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Introduction to Physics & Nanotechnology: part 1

Учебное пособие

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INTRODUCTION TO PHYSICS & NANOTECHNOLOGY: part 1: Учебное пособие по физике и нанотехнологиям для студентов неязыкового вуза /Сост. А.И. Матяшевская, Е.В. Тиден. — Саратов, 2016. — 54 с.

Предлагаемое учебное пособие представляет собой тексты по данной специальности с системой упражнений, направленных на развитие навыков устной и письменной речи. Аутентичный учебный материал позволяет решать учебно-методические проблемы на современном уровне.

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PREFACE

Настоящее пособие включает тексты по актуальной на сегодняшний день проблемам физики и нанотехнологий.

Пособие предназначено для студентов факультета нано- и биомедицинских технологий.

Целью данного пособия является формирование навыка чтения и перевода научной литературы, а также развитие устной речи.

Данное пособие помогает подготовить студентов к самостоятельной работе со специальной литературой, обучить устным формам общения по научной тематике на материале предложенных специальных текстов.

Пособие состоит из разделов, посвященных нанотехнологиям, механике, каждый из которых содержит тексты и упражнения. Раздел “Supplementary reading“ служит материалом для расширения словарного запаса и дальнейшего закрепления навыков работы с текстами по специальности.

Пособие предназначено как для аудиторных занятий, так и для внеаудиторной практики.

1. Nanotechnology and Medicine

Part 1

Exercise I.

Say what Russian words help to guess the meaning of the following words: characteristic, methodology, optimism, nanotechnology, medicine, diagnosis, interest, medical, nanotechnology, nanomedicine

Exercise II

Make sure you know the following words and word combinations. Nanoscience (1), treatment (1), dentistry (1), molecule (2), viruses (2), semiconductor (3), quantum dot (3), infrared rays (3), at the nanoscale (3), tissue engineering (4)

Future impact of nanotechnology on medicine

The human characteristics of curiosity, wonder, and ingenuity are as old as mankind. People around the world have been harnessing their curiosity into inquiry and the process of scientific methodology. Recent years have witnessed an unprecedented growth in research in the area of nanoscience. There is increasing optimism that nanotechnology applied to medicine and dentistry will bring significant advances in the diagnosis, treatment, and prevention of disease. Growing interest in the future medical applications of nanotechnology is leading to the emergence of a new field called nanomedicine. Nanomedicine needs to overcome the challenges for its application, to improve the understanding of physiologic basis of disease, bring more sophisticated diagnostic opportunities, and yield more effective therapies and preventive properties. When doctors gain access to medical robots, they will be able to quickly cure most known diseases that kill people today, to rapidly repair most physical injuries our bodies can suffer, and to vastly extend the human health span. Nanotechnology is destined to become the core technology underlying all of 21st century medicine and dentistry. In this article, we have made an attempt to have an early glimpse on future impact of nanotechnology in medicine and dentistry. (1)

Usually nanotechnology is defined as the research and development of materials, devices, and systems exhibiting physical, chemical, and biological properties that are different from those found on a larger scale (matter smaller than scale of things like molecules and viruses). (2)

Old rules don't apply, small things behave differently. In nanoland, tiny differences in size can add up to huge differences in function. Ted Sergent, author of The dance of Molecules, says matter is tunable at nanoscale. For example, change the length of a guitar string and you change the sound it makes; change the size of semiconductors called quantum dots, and you change their rainbow of colors from a single material. Sergent made a three-nanometric dot that ‘glows’ blue, and four nanometer dot that glows red and a five nanometer dot that emits infrared rays or heat. (3)

Nanotechnology will affect everything. Nanotechnology and the big changes coming from the inconceivably small. It'll be like a blizzard; snowflakes whose weight you can't detect can bring a city to a standstill.

Nanotechnology is going to be like that. The unique quantum phenomena that happen at the nanoscale, draw researchers from many different disciplines to the field, including medicine, chemistry, physics, engineering and dentistry. The scientists in the field of regenerative medicine and tissue engineering are continually looking for new ways to apply the principles of cell transplantation and bioengineering to construct biological substitutes that will restore and maintain normal function in diseased and injured tissue. Development of more refined means of delivering medications at therapeutic levels to specific sites is an important clinical issue, for applications of such technology in medicine, and dentistry. Diagnosis and treatment will be customized to match the preferences and genetics of each patient. (4)

The field of "Nanomedicine" is the science and technology of diagnosing, treating, and preventing disease and traumatic injury, of relieving pain, and of preserving and improving human health, using nanoscale structured materials, biotechnology, and genetic engineering. Nanomedicine could increase the efficiency and reliability of the diagnostics using human fluids or tissues samples by using selective nanodevices, to make multiple analyses at subcellular scale. Nanomedicine could develop devices able to work inside the human body in order to identify the early presence of a disease, to identify and quantify toxic molecules, tumor cells. (5)

Regenerative medicine is an emerging field to look for the reparation, improvement, and maintenance of cells, tissues, and organs by applying cell therapy and tissue engineering methods. Years ahead, complex nanodevices and even nanorobots will be fabricated, first of biological materials but later using more durable materials such as diamond to achieve the most powerful results. The human body is comprised of molecules, hence the availablity of molecular nanotechnology will permit dramatic progress to address medical problems and will use molecular knowledge to maintain and improve human health. (6)

Nanotechnology has brought new opportunities to develop powerful diagnostic tools able to identify genetic predisposition to diseases. In the future, point of care diagnosis will be routinely used to identify those patients requiring preventive medication to select the most appropriate medication for individual patients, and to monitor response to treatment. Nanotechnology has a vital role to play in realizing cost-effective diagnostic tools. Currently, most legal and illegal drug overdoses have no specific way to be effectively neutralized, using nanoparticles as absorbents of toxic drugs, is another area of medical nanoscience that is rapidly gaining momentum. A surgical nanorobot could perform various functions such as searching for pathology and then diagnosing and correcting lesions by nanomanipulation, coordinated by an onboard computer while maintaining contact with the supervising surgeon via coded ultrasound signals. Durability and appearance of tooth may be improved by replacing upper enamel layers with covalently bonded artificial materials such as sapphire or diamond, which have 20–100 times the hardness and failure strength of natural enamel. Pure sapphire and diamond are brittle and prone to fracture, can be made more fracture resistant as part of a nanostructured material. (7)

Potential benefits of nanotechnology are its ability to exploit the atomic or molecular properties of materials and the development of newer materials with better properties. Nanoproducts can be made by: building-up particles by combining atomic elements and using equipments to create nanoscale objects. Researchers are looking at ways to use microscopic entities to perform tasks that are now done by hand or with equipment. (8)

The visions described in this article may sound unlikely. Yet, the theoretical and applied research to turn them into reality is progressing rapidly. Nanotechnology will change dentistry, healthcare, and human life more profoundly than many developments of the past. It has potential to bring about significant benefits, such as improved health, better use of natural resources, and reduced environmental pollution. These truly are the days of miracle and wonder. (9)

Exercise III.

Find paragraphs, dealing with the following:

robots, viruses, nanoland, blizzard, tumor, sapphire, predisposition, exploit, nanoproducts, pollution

Exercise IV.

Answer the following questions:

1. What is nanotechnology? Is it new? Whre did it come from?

2. Why do scientists develop nanotechnology? Where is it used today? Where are some future uses of nanotechnology?

3. How can nanotechnology promise to develop products with both extreme precision in structure and environmental cleanliness in production process?

4. How is nanotech different from biotech?

5. Where is nanotechnology being developed? Which country leads in nanotechnology?

6. What are nanomaterials? Do they exist in nature? Classify nanomaterials and give examples for them. Classify nanocomposites.

7. What are nanoparticles, nanotubes and nanoplates? How do nanoparticles enter the body and how can you control exposure to them? What do you mean by quantum dots & nanocrystals?

8. What results can be expected in the near-term? The mid-term? The long-term?

9. How can you study nanotechnology at University and move your career in this direction?

10. List any 4 day to day live commercial applications of nanotechnology

11. List any 4 challenges that are faced by researchers in nanotechnology

12. What do you mean by characterization in relation with materials? List any 4 material characterization techniques.

13. Which are possible risks of nanotechnology today?

14. In nanotechnology, this is a process in which devices whose diameters are of atomic scale, on the order of nanometers, create copies of themselves. What is it?

15. The average carbon nanotube, in diameter, is one nanometer. If you had 10 million of these nanotubes lined right next to each other, how long would it be?

16. Nanomaterials are not only human-made materials; can you remember some examples of "non-intentionally made" nanomaterials, i.e. a nanomaterial that you can find in nature?

Exercise V.

Fill in the gaps according to the text.

1. Growing interest in the future medical applications of nanotechnology is leading to the emergence of a new field called…………….
2. For example, change the length of a guitar string and you change the sound it makes; change the size of …………..called quantum dots, and you change their rainbow of colors from a single material.
3. ……………medicine is an emerging field to look for the reparation, improvement, and maintenance of cells, tissues, and organs by applying cell therapy and tissue engineering methods.

4. Years ahead, complex ……………and even nanorobots will be fabricated, first of biological materials but later using more durable materials such as diamond to achieve the most powerful results.
5. Currently, most legal and illegal drug overdoses have no specific way to be effectively neutralized, using ……………as absorbents of toxic drugs, is another area of medical nanoscience that is rapidly gaining momentum.
6. Pure …………and diamond are brittle and prone to fracture, can be made more fracture resistant as part of a nanostructured material.
7. A surgical ……….could perform various functions such as searching for pathology and then diagnosing and correcting lesions by nanomanipulation, coordinated by an onboard computer while maintaining contact with the supervising surgeon via coded ultrasound signals.
8. Nanotechnology has brought new opportunities to develop powerful diagnostic tools able to identify genetic ………..to diseases.
9. Nanomedicine could develop devices able to work inside the human body in order to identify the early presence of a disease, to identify and quantify toxic molecules, cells.
10. It'll be like a blizzard; snowflakes whose weight you can't ………..can bring a city to a standstill.

Exercise VI .

Make up sentences of your own with the following word combinations: make an attempt, to have an early glimpse, to identify the early presence of a disease, bring new opportunities, have a vital role, done by hand, sound unlikely, to turn something into reality, to bring about, done by hand or with equipment

Exercise VII.

Determine whether the statements are true or false. Correct the false statements:

1. Nanotechnology is destined to become the core technology underlying all of 20th century medicine and dentistry.
2. When doctors gain access to medical robots, they will be able to quickly cure most known diseases that kill people today, to rapidly repair most physical injuries our bodies can suffer, and to vastly extend the human health span.
3. In nanoland, big differences in size can add up to huge differences in function.
4. Sergent made a three-nanometric dot that 'glows' yellow, and four nanometer dot that glows green and a five nanometer dot that emits infrared rays or heat.
5. The field of "Nanomedicine" is the science and technology of diagnosing, treating, and preventing disease and traumatic injury, of relieving pain, and of preserving and improving human health, using nanoscale structured materials, biotechnology, and genetic engineering.

6. Nanomedicine could increase the efficiency and reliability of the diagnostics using human fluids or tissues samples by using selective nanodevices, to make multiple analyses at cellular scale.
7. Durability and appearance of tooth may be improved by replacing upper enamel layers with covalently bonded artificial materials such as sapphire or diamond, which have 10–50 times the hardness and failure strength of natural enamel.
8. Nanotechnology will change dentistry, healthcare, and human life more profoundly than many developments of the past.
9. Nanotechnology has a vital role to play in realizing cost-effective diagnostic tools.
10. Diagnosis and treatment will be customized to match the preferences and genetics of each patient.

<u>Exercise VIII</u> .

Match the words to the definitions in the column on the right:

quantum	a material, such as silicon, that allows electricity to move through it more easily when its temperature increases, or an electronic device made from this material
nanomedicine	the area of medicine concerned with the development of treatments promoting the repair and replacement of tissues and organs, by stimulation of the body's natural capacity for regeneration, the use of stem cell therapy, etc.
methodology	The use of artificial tissues, organs, or organ components to replace damaged or absent body

	parts
semiconductor	An area of science that deals with developing and producing extremely small tools and machines by controlling the arrangement of separate atoms
regenerative medicine	the smallest amount or unit of something, especially energy
bioengineering	taking body tissues from one body and placing them in another body or in another part of the same body
nanoscale	a system of ways of teaching, or studying something
biotechnology	the use of nanotechnology for diagnosing, treating and preventing disease
nanotechnology	the use of living things, especially cells and bacteria, in industrial processes
transplantation	on a scale measured in nanometers

Exercise IX.

Summarize the article “Future impact of nanotechnology on medicine.”

Part 2

Exercise I.

Identify the part of speech the words belong to.

curiosity, ingenuity, dentistry, significant, treatment, prevention, medical, application, emergence, preventive

Exercise II .

Form nouns from the following words:

scientific(1), diagnostic(1), to improve (1), physiologic (1), chemical(2), biological(2), define(3), behave(3), tunable(3), apply(4)

Exercise III.

Find synonyms to the following words. Translate them into Russian: interest (1), surprise (1), inventiveness(1), globe(1), empirical (1), progress (1), area (1), defeat (1), trouble (1), chance (1), genetic engineering(4)

Exercise IV .

Find antonyms to the following words. Translate them into Russian:

unhitch (1), common (1), decrease (1), pessimism (1), minor (1), disappearance (1), crude (1), prophylactic (1), destroy (1), shorten (1)

Exercise V.

Match the words to make word combinations:

quantum	rays
regenerative	cells
cell	molecules
tumor	dots
injured	materials
tissue	transplantation
infrared	medicine
toxic	engineering
selective	tissue

structured	nanodevices

Exercise VI .

QUIZ:

1. The prefix "nano" comes from a ……….

A. French word meaning billion

B. Greek word meaning dwarf

C. Spanish word meaning particle

D. Latin word meaning invisible

2. Who first used the term nanotechnology and when?

A. Richard Feynman, 1959

B. Norio Taniguchi, 1974

C. Eric Drexler, 1986

D. Sumio Iijima, 1991

3. What is a buckyball?

A. A carbon molecule (C60)

B. Nickname for Mercedes-Benz's futuristic concept car (C111)

C. Plastic explosives nanoparticle (C4)

D. Concrete nanoparticle with a compressive strength of 20 nanonewtons (C20)

4. Which of these historical works of art contain nanotechnology?
A. Lycurgus cup

B. Medieval stained glass windows in churches

C. Damascus steel swords

D. All of the above

5. Richard Feynman is often credited with predicting the potential of nanotechnology. What was the title of his famous speech given on December 29, 1959?
A. There is a tiny room at the bottom

B. Things get nanoscopic at the bottom

C. Bottom? What bottom?

D. There is plenty of room at the bottom

6. How many oxygen atoms lined up in a row would fit in a one nanometer space?
A. None; an oxygen atom is bigger than 1 nm

B. One

C. Seven

D. Seventy

7. Which one of these statements is NOT true?
A. Gold at the nanoscale is red

B. Copper at the nanoscale is transparent

C. Silicon at the nanoscale is an insulator

D. Aluminum at the nanoscale is highly combustible

8. Which of these consumer products is already being made using

nanotechnology methods?

A. Fishing lure

B. Golf ball

C. Sunscreen lotion

D. All of the above

9. If you were to shrink yourself down until you were only a nanometer tall, how thick would a sheet of paper appear to you?

A. 170 meters

B. 1.7 kilometers (a bit more than a mile)

C. 17 kilometers

D. 170 kilometers

10.What is graphene?

A. A new material made from carbon nanotubes

B. A one-atom thick sheet of carbon

C. Thin film made from fullerenes

D. A software tool to measure and graphically represent nanoparticles

11.What is grey goo?

A. A hypothetical substance composed of out-of-control self-replicating nanobots that consumes all living matter on Earth

B. The feeder material used to grow grey nanoparticles in the laboratory

C. Toxic byproduct resulting from the synthesis of carbon nanotubes

D. Waste product from the production of nanoglue made from the membranes on the feet of the Madagascan Grey Gecko

12. Which one of these condiments is unique due to the nanoscale interactions between its ingredients?
A. Ketchup

B. Mustard

C. Mayonnaise

D. All of the above

13. Nanorobots (nanobots)...

A. Do not exist yet

B. Exist in experimental form in laboratories

C. Are already used in nanomedicine to remove plaque from the walls of arteries

D. Will be used by NASA in the next unmanned mission to Mars

14. Plasmonics is..........

A. A field of nanophotonics that holds the promise of molecular-size optical device technology

B. The science of fluorescent nanoparticles used in modern fireworks

C. A hypothetical science used in science fiction weaponry (plasma cannons)

D. The technology used to design and build the laser-guided photonic gyroscopes used in aviation

15. Optical tweezers..........

A. Are used to remove facial hair with miniaturized laser beams

B. Use light to manipulate particles as small as a single atom

C. Are a nanotechnology-based tool for stamp collectors

D. Don't exist

16. A silver coin with a diameter of 4 cm (such as the U.S. silver dollar) contains 26.96 grams of coin silver and has a surface area of about 27.7 square cm. If the same 26.96 grams of coin silver were divided into particles 1 nanometer in diameter, what would their combined surface area be?

A. 11.4 square meters

B. 140 square meters

C. 1,400 square meters

D. 11,400 square meters

17. What exactly is a quantum dot?

A. A semiconductor nanostructure that confines the motion of conduction band electrons, valence band holes, or excitons in all three spatial directions.

B. The sharpest possible tip of an Atomic Force Microscope

C. A fictional term used in science fiction for the endpoints of wormholes

D. Unexplained spots that appear in electron microscopy images of nanostructures smaller than 1 nanometer

2. Mechanics and Motion

Part 1

Exercise I.

Say what Russian words help to guess the meaning of the following words:

physics(1), galaxy(1), term(2), object(2), acceleration(3), gram(3), kilogram(3), normal(5), molecular(6), gas(6)

Exercise II

Make sure you know the following words and word combinations.
key topic(1), speed of light(1), to act upon(2), to be measured in(grams)(3), at constant velocity(4), speed up(4), slow down(4), at angles to(4), to act on(5), on a molecular level(6)

Mechanics and Motion

Motion is one of the key topics in physics. Everything in the universe moves. It might only be a small amount of movement and very very slow, but movement does happen. Don't forget that even if you appear to be standing still, the Earth is moving around the Sun, and the Sun is moving around our galaxy. The movement never stops. Motion is one part of what physicists call mechanics. Over the years, scientists have discovered several rules or laws that explain motion and the causes of changes in motion. There are also special laws when you reach the speed of light or when physicists look at very small things like atoms.

The physics of motion is all about forces. Forces need to act upon an object to get it moving, or to change its motion. Changes in motion won't just happen on their own. So how is all of this motion measured? Physicists use some basic terms when they look at motion. How fast an object moves, its speed or velocity, can be influenced by forces.

Acceleration is a twist on the idea of velocity. Acceleration is a measure of how much the velocity of an object changes in a certain time (usually in one second).Velocities could either increase or decrease over time. Mass is another big idea in motion. Mass is the amount of something there is, and is measured in grams (or kilograms).

There are two main ideas when you study mechanics. The first idea is that there are simple movements, such as if you're moving in a straight line, or if two objects are moving towards each other in a straight line. The simplest movement would be objects moving at constant velocity. Slightly more complicated studies would look at objects that speed up or slow down, where forces have to be acting. There are also more complex movements when an object's direction is changing. These would involve curved movements such as circular motion, or the motion of a ball being thrown through the air. For such complex motions to occur, forces must also be acting, but at angles to the movement.

Forces are a big part of physics. Physicists devote a lot of time to the study of forces that are found everywhere in the universe. The forces could be big, such as the pull of a star on a planet. The forces could also be very small, such as the pull of a nucleus on an electron. Forces are acting everywhere in the universe at all times. If you were a ball sitting on a field and someone kicked you, a force would have acted on you. As a result, you would go bouncing down the field. There are often many forces at work. Physicists might not study them all at the same time, but even if you were standing in one place, you would have many forces acting on you. Those forces would include gravity, the force of air particles hitting your body from all directions (as well as from wind), and the force being exerted by the ground (called the normal force).

Let's look at the forces acting on that soccer ball before you kicked it. As it sat there, the force of gravity was keeping it on the ground, while the ground pushed upward, supporting the ball. On a molecular level, the surface of the ball was holding itself together as the gas inside of the ball tried to escape. There may have also been small forces trying to push it as the wind blew. Those forces were too small to get it rolling, but they were there. And you never know what was under the ball. Maybe an insect was stuck under the ball trying to push it up. That's another force to consider. If there is more than one force acting on an object, the forces can be added up if they act in the same direction, or subtracted if they act in opposition. Scientists measure forces in units called Newtons.

A vector can be used to represent any force. A force vector describes a specific amount of force that is applied in a specific direction. Imagine a situation where you're in a boat or a plane, and you need to plot a course. There aren't streets or signs along the way. You will need to plan your navigation on a map. You know where you're starting and where you want to be. The problem is how to get there. Now it's time to use a couple of vectors. Draw the vector between the two points. As you move along your course, you will probably swerve a bit off course because of wind or water currents. Just go back to the map, find your current location, and plot a new vector that will take you to your destination. Captains use vectors (they know the speed and direction) to plot their courses.

Newton's Laws of Motion

There was this fellow in England named Sir Isaac Newton. A little bit stuffy, but quite an intelligent guy. He worked on developing calculus and physics at the same time. During his work, he came up with the three basic ideas that are applied to the physics of most motion (NOT modern physics). The ideas have been tested and verified so many times over the years, that scientists now call them Newton's Three Laws of Motion. The first law says that an object at rest tends to stay at rest, and an object in motion tends to stay in motion, with the same direction and speed. Motion (or lack of motion) cannot change without an unbalanced force acting. If nothing is happening to you, and nothing does happen, you will never go anywhere. If you're going in a specific direction, unless something happens to you, you will always go in that direction. Forever.You can see good examples of this idea when you see video footage of astronauts. Have you ever noticed that their tools float? They can just place them in space and they stay in one place. There is no interfering force to cause this situation to change. The same is true when they throw objects for the camera. Those objects move in a straight line. If they threw something when doing a spacewalk, that object would continue moving in the same direction and with the same speed unless interfered with; for example, if a planet's gravity pulled on it.

The second law says that the acceleration of an object produced by a net (total) applied force is directly related to the magnitude of the force, the same direction as the force, and inversely related to the mass of the object. The second law shows that if you exert the same force on two objects of different mass, you will get different accelerations (changes in motion). The effect (acceleration) on the smaller mass will be greater (more noticeable). The effect of a 10 newton force on a baseball would be much greater than that same force acting on a truck. The difference in effect (acceleration) is entirely due to the difference in their masses.

The third law says that for every action (force) there is an equal and opposite reaction (force). Forces are found in pairs. Think about the time you sit in a chair. Your body exerts a force downward and that chair needs to exert an equal force upward or the chair will collapse. It's an issue of symmetry. Acting forces encounter other forces in the opposite direction. There's also the example of shooting a cannonball. When the cannonball is fired through the air, the cannon is pushed backward. The force pushing the ball out was equal to the force pushing the cannon back, but the effect on the cannon is less noticeable because it has a much larger mass. That example is similar to the kick when a gun fires a bullet forward.

<u>**Exercise III**</u>.

Find paragraphs, dealing with the following:

magnitude, still, speed, acceleration, mass, simple, complex, curved, molecular, calculus

Exercise IV.

Answer the following questions:

1. What is classical mechanics?
2. What are some examples of curvilinear motion?
3. What are some examples of centrifugal force?
4. If you were to measure the velocity of an object at one moment, what type of velocity did you measure?
5. What does a vector need? What is the difference between a vector and a scalar physical quantity? Is gravity a vector or a scalar? What does it mean when astronauts are described as weightless?
6. What do you call the force that always acts opposite to the direction of the motion?
7. Which of Newton's 3 laws does the following example illustrate: if you have a hockey puck sliding along a table, it will eventually come to a stop.
8. Imagine a ball moving in a straight line directly toward when another ball collides with it . The moving ball exerts a force on the ball at rest. This causes the ball at rest to accelerate. However, the ball at rest also exerts the same magnitude of force (in the opposite direction) of the moving ball. This will cause the moving ball to decelerate or even move in another direction. Which of Newton's Laws does this situation represent?
9. If a ball is thrown in the air, it will keep going the same velocity unless a force changes the velocity (speed and direction). What are the forces that are acting on the ball? Check all that apply.
10. Which Newton's law states the need to wear seatbelts?

11. Which of Newton's Three Law does the following example illustrate? The blood in your head rushes to your feet when riding on an elevator this is descending and abruptly stops.
12. If two boxes are pushed with the same amount of total force, and one weighs 1kg and the other weighs 100kg, which one will accelerate faster and why?
13. If an eagle and a bumblebee are both traveling at 10 km/hr, which has the greater momentum?
14. Which has a greater momentum: a 2-ton rollercoaster moving at 50km/hr or a 2.5 ton truck moving at 35 km/hr?
15. Which has the greater momentum: a large object moving slowly or a small object moving fast?
16. How does impulse differ from force? Does a moving object have impulse? What about a stationary object?

Exercise V.

Fill in the gaps according to the text.

1. The physics of ……….is all about forces.

2. ………… is another big idea in motion.

3. The first idea is that there are………., such as if you're moving in a straight line, or if two objects are moving towards each other in a straight line.

4. There are also more………. when an object's direction is changing.

5. Physicists devote a lot of time to the study of……….. that are found everywhere in the universe.

6. A……….. describes a specific amount of force that is applied in a specific direction.

7. Sir ………worked on developing calculus and physics at the same time.

8. The ……….says that an object at rest tends to stay at rest, and an object in motion tends to stay in motion, with the same direction and speed.

9. The ………….says that the acceleration of an object produced by a net (total) applied force is directly related to the magnitude of the force, the same direction as the force, and inversely related to the mass of the object.

10. The …….. says that for every action (force) there is an equal and opposite reaction (force).

Exercise VI .

Make up sentences of your own with the following word combinations:

key topic, speed of light, to act upon, to be measured in(grams), at constant velocity, speed up, slow down, at angles to, to act on, on a molecular level

Exercise VII.

Determine whether the statements are true or false. Correct the false statements:

1. Everything in the universe moves.
2. Earth is moving around our galaxy.

3. The movement never stops.
4. Changes in motion happen on their own.
5. Motion can change without an unbalanced force acting.
6. There are three main ideas when you study mechanics.
7. Forces are acting everywhere in the universe at all times.
8. A vector can be used to represent any force.
9. If you're going in a specific direction, unless something happens to you, you will always go in that direction.
10. The second law says that for every action (force) there is an equal and opposite reaction (force).

Exercise VIII .

Match the words to the definitions in the column on the right:

force	the speed of something in a given direction
acceleration	specific amount of force that is applied in a specific direction
mechanics	when an object's direction is changing
velocity	an influence tending to change the motion of a body or produce motion or stress in a stationary body
mass	the action or process of moving or being moved
simple movements	a measure of how much the velocity of an object changes in a certain time
force vector	the branch of applied mathematics dealing with motion and forces producing motion
complex movements	the amount of something there is, and is measured

	in grams (or kilograms)
motion	moving in a straight line, or if two objects are moving towards each other in a straight line

Exercise IX.

Summarize the article “Mechanics and Motion.”

Part 2

Exercise I.

Identify the part of speech the words belong to.

magnitude, velocity, acceleration, measure, straight, circular, occur, particle, escape, consider

Exercise II .

Form nouns from the following words:

acceleration (3), unit (6), navigation (7), location (7), noticeable (10), action (11)

Exercise III.

Find synonyms to the following words. Translate them into Russian:

motion (1), universe (1), force (2), velocity (3), acceleration (3), measure (3), complex (4), normal (5), specific (7), law (9)

Exercise IV .

Find antonyms to the following words. Translate them into Russian:

motion (1), key (1), still (1), force (2), basic (2), velocity (3), certain (3), main (4), simple (4), constant (4)

Exercise V.

Match the words to make word combinations:

force	movement
key	level
normal	law
opposite	vector
complex	topic
molecular	direction
second	force

Exercise VI .

QUIZ *(Please choose only one answer)* :

1. How is the difference between the gravitational potential at a position one meter above the ground and its potential energy on the ground defined?

a) It is equal to the work done by an applied force to move the object from the ground to one meter above the ground.

b) It is equal to the work done by gravity when the object is moved from the ground to one meter above the ground.

c) It is equal to the vertical component of to the work done by an applied force to move the object from the ground to one meter above the ground.

d) It is equal to the vertical component of the work done by gravity when the object is moved from the ground to one meter above the ground.

2. How is the net work done on an object related to the kinetic energy of the object?

a) The kinetic energy is equal to the net work.

b) The change in kinetic energy is equal to the net work.

c) The change in kinetic plus potential energies is equal to the net work.

d) There is no specific relationship between net work and kinetic energy.

3. If a 4 kg object slides down a frictionless incline from a height of 1.5 m above the ground, what will be its speed when it reaches the ground?

a) 29.4 m/s

b) 16.2 m/s

c) 8.7 m/s

d) 5.4 m/s

4. What is the definition of power?

a) Power is the amount of work consumed in a particular process.

b) Power is the amount of work done divided by the time required to do the work.

c) Power is the product of the work done and the time required to do the work.

d) Power is the difference in the potential energy of the system before and after a particular process.

5. What is the definition of the work done on an object by a force?

a) The change in kinetic energy of the object resulting from the work done

b) The force exerted times the resultant displacement

c) The force exerted times the distance over which the force is exerted

d) The product of component of the force along the line of motion and the distance over which the force is exerted

6. What is the work-energy theorem?

a) The work done on an object by non-conservative forces is equal to the change in its kinetic energy.

b) The work done on an object by a conservative force is equal to the change in its kinetic energy.

c) The work done on an object by the applied external force is equal to the change in its kinetic energy.

d) The work done on an object by the net force is equal to the change in its kinetic energy.

7. Which of the following is a non-renewable energy source?

a) Wind

b) Coal

c) Geothermal

d) Solar

8. Which of the following statements regarding conservative and non-conservative forces is false?

a) The mechanical energy of the system is conserved if the work is done by conservative forces.

b) Energy is not conserved if work is done by non-conservative forces.

c) The work done by conservative forces is independent of the path taken.

d) Friction is a non-conservative force.

9. How is the work done on an object by a force defined?

a) It is a vector physical quantity with a magnitude of force times the distance over which the force is applied.

b) It is a vector physical quantity with a magnitude of distance times the component of the force in the direction of the motion.

c) It is a scalar physical quantity with a magnitude of force times the distance over which the force is applied.

d) It is a scalar physical quantity with a magnitude of distance times the component of the force in the direction of the motion.

10. In Newton's law of gravity, which of the following statements is correct?

a) The force of gravity is proportional to the sum of the masses involved.

b) The force of gravity is inversely proportional to the distance between the objects.

c) The force of gravity is proportional to the square of the distance between the objects.

d) The force of gravity is inversely proportional to square of the distance between the objects.

11. What does it mean when astronauts are described as weightless?

a) There is no force of gravity acting on them.

b) The centripetal force of gravity is balanced by the centrifugal force due to their motion.

c) They are free falling.

d) They are in orbit above Earth's atmosphere; therefore, there are no drag forces acting on the space craft

12. Which of the following statements regarding an object in uniform circular motion is true?

a) The object is not accelerating, because the speed of the object is constant.

b) The object is accelerating, because the speed of the object is not constant.

c) The object is not accelerating, because there is no net force on the object.

d) The object is accelerating, because there is a net force on the object.

13. Which of the following statements is true regarding linear and rotational motion?

a) Linear motion is always one-dimensional, whereas rotational motion is always two-dimensional.

b) For every physical quantity associated with linear motion, there is a corresponding physical quantity associated with rotational motion.

c) There is no correspondence between the physical quantities for linear and rotational motion.

d) There is only correspondence between the physical quantities for kinematic but not for dynamic physical quantities for linear and rotational motion.

14. When an ice skater goes into a spin with arms extended and then pulls her arms into her body, she spins faster. This is an example of which physics principle?

a) Conservation of energy

b) The work-energy theorem

c) Conservation of mechanical energy

d) Conservation of angular momentum

15. If a meter stick is pivoted at the 50 cm mark and a mass of 50 grams is hung at the 20 cm mark, then what mass must be hung from the 100 cm mark to balance the meter stick?

a) 50 grams

b) 40 grams

c) 30 grams

d) 20 grams

16. What is the definition of torque?

a) Torque is a scalar, in which magnitude is the product of the force applied and the distance between the point of application of the force and the axis of rotation.

b) Torque is a vector, in which the magnitude is the product of the force applied and the distance from the point of application of the force and the axis of rotation.

c) Torque is a scalar, in which the magnitude is the product of the force applied and the lever arm.

d) Torque is the cross product of the force applied and the distance between the point of application of the force and the axis of rotation.

17. How is Newton's 2nd law expressed in terms of momentum?

a) Force is equal to the average momentum of an object divided by the time interval over which the average is taken.

b) Force is equal to the average momentum of an object times the time interval over which the average is taken.

c) Force is equal to the change in momentum of an object divided by the time interval over which the change occurred.

d) Force is equal to the change in momentum of an object times the time interval over which the change occurred.

18. If a 10 gram ball with a speed of 24 cm/s collides with a 20 gram ball at rest and they stick together, then what will be their speed after the collision?

a) 12 cm/s

b) 10cm/s

c) 8 cm/s

d) 6 cm/s

19. Which of the following best describes the relationship between impulse and momentum?

a) Impulse is equal to the change in momentum occurring in a small interval of time.

b) Impulse is equal to the change in momentum divided by the small interval of time over which the change occurred.

c) Impulse is equal to the change in kinetic energy divided by the small interval of time over which the change occurred.

d) Impulse is the product of the change in momentum and the time interval over which the change occurs

20. A person is dragging an object across a rough surface using a rope. Which of the following statements is correct?

a) The force the rope exerts on the person is greater than the force the rope exerts on the object because of the resistance due to friction.

b) The force the rope exerts on the person is less than the force the rope exerts on the object because of the resistance due to friction.

c) The force the rope exerts on the person is equal to the force the rope exerts on the object.

d) All of these answers are possible, depending on the nature of the other forces involved. For instance, is someone else helping him drag the object?

21. If two equal non-zero forces are acting on an object, which of the following statements is correct?

a) The net force on the object cannot be zero even if the motion is one-dimensional.

b) The net force cannot be zero if there is an angle between the two forces.

c) The net force can be zero if the angle between the two forces is zero.

d) The net force can be zero if the angle between the two forces is 180 o.

22. Which of the following statements regarding friction is false?

a) Friction always acts in the direction opposite the motion.

b) Friction always causes a reduction of the kinetic energy of the object.

c) Friction always produces heat.

d) Friction always does negative work on the object.

23. Which of the following statements regarding the concepts of mass and inertia is true?

a) Both mass and inertia are measured in the same units.

b) Mass is a quantitative property of an object, whereas inertia refers to the tendency of an object to maintain its state of motion.

c) The inertia of an object is the product of its mass and its velocity.

d) All of these answers

24. For an object with constant acceleration, how is the acceleration of an object determined from a plot of velocity verses time?

a) Acceleration is the average of the initial and final velocities divided by the time interval.

b) Acceleration is the difference between the initial and final velocities divided by the time interval.

c) Acceleration is the sum of the initial and final velocities divided by the time interval.

d) Acceleration cannot be determined from the plot of velocity verses time.

25. Which of the following statements regarding an object with initial velocity of zero dropped from rest is false?

a) Its speed will be 19.6 m/s after it has fallen for 2 seconds.

b) Its location will be 9.8 m below where it was released after 2 seconds.

c) It will take it 3 seconds to fall 44.1 m.

d) After it has fallen 44.1 m, its speed will be 32.4 m/s.

26. Which of the following statements regarding the effect of gravity on a free-falling object near the surface of the earth dropped from rest is false?

a) The object's speed will increase at a rate of 9.8 meters per second each second.

b) The distance that the object travels in 1 second will increase by 9.8 meters each second.

c) The total distance the object has traveled increases with the square of the time it has been free-falling.

d) The average speed of the object increases with the square of the time it has been free-falling.

27. Which of the following statements regarding the relationship between instantaneous speed and average speed is true?

a) The average speed is the average of the initial and final instantaneous speeds.

b) The instantaneous speed is the average speed taken over an infinitesimal time interval.

c) The average speed is the average of the maximum and minimum instantaneous speeds.

d) All of these answers

28. Which of the following is true regarding distance and displacement?

a) Distance is a scalar, whereas displacement is a vector.

b) Distance is equal to the magnitude of the displacement.

c) Distance is a vector, whereas displacement is a scalar.

d) Displacement is equal to the magnitude of distance.

SUPPLEMENTARY READING

1. What is a Buckyball?

In 1999 a team of physicists in Austria fired a series of soccer-ball-shaped molecules toward a barrier. Those molecules, each made of sixty carbon atoms, are sometimes called buckyballs because the architect Buckminster Fuller built buildings of that shape. Fuller's geodesic domes were probably the largest soccer-ball-shaped objects in existence. The buckyballs were the smallest. The barrier toward which the scientists took their aim had, in effect, two slits through which the buckyballs could pass. Beyond the wall, the physicists situated the equivalent of a screen to detect and count the emergent molecules. If we were to set up an analogous experiment with real soccer balls, we would need a player with somewhat shaky aim but with the ability to launch the balls consistently at a speed of our choosing. We would position this player before a wall in which there are two gaps. On the far side of the wall, and parallel to it, we would place a very long net. Most of the player's shots would hit the wall and bounce back, but some would go through one gap or the other, and into the net. If the gaps were only slightly larger than the balls, two highly collimated streams would emerge on the other side. If the gaps were a bit wider than that, each stream would fan out a little. Notice that if we closed off one of the gaps, the corresponding stream of balls would no longer get through, but this would have no effect on the other stream. If we reopened the second gap, that would only increase the number of balls that land at any given point on the other side, for we would then get all the balls that passed through the gap that had remained open, plus other balls coming from the newly opened gap. What we observe with both gaps open, in other words, is the sum of what we observe with each gap in the wall separately opened. That is the reality we are accustomed to in everyday life. But that's not what the Austrian researchers found when they fired their molecules. In the Austrian experiment, opening the second gap did indeed increase the number of molecules arriving at some points on the screen—but it decreased the number at others. In fact, there were spots where no buckyballs landed when both slits were open but where balls did land when only one or the other gap was open. That seems very odd. How can opening a second gap cause fewer molecules to arrive at certain points?

We can get a clue to the answer by examining the details. In the experiment, many of the molecular soccer balls landed at a spot centered halfway between where you would expect them to land if the balls went through either one gap or the other. A little farther out from that central position very few molecules arrived, but a bit farther away from the center than that, molecules were again observed to arrive. The areas where no molecules arrive correspond to regions in which waves emitted from the two gaps arrive out of phase, and create destructive interference; the areas where many molecules arrive correspond to regions where the waves arrive in phase, and create constructive interference.

In the first two thousand or so years of scientific thought, ordinary experience and intuition were the basis for theoretical explanation. As we improved our technology and expanded the range of phenomena that we could observe, we began to find nature behaving in ways that were less and less in line with our everyday experience and hence with our intuition, as evidenced by the experiment with buckyballs. That experiment is typical of the type of phenomena that cannot be encompassed by classical science but are described by what is called quantum physics. In fact, Richard Feynman wrote that the double-slit experiment like the one we described above "contains all the mystery of quantum mechanics." The principles of quantum physics were developed in the first few decades of the twentieth century after Newtonian theory was found to be inadequate for the description of nature on the atomic—or subatomic—level. The fundamental theories of physics describe the forces of nature and how objects react to them. Classical theories such as Newton's are built upon a framework reflecting everyday experience, in which material objects have an individual existence, can be located at definite locations, follow definite paths, and so on. Quantum physics provides a framework for understanding how nature operates on atomic and subatomic scales, but as we'll see in more detail later, it dictates a completely different conceptual schema, one in which an object's position, path, and even its past and future are not precisely determined. Quantum theories of forces such as gravity or the electromagnetic force are built within that framework.

Can theories built upon a framework so foreign to everyday experience also explain the events of ordinary experience that were modeled so accurately by classical physics? They can, for we and our surroundings are composite structures, made of an unimaginably large number of atoms, more atoms than there are stars in the observable universe. And though the component atoms obey the principles of quantum physics, one can show that the large assemblages that form soccer balls, turnips, and jumbo jets—and us—will indeed manage to avoid diffracting through slits. So though the components of everyday objects obey quantum physics, Newton's laws form an effective theory that describes very accurately how the composite structures that form our everyday world behave.

That might sound strange, but there are many instances in science in which a large assemblage appears to behave in a manner that is different from the behavior of its individual components. The responses of a single neuron hardly portend those of the human brain, nor does knowing about a water molecule tell you much about the behavior of a lake. In the case of quantum physics, physicists are still working to figure out the details of how Newton's laws emerge from the quantum domain. What we do know is that the components of all objects obey the laws of quantum physics, and the Newtonian laws are a good approximation for describing the way macroscopic objects made of those quantum components behave.

The predictions of Newtonian theory therefore match the view of reality we all develop as we experience the world around us. But individual atoms and molecules operate in a manner profoundly different from that of our everyday experience. Quantum physics is a new model of reality that gives us a picture of the universe. It is a picture in which many concepts fundamental to our intuitive understanding of reality no longer have meaning. The double-slit experiment was first carried out in 1927 by Clinton Davisson and Lester Germer, experimental physicists at Bell Labs who were studying how a beam of electrons—objects much simpler than buckyballs—interacts with a crystal made of nickel. The fact that matter particles such as electrons behave like water waves was the type of startling experiment that inspired quantum physics. Since this behavior is not observed on a macroscopic scale, scientists have long wondered just how large and complex something could be and still exhibit such wavelike properties. It would cause quite a stir if the effect could be demonstrated using people or a hippopotamus, but as we've said, in general, the larger the object the less apparent and robust are the quantum effects. So it is unlikely that any zoo animals will be passing wavelike through the bars of their cages. Still, experimental physicists have observed the wave phenomenon with particles of ever-increasing size. Scientists hope to replicate the buckyball experiment someday using a virus, which is not only far bigger but also considered by some to be a living thing.

2. Overvalued Innovation

Capitalism excels at innovation but is failing at maintenance, and for most lives it is maintenance that matters more

Innovation is a dominant ideology of our era, embraced in America by Silicon Valley, Wall Street, and the Washington DC political elite. As the pursuit of innovation has inspired technologists and capitalists, it has also provoked critics who suspect that the peddlers of innovation radically overvalue it. What happens after innovation, they argue, is more important. Maintenance and repair, the building of infrastructures, the mundane labour that goes into sustaining functioning and efficient infrastructures, simply has more impact on people's daily lives than the vast majority of technological innovations. The fates of nations on opposing sides of the Iron Curtain illustrate good reasons that led to the rise of innovation as a buzzword and organising concept. Over the course of the 20th century, open societies that celebrated diversity, novelty, and progress performed better than closed societies that defended uniformity and order. In the late 1960s in the face of the environmental degradation and other social and technological disappointments, it grew more difficult for many to have faith in moral and social progress. To take the place of progress, 'innovation', a smaller, and morally neutral, concept arose. Innovation provided a way to celebrate the accomplishments of a high-tech age without expecting too much from them in the way of moral and social improvement. Beginning in the late 1950s, the prominent economists found that traditional explanations of the economic growth and high standards of living in capitalist democracies– changes in education, for example –

could not account for significant portions of growth. They hypothesised that technological change was the hidden X factor. Their finding fit hand-in-glove with all of the technical marvels that had come out of the Second World War, the Cold War craze for science and technology, and the post-war vision of a material abundance.

Robert Gordon's important new book, The Rise and Fall of American Growth, offers the most comprehensive history of this golden age in the US economy. As Gordon explains, between 1870 and 1940, the United States experienced an unprecedented – and probably unrepeatable – period of economic growth. That century saw a host of new technologies and new industries produced, including the electrical, chemical, automobile, gas and electronics. Demand for a wealth of new home equipment and kitchen appliances, that typically made life easier and more bearable, drove the growth. Growth was strongly tied to continued social improvement. As older industries matured and declined, new industries associated with new technologies would have to rise to take their place. Yet, this need for booming new industries became problematic as the United States headed into the troubled times of the 1970s and early 1980s. Whole economic sectors, the auto industry, for example, hit the skids. A new term – 'innovation policy' – arose, designed to spur economic growth by fostering technological change, particularly in the face of international economic competition from Japan. Silicon Valley, a term that had just emerged in the late 1970s, became the exemplar of innovation during this time. By the early 1980s, books casting Silicon Valley as a land of almost magical technological ingenuity had begun to hit the market. This theme reached its apotheosis in Richard Florida's 2002 book, that used the word 'innovation' more than 90 times and heavily idealised Silicon Valley.

During the 1990s, scholars and pop audiences also rediscovered the work of Joseph Schumpeter. Schumpeter was an Austrian economist who championed innovation. Schumpeter pictured economic growth and change in capitalism as a 'gale of creative destruction', in which new technologies and business practices destroyed old ones. At the turn of the millennium, in the world of business and technology armies of young tech wizards aspired to become disrupters. The ambition to disrupt in pursuit of innovation was vague enough to do nearly anything in its name without feeling the slightest conflict, just as long as you repeated the mantra: INNOVATION. A few years later, in a biting essay Michael Bierut, writing in Design Observer in 2005, lamented the 'mania for innovation, or at least for endlessly repeating the word "innovation"'. Soon, even business publications began to raise the question of inherent worth. In 2006, The Economist noted that Chinese officials had made innovation into a 'national buzzword', even as it reported that China's educational system 'does little to foster independent thinking'. Later that year, Businessweek warned: 'Innovation is in grave danger of becoming the latest overused buzzword.' Again in Businessweek Bruce Nussbaum returned to the theme, declaring that innovation 'died in 2008, killed off by overuse, misuse, narrowness and failure to evolve' In 2012, even the Wall Street Journal got into innovation-bashing act, noting 'the Term Has Begun to Lose Meaning'. At the time, it counted 'more than 250 books with "innovation" in the title published in the last three months'. A professional innovation consultant it interviewed advised his clients to ban the word at their companies. He said it was just a ‘word to hide the lack of substance’.

The trajectory of ‘innovation’ from core, valued practice to slogan of dystopian societies, is not entirely surprising, at a certain level: a term gains popularity, reaches buzzword status, then suffers from overexposure. Right now, the formula has brought society to a question: is there a better way to characterise relationships between society and technology? There are three basic ways to answer that question. First, it is crucial to understand that technology is not innovation. Innovation is only a small piece of what happens with technology. This preoccupation with novelty is unfortunate because it fails to account for technologies in widespread use, and it obscures how many of the things around us are quite old. In his book,Shock of the Old, the historian David Edgerton examines technology-in-use. He finds that common objects, like many parts of the automobile, have been virtually unchanged for a century or more. The stalest innovation stories focus on well-to-do white guys sitting in garages in a small region of California, but human beings in other places live with technologies too. Which ones? Where do they come from? How are they produced, used, repaired?

Second, by dropping innovation, we can recognise the essential role of basic infrastructures. ‘Infrastructure’ is a most unglamorous term, the type of word that would have vanished from our lexicon long ago if it didn’t point to something of immense social importance. Remarkably, in 2015 ‘infrastructure’ came to the fore of conversations in many walks of American life. The best of these conversations about infrastructure move away from narrow technical matters to engage deeper moral implications. Infrastructure failures – train crashes, bridge failures, urban flooding, and so on – are manifestations of America's dysfunctional political system, and its enduring fascination with flashy shiny things. Third, focusing on infrastructure or on old, existing things rather than novel ones reminds us of the absolute centrality of the work that goes into keeping the entire world going. Despite recurring fantasies about the end of work or the automation of everything, the central fact of our industrial civilisation is labour, and most of this work falls far outside the realm of innovation. Inventors and innovators are a small slice – perhaps somewhere around one per cent – of this workforce. If gadgets are to be profitable, corporations need people to manufacture, sell, and distribute them. Another important facet of technological labour comes when people actually use a product. In some cases, the image of the 'user' could be an individual like you, sitting at your computer, but in other cases, end users are institutions – companies, governments, or universities that struggle to make technologies work in ways that their inventors and makers never envisioned. The most unappreciated and undervalued forms of technological labour are also the most ordinary: those who repair and maintain technologies that already exist, that were 'innovated' long ago. Why not extend this style of analysis to think more clearly about subjects such as 'cybersecurity'? The need for coders and programmers in the cybersecurity field is obvious, but it should be equally obvious that fundamental vulnerabilities in our cyber-infrastructures are protected by the staff who repair ID card-readers. We can think of labour that goes into maintenance and repair as the work of the maintainers, those individuals whose work keeps ordinary existence going rather than introducing novel things. Brief reflection demonstrates that the vast majority of human labour, from laundry and trash removal to food preparation, is of this type: upkeep. This realisation has significant implications for gender relations in and around technology. Feminist theorists have long argued that obsessions with technological novelty obscures all of the labour, including housework, that women, disproportionately, do to keep life on track. One of their famous findings was that new housekeeping technologies, which promised to save labour, literally created more work for mother as cleanliness standards rose, leaving women unable to keep up.

We organise a conference to bring the work of the maintainers into clearer focus. More than 40 scholars answered a call for papers asking, 'What is at stake if we move scholarship away from innovation and toward maintenance?' Historians, social scientists, economists, and activists responded. They all want to talk about technology outside of innovation's shadow. One important topic of conversation is the danger of moving too triumphantly from innovation to maintenance. There is an urgent need to reckon more honestly with our machines and ourselves. Ultimately, emphasising maintenance involves moving from buzzwords to values, and from means to ends. In formal economic terms, 'innovation' involves the diffusion of new things and practices. The term is completely agnostic about whether these things and practices are good. Cocaine, for example, was a highly innovative product in the 1980s. Perhaps this point is cynical, but it draws our attention to the reality: contemporary discourse treats innovation as a positive value in itself, when it is not. Entire societies have come to talk about innovation as if it were an inherently desirable value, like love, courage, beauty, dignity, or responsibility. Innovation-speak worships at the altar of change, but it rarely asks who benefits, to what end? A focus on maintenance provides opportunities to ask questions about what we really want out of technologies. What do we really care about? What kind of society do we want to live in? Will this help get us there? We must shift from means, including the technologies that underpin our everyday actions, to ends, including the many kinds of improvement that technology can offer.