the given information:

1. Energy is the description of motion with regard to what causes motion.
2. Velocity may be measured in such units as kilograms.
3. Velocity has both mass and energy.
4. Because the velocity is stable, instantaneous velocity must be defined.
5. Because of magnitude, the ball undergoes a constant downward acceleration.
6. To understand why and how objects move, energy and velocity must be defined.
7. For many springs, over a limited range, the stretch isn't proportional to the acceleration.
8. Matter in physics is stated as an amount of mass that a body contains.
9. Taking into consideration air resistance, a ball thrown into the air at an angle will travel in a narrow path.
10. A mass in interstellar space may have high weight.

Task 14. a) Choose the right variant from the listed below:

1. When several forces act on an object, the forces can be combined to give a ____

a) potential energy; b) net force; c) vector; d) equation.

2. A mass in interstellar space may have_____

a) high velocity; b) net force; c) small weight; d) zero weight.

3. Mass is different from weight, which is a measure of the _____of the earth for a given mass.

a) diameter; b) addition; c) attraction; d) subtraction.

4. A force can ____ something, such as a spring.

a) tease; b) create; c) distort; d) ruin.

5. Force is a _____, which means that it has both direction and magnitude.

a) detector; b) vector; c) quantity; d) conductor.

b) Match the word on the left with the correct definition on the right:

1. pull	a) act upon or have an effect on sb or sth;
2. define	b) break into components or fragments;
3. push	c) state or describe sth clearly;
4. distort	d) extend sth;
5. intuitive	e) apply force to a physical object;
6. net	f) resilient metal coil;
7. affect	g) bend, or change from a normal or natural shape;
8. stretch	h) known directly and instinctively, without being discovered or consciously perceived;
9. disintegrate	i) remaining from the amount after all deductions;
10. spring	j) press against sb or sth in order to move that person or object;

Task 15. Using active vocabulary of the module speak on the following topics:

a) Aristotle, Galileo, Newton and Einstein with regard to kinetics;

b) Cornerstone of dynamics;

c) Causes and special types of motion.