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Professional English Physics

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Навчальний посібник містить професійно орієнтовані текстові матеріали з різних розділів фізики, наукового та професійного спілкування, відповідні лексичні та граматичні вправи і списки термінів згідно з навчальною програмою.

Для студентів I–V курсів напряму 6.040204 "Прикладна фізика".

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ПЕРЕДМОВА

Навчальний посібник укладений для студентів 1–5 курсів напряму 6.040204 “Прикладна фізика”. Навчальними програмами з іноземної мови передбачено вивчення студентами п’яти курсів напряму “Прикладна фізика” тем, що включені до змісту навчального посібника, а саме: “Комп’ютери”, “Фізика. Механіка. Кінематика. Статика”, “Динаміка. Закони Ньютона”, “Молекулярна фізика і термодинаміка”, “Електрика і магнетизм”, “Оптика”, “Квантова фізика. Атомна фізика”, “Ядерна фізика”, “Наноструктури та нанотехнології”, “Наукова мова”, “Наукові конференції”, “Професійне спілкування” та “Науковий і технічний переклад. Мова наукових досліджень”.

Основна мета навчального посібника – навчити майбутніх фізиків основам професійного спілкування англійською мовою. Автори також ставили перед собою завдання розвинути у студентів стійкі навички читання, перекладу, анотування, реферування технічної літератури з метою отримання і використання інформації, необхідної для професійної діяльності.

Граматичні вправи охоплюють такі граматичні категорії: Nouns, Articles, Adjectives, Adverbs, Numerals, Verb Tenses, Passive Voice, Indirect Constructions, Infinitive, Gerund, Participle, Modals, Conditionals, Formal and Informal Styles of Writing.

Наявність списків термінів до кожної теми допомагає студентам краще оволодіти лексичним матеріалом та дає змогу розширити словниковий запас. Тематичний матеріал кожного модуля закріплюється системою вправ, які дозволяють працювати окремо з лексичними одиницями, зі словосполученнями, реченнями та з текстом і які розподіляються за рівнем складності. Серед запропонованих навчальних матеріалів підручник містить також завдання комунікативної спрямованості з використанням сучасних інтерактивних технологій: рольові ігри, “мозковий штурм”, робота у парах, групах, підготовка презентацій та творчі завдання, що сприяють активізації роботи студентів. Наукові та професійні тексти підібрані з оригінальної літератури з урахуванням фаху студентів.

Засвоєння лексичного та граматичного матеріалу допоможе студентові орієнтуватися в англомовній літературі фахового спрямування, брати участь у міжнародних конференціях.

Unit 2. Inertia, Mass and Weight. Newton's First Law.

Active vocabulary

1. Acceleration [əkˌselə'reɪʃ(ə)n]	прискорення
2. Applied force [ə'plaɪd'fɔːs]	прикладена сила
3. Axis ['æksɪs] (*pl.* axes)	вісь
4. Centripetal acceleration [sen'trɪpɪtl əkˌselə'reɪʃən]	доцентрове прискорення
5. Constant velocity ['kɔnstənt vɪ'lɔsətɪ]	постійна швидкість
6. Direction [d(a)ɪ'rekʃ(ə)n]	напрямок
7. External force [ɪk'stɜːnəl'fɔːs]	зовнішня сила
8. Inertia [ɪ'nɜːʃə]	інерція, сила інерції
9. Inertial reference frame [ɪ'nɜːʃəlˌrefərəns'freɪm] Inertial frame of reference	інерціальна система відліку
10. (To) interact [ˌɪntər'ækt]	взаємодіяти
11. Isolated ['aɪsəleɪtɪd]	ізольований
12. Law of inertia [lɔː əv ɪ'nɜːʃə]	закон інерції
13. Mass [mæs]	маса
14. (To) measure ['meʒə]	вимірювати
15. Motionless ['məuʃ(ə)nlɪs]	нерухомий
16. Moving object ['muːvɪŋ'ɒbʤekt]	об'єкт, що рухається
17. Newton's law ['njuːt(ə)nz lɔː]	закон Ньютона
18. Non-inertial reference frame [nɔnɪ'nɜːʃəlˌrefərəns'freɪm]	неінерціальна система відліку
19. Property ['prɒpətɪ]	властивість, якість
20. (To) observe [əb'zɜːv]	спостерігати
21. (To) quantify ['kwɒntɪfaɪ]	визначати кількість
22. Quantity ['kwɒntɪtɪ]	кількість, величина
23. Reference frame [ˌref(ə)rəns 'freɪm]	система відліку
24. (To) resist [rɪ'zɪst]	протистояти, протидіяти
25. Rotational motion [rəu'teɪʃənəl'məuʃən]	обертальний рух
26. (To) weigh [weɪ]	важити, зважувати(ся)

Pre-reading task (discussion)

Exercise 14. Answer the following questions.

1. What is Newton famous for?
2. When and where did Newton live?
3. What contribution into dynamics did Newton make?

Reading

Exercise 15. Read and translate the text. Pay attention to pronunciation of Isaac Newton ['aɪzək 'njuːtən].

NEWTON'S FIRST LAW OF MOTION AND INERTIAL FRAME

We begin our study of forces by imagining some situations. Imagine placing a puck on a perfectly level air hockey table. You expect that it will remain where it is placed. Now imagine your air hockey table is located on a train moving with constant velocity. If the puck is placed on the table, the puck again remains where it is placed. If the train accelerates, the puck would start moving along the table.

A moving object can be observed from any number of reference frames. *Newton's first law of motion*, sometimes called the *law of inertia*, defines a special set of reference frames called inertial frames. This law can be stated as follows: *If an object does not interact with other objects, it is possible to identify a reference frame in which the object has zero acceleration.*

Such a reference frame is called an inertial frame of reference. When the puck is on the air hockey table located on the ground, you are observing it from an inertial reference frame − there are no horizontal interactions of the puck with any other objects and you observe it to have zero acceleration in that direction. When you are on the train moving at constant velocity, you are also observing the puck from an inertial reference frame. Any reference frame that moves with constant velocity relative to an inertial frame is itself an inertial frame. When the train accelerates, however, you are observing the puck from a non-inertial

Isaac Newton (1642–1727)
English physicist

Isaac Newton was one of the most brilliant scientists in history. Before the age of 30, he formulated the basic concepts and laws of mechanics, discovered the law of universal gravitation, and invented the mathematical methods of calculus. Newton was able to explain the motions of the planets, the ebb and flow of the tides, and many special features of the motions of the Moon and the Earth. He also interpreted observations concerning the nature of light.

reference frame because you and the train are accelerating relative to the inertial reference frame of the surface of the Earth. While the puck appears to be accelerating according to your observations, we can identify a reference frame in which the puck has zero acceleration. For example, an observer standing outside the train on the ground sees the puck moving with the same velocity as the train had before it started to accelerate.

A reference frame that moves with constant velocity relative to the distant stars is the best approximation of an inertial frame. The Earth is not really an inertial frame because of its orbital motion around the Sun and its rotational motion around its own axis, both of which result in centripetal accelerations. These accelerations are small compared with *g* and can often be neglected. For this reason, we assume that the Earth is an inertial frame, as is any other frame attached to it.

Let us assume that we are observing an object from an inertial reference frame, so we can give a practical statement of Newton's first law of motion: In the absence of external forces, when viewed from an inertial reference frame, an object at rest remains at rest and an object in motion continues in motion with a constant velocity.

In simpler terms, **Newton's first law** states*: when no force acts on an object, or if the total force on an object is zero, its center of mass continues in the same state of motion (and the acceleration of the object is zero).* If nothing acts to change the object's motion, then its velocity does not change. From the first law, we conclude that any *isolated object* (that does not interact with its environment) is either at rest or moving with constant velocity. The tendency of an object to resist any attempt to change its velocity is called *inertia (from 'Physics for Scientists and Engineers').*

Exercise 16. Translate the following phrases into English.

1. потяг, що рухається з постійною швидкістю
2. шайба, розміщена на столі
3. взаємодіяти з іншими об'єктами
4. можливо визначити систему відліку
5. нульове прискорення
6. ви спостерігаєте її з інерціальної системи відліку
7. рухатись з постійною швидкістю відносно інерціальної системи
8. ви і потяг прискорюєтесь відносно інерціальної системи відліку

9. спостерігач, який стоїть ззовні потягу
10. далекі зірки
11. найкраще наближення
12. рух по орбіті (орбітальний рух)
13. обертальний рух навколо своєї осі
14. обидва призводять до доцентрового прискорення
15. часто можна знехтувати
16. при відсутності зовнішніх сил

Exercise 17. Answer the questions to the text.
1. What is another name for Newton's first law of motion?
2. State Newton's first law of motion.
3. What is an inertial reference frame? Give an example.
4. What is an isolated object?
5. What is inertia?

Exercise 18. Read and translate the text below.

INERTIA, MASS AND WEIGHT

Newton's first law of motion states: An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force. It is the natural tendency of objects to resist changes in their state of motion which is called inertia. So, *inertia* is the resistance an object has to a change in its state of motion.

All objects resist changes in their state of motion. All objects have this tendency − they have inertia. But some objects have more of a tendency to resist changes than others. The tendency of an object to resist changes in its state of motion varies with mass. Mass is dependent upon the inertia of an object. The more inertia an object has, the more mass it has. A more massive object has a greater tendency to resist changes in its state of motion. Suppose that there are two seemingly identical bricks at rest on the table. But one brick consists of mortar and the other brick consists of Styrofoam. If you don't lift the bricks, you cannot tell which brick is the Styrofoam brick. You can give the bricks an identical push in an effort to change their state of motion. The brick that offers the least resistance is the brick with the least inertia − and therefore the brick with the least mass.

Imagine playing with either a basketball or a bowling ball. Which ball is more likely to keep moving when you try to catch it? Which ball has the greater tendency to remain motionless when you try to throw it? The bowling ball is more resistant to changes in its velocity than the basketball.

Mass is that property of an object that specifies how much resistance an object exhibits to changes in its velocity. Mass is the quantity of matter in an object. Mass is also the measure of inertia of an object. The SI unit of mass is the kilogram. The greater the mass of an object, the less that object accelerates under the action of a given applied force. Mass is a property of an object and is independent of the object's surroundings and the method used to measure it. Mass is a scalar quantity.

Mass should not be confused with weight. Mass and weight are two different quantities. The SI unit of weight is the Newton. People commonly refer to the kilogram as a unit of weight, but the kilogram is a unit of mass, not weight.

The *weight* of an object is equal to the magnitude of the gravitational force exerted on the object and it varies with location. For example, a person who weighs 180 lb on the Earth weighs only about 30 lb on the Moon. On the other hand, the mass of an object is the same everywhere: an object having a mass of 2 kg on the Earth also has a mass of 2 kg on the Moon. Mass and weight are proportional to each other in a given place. Objects with great mass have great weight; objects with little mass have little weight *(from "Physics for Scientists and Engineers").*

Exercise 19. Review the distinction between mass and weight and circle the correct answer below.

1. *Mass/ Weight* is the quantity of matter in an object.
2. *Mass/ Weight* is a measure of the gravitational force acting on an object.
3. *Mass/ Weight* is measured in kilograms.
4. The more *mass/ weight* the object has, the greater its inertia.
5. *Mass/ Weight* is measured in Newtons.
6. *Mass/ Weight* depends on an object's location, whereas *mass/ weight* does not.
7. A stone has the same *mass/ weight* on the Earth and on the surface of the Moon, but its *mass/ weight* is different.
8. *Mass/ Weight* is a measure of the amount of matter in an object and it only depends on the number and kind of atoms that compose it.

Exercise 20.Match each phrase with the correct word.

1. traditional unit of weight in the USA	a) kilogram
2. measure of matter in most parts of the world	b) mass
3. SI unit of mass	c) pound
4. SI unit of force	d) newton

Exercise 21. Which of the following statements about inertia, mass and weight are true? Circle the numbers of seven correct statements.

1. Inertia is a force.
2. All objects have inertia.
3. Fast-moving objects have more inertia than slow-moving objects.
4. The standard metric unit of mass is the kilogram.
5. Mass depends on how much stuff is present in an object.
6. The mass of an object is variable and dependent upon its location.
7. The weight of an object is dependent upon the value of the acceleration of gravity.
8. Weight refers to a force experienced by an object.
9. The weight of an object would be less on the Moon than on the Earth.
10. The weight of an object can be measured in kilograms.

Exercise 22. Answer the questions.

1. Describe the property of inertia in your own words.
2. What is mass? What is the SI unit of mass?
3. What is the relationship between the mass of an object and its acceleration under the action of a given applied force?
4. What is weight? What is the SI unit of weight?
5. What are the differences of weight and mass?

Grammar. Revision (all, another, other, each, every, neither, both).

Exercise 23. Complete the text with the words in the box.

~~*both*~~	*other*	*other*	*another*	*another*
both	*neither*	*every*	*all*	*each*

WEIGHT, MASS AND INERTIA

What is the difference between mass and weight? It is confusing and people often think [1] *both* words mean the same thing, but to an astronomer or a physicist [2]_____ concept is completely different.

What is weight? [3]_____ object in the universe attracts [4]_____ objects. The attraction depends on the size of the objects

and the distance between them. This attraction is called gravity. Weight is the effect of the Earth's gravity on objects on its surface. If you weigh 70 kg, that is the result of the earth gravity on your body, but on [5]_____ planet of a different size your weight would be different.

What is mass? [6] _____ objects have a quality called 'inertia'. Mass is a measure of how much inertia an object has. Imagine you are an astronaut floating in space with [7]_____ astronaut. In space [8]_____ of you would be weightless but [9]_____ of you would be mass-less. If you wanted to move the [10]_____ astronaut, you would have to push him to get him going and pull him to make him stop. A body in space has inertia, and therefore mass, but it has no weight.

Grammar. Passive Voice.

Exercise 24. Rewrite the sentences in Passive Voice.

1. Somebody stole my bag in the shop. 2. The police have arrested three men. 3. The bill includes service. 4. People don't use this road very often. 5. They cancelled all flights because of fog. 6. Someone has accused me of stealing the money. 7. I didn't realize that someone was recording our conversation. 8. They have changed the date of general meeting. 9. Brian told me that somebody had attacked and robbed him in the street. 10. Van Gogh painted "Sunflowers". 11. The government will introduce new measures against crime. 12. They killed elephants for ivory. 13. They check passports at Passport Control.

Exercise 25. Put the verbs in brackets into the correct Passive form.

Professor Higgins, who *1)* *was awarded (to award)* a major science prize last month, *2)* _____ *(to invite)* to take part in a conference which *3)* _____ *(to hold)* in London last week. He *4)* _____ *(to meet)* at the airport by a driver who, unfortunately *5)* _____ *(to give)* the name of the wrong hotel to take the professor to. A large reception *6)* _____ *(to organize)* for the professor, and at least 200 eminent scientists *7)* _____ *(to invite)* to meet him that evening. The poor professor, however, *8)* _____ *(to leave)* at a small hotel in a rather bad area, and when he asked to speak to the Head of the Conference Committee he *9)* _____ *(to tell)* to try somewhere else because he *10)* _____ *(not/hear of)* there. Luckily, later that evening, the driver *11)* _____ *(to send)* to

the hotel where the reception [12] _____ *(to hold)*, and when he [13] _____ *(to ask)* what he had done with the professor, everyone realized that a mistake [14] _____ *(to make).*

Exercise 26. Rewrite the following passages in the Passive.

1. Our apartment-block is starting a new scheme. We will collect all the old newspapers and tin cans. We will put them in a special container. When the container is full, the council will collect it. They will take it to a factory. The factory will recycle the newspapers and cans into something new. – *A new scheme…*

2. James Cameron wrote and directed the hit science fiction film *Avatar*. 20th Century Fox released the film in 2009. Most critics gave the film excellent reviews. The film impressed the public, too. Within 3 weeks of its release, *Avatar* had made over 1 billion dollars at the box office! Cameron will make two sequels. He has already asked the same actors to star in the sequels. - *The hit science fiction film 'Avatar'…*

Speaking

Exercise 27. In pairs, give definitions to the following terms.
Student A: mass, inertia, kilogram, inertial frame of reference.
Student B: weight, newton, constant velocity, law of inertia.

Writing

Exercise 28. Translate the sentences into English using active vocabulary.
1. Інерція – це явище збереження стану спокою або рівномірного прямолінійного руху тілом, коли зовнішній вплив відсутній або компенсується. 2. Прямолінійний і рівномірний рух вільного тіла в інерціальній системі відліку називають рухом за інерцією, а перший закон Ньютона – законом інерції. 3. Перший закон Ньютона можна виразити наступним чином: коли ніякі тіла чи сили не діють на тіло, або їхня дія скомпенсована, воно знаходиться у стані спокою або рівномірного прямолінійного руху. 4. Тіло, на яке не діють інші тіла чи поля, або їхні дії скомпенсовані, називають ізольованими тілами. 5. Системи відліку, в яких ізольоване тіло перебуває у стані спокою або рухається рівномірно і прямолінійно, називаються інерціальними системами відліку. 6. В основі динаміки лежать три закони Ньютона, які є основними законами класичної механіки.

Unit 3. Newton's Second and Third Laws of Motion.

Active vocabulary

1. (To) apply [ə'plaɪ]	прикладати, застосовувати
2. Approximately [ə'prɔksɪmətlɪ]	приблизно
3. (To) balance ['bæləns]	балансувати, зрівноважувати
4. (To) be at rest [rest]	знаходитись у стані спокою
5. Binomial theorem [baɪ'nəumɪəl'θɪərəm]	біном Ньютона, біноміальна теорема
6. Differential calculus [ˌdɪfə'renʃəl 'kælkjuləs]	диференціальне числення
7. Directly proportional [d(a)ɪ'rektlɪ prə'pɔːʃənəl]	прямо пропорційний
8. (To) double ['dʌbl]	подвоювати
9. Downward ['daunwəd]	вниз
10. Frictionless surface ['frɪkʃənləs'sɜːfɪs]	поверхня без тертя
11. (To) increase [ɪn'kriːs]	зростати, збільшувати(ся)
12. Inversely proportional ['ɪn'vɜːslɪ prə'pɔːʃənəl]	обернено пропорційний
13. Integral calculus ['ɪntɪgrəl'kælkjuləs]	інтегральне числення
14. Non-inertial frame of reference [nɔnɪ'nɜːʃəl'freɪm əv'ref(ə)rəns]	неінерціальна система відліку
15. Reaction force [rɪ'ækʃən'fɔːs]	сила реакції, протидійна сила
16. Rotation [rəu'teɪʃ(ə)n]	обертання
17. Subscript ['səbˌskript]	нижній індекс
18. (To) triple ['trɪpl]	потроювати
19. (To) undergo [ˌʌndə'gəu]	зазнавати, піддаватися
20. Upward force ['ʌpwəd'fɔːs]	підйомна сила
21. Value ['vælju:]	величина, значення

Reading

Exercise 29. Read and translate the text below.

NEWTON'S SECOND AND THIRD LAWS

Newton's first law explains what happens to an object when no forces act on it. It either remains at rest or moves in a straight line with constant velocity. Newton's second law answers the question of what happens to an object that has nonzero resultant force acting on it.

Imagine performing an experiment in which you push a block of ice across a frictionless horizontal surface. When you exert some horizontal

force on the block, it moves with some acceleration. If you apply a force twice as great, you find that the acceleration of the block doubles. If you increase the applied force to 3, the acceleration triples, and so on. From such observations, we conclude that the acceleration of an object is directly proportional to the force acting on it.

The acceleration of an object also depends on its mass. We can understand this by considering the following experiment. If you apply a force *F* to a block of ice on a frictionless surface, the block undergoes some acceleration *a*. If the mass of the block is doubled, the same applied force produces acceleration *a/2*. If the mass is tripled, the same applied force produces acceleration *a/3*, and so on. According to this observation, we conclude that the magnitude of the acceleration of an object is inversely proportional to its mass.

These observations are summarized in *Newton's second law*: **When viewed from an inertial reference frame, the acceleration of an object is directly proportional to the net (total) force acting on it and inversely proportional to its mass.**

Thus, we can relate mass, acceleration, and force through the following mathematical statement of Newton's second law: $a = F_{total} / m$

The SI unit of force is the newton, which is defined as the force that, when acting on an object of mass 1 kg, produces an acceleration of 1 m/s^2. From this definition and Newton's second law, we see that the newton can be expressed in terms of the fundamental units of mass, length, and time: 1 N=1 $kg \times m/s^2$. In the U.S. customary system, the unit of force is the pound.

If you press against a corner of the book with your fingertip, the book pushes back and makes a small dent in your skin. If you push harder, the book does the same and the dent in your skin is a little larger. This simple experiment illustrates a general principle of *Newton's third law*: **If two objects interact, the force $\mathbf{F_{12}}$ exerted by object 1 on object 2 is equal in magnitude and opposite in direction to the force $\mathbf{F_{21}}$ exerted by object 2 on object 1**.

When it is important to designate forces as interactions between two objects, we will use this subscript notation, where F_{ab} means "the force exerted by *a* on *b*." The third law is equivalent to stating that forces always occur in pairs, or that a single isolated force cannot exist. The force that object 1 exerts on object 2 may be called the *action force* and the force of object 2 on object 1 the *reaction force*. In reality, either

force can be labeled the action or reaction force. The action force is equal in magnitude to the reaction force and opposite in direction.

You experience the third law directly if you slam your fist against a wall or kick a football with your bare foot. You can feel the force back on your fist or your foot. The Earth exerts a gravitational force F_g on any object. If the object is a computer monitor at rest on a table, the reaction force to $F_g=F_{Em}$ is the force exerted by the monitor on the Earth $F_{mE} = - F_{Em}$. The monitor does not accelerate because it is held up by the table. The table exerts on the monitor an upward force $n = F_{tm}$, called the normal force. This is the force that prevents the monitor from falling through the table. The normal force balances the gravitational force on the monitor, so that the net force on the monitor is zero *(from "Physics for Scientists and Engineers").*

Exercise 30. Look for the English equivalents for the phrases in the text.
Він *(об'єкт)* або залишається у стані спокою, або рухається вздовж прямої лінії; через горизонтальну поверхню без тертя; рухатися з якимсь прискоренням; якщо ви застосовуєте вдвічі більшу силу; рівнодійна сила, що діє на нього *(об'єкт);* розглядаючи наступний експеримент; величина прискорення об'єкта обернено пропорційна; штовхати (натискати) сильніше; рівний за значенням і протилежний за напрямком; сила, з якою об'єкт 1 діє на об'єкт 2.

Exercise 31. Answer the questions.
1. State Newton's second law.
2. What does the acceleration of an object depend on?
3. Explain Newton's second law using your examples.
4. Explain Newton's third law using your examples.
5. What is the SI unit of force?

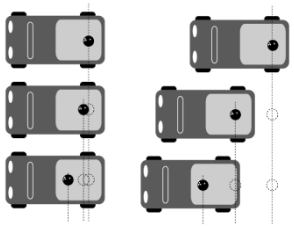
Exercise 32. Circle the correct answer.
1. Every action or force upon an object must have an equal and ___ reaction.
a) measurable b) complete c) opposite d) correct
2. In a vacuum, you throw a baseball. It travels at the _____ forever due to _____.
a) initial velocity, inertia d) initial acceleration, inertia
b) initial velocity, gravity e) initial acceleration, gravity
c) gravitational constant velocity, inertia

3. When a box rests on the floor, it is acted upon by the gravitational and the _____ force.
a) friction b) acceleration c) normal d) inertia
4. According to Newton, force is equal to mass multiplied by _____.
a) velocity b) acceleration c) momentum d) speed

Exercise 33. Read and translate the text below.

INERTIAL AND NON-INERTIAL REFERENCE FRAMES

You're driving in your pickup truck, on your way to deliver a bowling ball. The ball is in the back of the truck. Then you have to slow down because a stop sign is coming up. As you brake, you see the ball accelerating toward you. Did some mysterious force push it forward? No, it only seems that way because you and the car are slowing down. The ball is obeying Newton's first law, and as it continues at constant velocity it gets ahead relative to the slowing truck. No forces are acting on it. The ball only appeared to violate Newton's first law because there was something wrong with your frame of reference, which was based on the truck. In a frame of reference that moves with the truck, the bowling ball appears to violate Newton's first law by accelerating despite having no horizontal forces on it (Fig. 3.3a). In an inertial frame of reference, which the surface of the earth approximately is, the bowling ball obeys Newton's first law. It moves equal distances in equal time intervals, i.e. maintains constant velocity. In this frame of reference, it is the truck that appears to have a change in velocity, which makes sense, since the road is making a horizontal force on it (Fig. 3.3b).



a *b*

Fig. 3.3. Moving and inertial frames of references

The reason why Newton's laws fail in the truck's frame of reference is not because the truck is moving but because it is accelerating. Newton's laws were working fine in the moving truck's frame of reference as long as the truck was moving at constant velocity. It was only when its speed changed that there was a problem. How, then, are we to tell which frames are accelerating and which are not? The way to settle such a dispute is to examine the motion of some

object, such as the bowling ball, which we know has zero total force on it. Any frame of reference in which the ball appears to obey Newton's first law is then a valid frame of reference.

Valid frames of reference, in which Newton's laws are obeyed, are called inertial frames of reference. Frames of reference that are not inertial are called non-inertial frames. In those frames, objects violate the principle of inertia and Newton's laws. While the truck was moving at constant velocity, both it and the sidewalk were valid inertial frames. The truck became an invalid frame of reference when it began changing its velocity.

Thus, a frame of reference that remains at rest or moves with constant velocity with respect to other frames of reference is called *inertial frame of reference*. It is actually a non-accelerating frame of reference. Newton's laws of motion and all the fundamental laws of mechanics are valid in all inertial frames of reference.

A frame of reference which is accelerating is called *non-inertial frame of reference.* In this reference frame the observers are undergoing some accelerating force, such as gravity or a mechanical acceleration. Newton's laws of motion are no longer valid in non-inertial frames of reference *(from 'Newtonian Physics').*

Exercise 34. Read the statements and identify the difference between inertial and non-inertial reference frames. Tick (✓) in the appropriate column.

Statement	Inertial reference frame	Non-inertial reference frame
1. _____ is accelerating.		
2. ____ is at rest or moves with constant velocity with respect to other frames of reference.		
3. The law of inertia is obeyed in _____.		
4. In _____, objects violate the principle of inertia and Newton's laws.		
5. Newton's Second Law is true in _____.		
6. In ____ a particle (body) is free from external forces and moves at constant velocity.		
7. If a person is observing a moving car while at rest or while moving at constant velocity, he is in ____.		

Video watching 'Sir Isaac Newton Biography' (Video 3.1)

Exercise 35. Watch the video extract and answer the questions.

1. What was Sir Isaac Newton? What did he do?
2. What does the first law state?
3. What does the second law state?
4. What does the third law state?
5. What did Newton invent?
6. What theory did he devise?

Exercise 36. Complete some notes from the video extract using no more than three words. Watch the video again and check your answers.

1. Much of classical mechanics of the set of physical laws describing the _____ and the force are laid out on the Newton's mathematical principles of _____ philosophy published in _____.
2. The first law, or the _____, states that an object at rest will _____, and an object in motion will _____ unless acted upon by an _____.
3. The second law states that acceleration is produced when an _____ acts on a mass.
4. Newton's third law of motion states that for every action there is an _____ and _____.
5. The theory was based on the observation that a prism breaks down _____ into many visible colours.
6. Newton is attributed with the development of _____ calculus as well as he generalized _____.

Speaking

Exercise 37. Make a list of Newton's contribution into physics generalizing video extract above. Discuss it with your group.

Exercise 38. Define the following terms.

Upward force	Inertial reference frame	To be at rest
Reaction force	Non-inertial reference frame	Acceleration

Grammar. Passive Voice.

Exercise 39 . Complete the text with the past simple form of the verbs in the box below. Use active or passive voice according to the context

die	*change*	*move*	*study*	*design*	*live*
publish	*produce*	*provide*	*bear*	*use*	

Sir Isaac Newton: scientist and mathematician

Isaac Newton _____ on December 25, 1642 in Woolsthorpe, near Grantham in Lincolnshire, England. He was born in the same year that Galileo _____. Newton is probably the most important scientist in history. His work on mathematics and physics _____ a basis for modern science, and his ideas _____ the world.

Newton's works _____ in two books, Optiks and Principia. These contained his laws of motion and gravity. These laws _____ to predict the movements of stars, and the planets around the Sun. Newton also _____ and built the world's first reflecting telescope.

Newton _____at Trinity College, Cambridge, from 1661 to 1696. In this period, most of his important work _____. Then, in 1696, he _____ to London, where he _____ until his death on March 20, 1727.

Exercise 40. Rewrite the following passage in the passive.

James Fitt witnessed a horrific plane crash last night. The fire brigade fought the wreckage fire while ambulance men rescued surviving passengers. Ambulances took all the survivors to hospital. No one knows yet what caused the plane to crash. Newspapers and TV reporters have already interviewed many of the survivors. The Civil Aviation Authority has launched a full investigation. They say that someone may have seen the accident happen. They hope that the aircraft's "black box" will provide the vital information but they haven't found it yet. They are continuing the search. – *A horrific plane crash …*

Exercise 41. Use Passive or Active according to the context.

1. The driver _____ *(go)* too fast when he hit the man.
2. We hope that the missing money _____ *(find)* soon. 3. A new bridge _____ *(build)* at the moment. 4. When she discovered that Tom _____ *(eat)* all the biscuits she got very angry. 5. It's no use trying – you _____ *(waste)* your time. 6. A

lot of money _____ *(spend)* on weapons nowadays. 7. Too many offices _____ *(build)* in London every year. 8. The president _____ *(give)* a speech next Monday.

Exercise 42. Translate the sentences into English using Passive voice.
1. Його вчора ніде не бачили. 2. Пожежа розпочалася вночі, і вогонь було видно здалеку. 3. Місто, в якому він народився, було засноване ще в 16 столітті. 4. Коли я увійшов, на зборах обговорювали дуже важливе питання. Його вже обговорювали протягом години. 5. За машиною відправлять, щойно вони складуть речі. 6. Його промова на зборах була такою яскравою, що про неї багато говорять до цього часу. 7. Вона дуже сумлінна людина, тому на неї можна завжди покластися. 8. На цих дітей зацікавлено подивились, коли вони з'явились у залі. 9. Зі мною раніше ніколи так не розмовляли. 10. Про цю історію часто говорять у нашому будинку. 11. На неї чекали вже півгодини, коли вона нарешті з'явилась. 12. На цю гору раніше ніколи не піднімались. 13. Київ поділяється річкою Дніпро на лівий і правий береги. 14. Цього лектора завжди слухають дуже уважно.

Writing

Exercise 43. Translate the sentences into English using active vocabulary.
1. Другий закон Ньютона можна сформулювати наступним чином: прискорення тіла прямо пропорційно сумі всіх сил, що діють на тіло, і обернено пропорційно його масі. 2. Напрямок вектору прискорення співпадає з напрямком вектору рівнодійної сили. 3. Закони Ньютона справедливі лише в інерціальних системах відліку. 4. Система відліку, що рухається з прискоренням відносно інерціальної системи відліку, називається неінерціальною системою відліку. 5. Третій закон Ньютона формулюють так: будь-якій дії є рівна й протилежно спрямована протидія. 6. Ньютон сформулював основні закони класичної механіки, відкрив закон всесвітнього тяжіння, розробив диференціальне та інтегральне числення.

Exercise 44. Summarize the information given in units 2 and 3 under the title 'Newton's Life and Scientific Activity. Newton's Laws of Motion'. Write a summary (10–15 sentences).

ЗМІСТ