

## Energy and Its Conservation



### تم تحميل هذا الملف من موقع المناهج الإماراتية

موقع المناهج ← المناهج الإماراتية ← الصف الثاني عشر المتقدم ← فيزياء ← الفصل الأول ← ملفات متنوعة ← الملف

تاريخ إضافة الملف على موقع المناهج: 2026-09-22 23:31:26

ملفات اكتب للمعلم اكتب للطالب ا اختبارات الكترونية ا اختبارات ا حلول ا عروض بوربوينت ا أوراق عمل  
منهج انجليزي ا ملخصات وتقارير ا مذكرات وبنوك ا الامتحان النهائي ا للمدرس

المزيد من مادة  
فيزياء:

إعداد: إيهاب جمال

### التواصل الاجتماعي بحسب الصف الثاني عشر المتقدم



صفحة المناهج  
الإماراتية على  
فيسبوك

الرياضيات

اللغة الانجليزية

اللغة العربية

التربية الاسلامية

المواد على تلغرام

### المزيد من الملفات بحسب الصف الثاني عشر المتقدم والمادة فيزياء في الفصل الأول

القوى الكهروستاتيكية

1

Module 1 A Physics Toolkit

2

ملخص القوى الكهروستاتيكية والشحنات الكهربائية

3

المجالات الكهربائية وقانون جاوس

4

ملخص الوحدة الثالثة: الجهد الكهربائي

5



مستقبل أفضل  
بالعلم

منهج  
INSPIRE

LEARN  
EXPLORE  
ACHIEVE

# فيزياء 12 متقدم

الفصل الدراسي الأول 2026 - 2027

INSPIRE



منهج

معاً نحو  
التميز

Unit  
1

## ENERGY AND ITS CONSERVATION

Small  
Steps  
Big  
Results

Lesson 2

THE MANY FORMS OF ENERGY

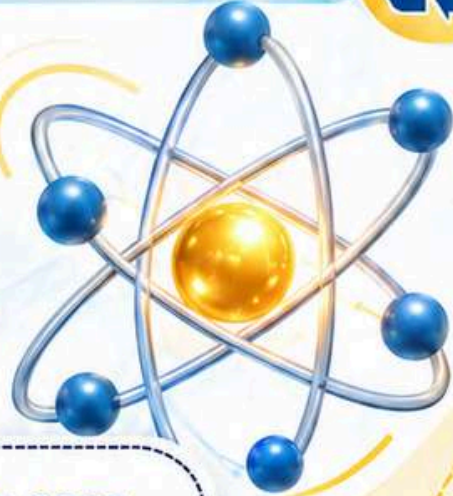


Lesson 3

CONSERVATION OF ENERGY



Energy  
Drives  
a Brighter  
Tomorrow



$$E=mc^2$$



PHYSICS  
BUILDS  
A BETTER  
WORLD

SCAN ME



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لزيارة الموقع



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للتواصل واتساب

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العلم  
يصنع  
المستقبل



EXPLORE  
LEARN  
GROW  
SUCCEED

PHYSICS  
FOR A BRIGHTER  
TOMORROW

أ/ إيهاب جمال

# فيزياء 12 متقدم inspire

## يمكنك مشاهدة شرح الحصة 1 مجاناً



### فيزياء الحصة 1

### 12 متقدم انسابير

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**971544448256**

قناة التليجرام

**جدول : فيزياء الصف 12 متقدم**

الانضمام اضغط هنا

الفصل الدراسي الأول

**12 متقدم (inspire)**

**المواعيد**

|      |        |
|------|--------|
| 5:00 | الأحد  |
| 5:00 | الخميس |

سيتم إضافة الطلاب إلى جروب واتساب

عدد الحصص قابل للزيادة ومسؤوليتي هي شرح المنهج كاملاً والمراجعة عليه والتأكد من جاهزيتك

الهم إنني أستودعك ما قرأت وما حفظت، وما تعلمت، فردّه عند حاجتي إليه، إنك على كل شيء قدير

للتواصل : 971544448256



# محتوي حصري

هذا المحتوى مخصص حصرياً للطلاب المشتركين فقط



لا يسمح  
بالتعديل



لا يسمح  
بالتداول



لا يسمح  
بالنسخ



لا يسمح  
بالنشر

هذا المحتوى غير مسموح بنشره أو بنسخه أو بتداوله  
أو بالتعديل عليه بأي طريقة كانت،  
ويُعد هذا المحتوى حصرياً للطلاب المشتركين فقط.

A+

كل اللي تحتاجه  
للتفوق بـمكان واحد



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lesson 2

# The many Forms OF energy

اضغط هنا لحضور الشرح



## ? FOCUS QUESTION

What are some forms of energy?



## What is Energy?

Energy is the **ability to cause change or do work.**

## Changing Forms of Energy

When a force causes an object to move, work is done. Work **transfers energy** between a system and its surroundings.

Energy can also change from one form to another. A system can have energy in different forms, and it can be transformed from one form into another.

Whenever work is done, the energy of a system changes — it can increase, decrease, or change form.



Energy  
in Action!

## Fireworks Show Many Forms of Energy

When fireworks explode, **chemical energy** stored in the fireworks is released and transformed into **light energy** (bright colors), **sound energy** (loud pops), and **thermal energy** (heat).

## Common Forms of Energy



### Kinetic Energy

The energy of motion (moving objects).



### Sound Energy

Energy that travels as sound waves (what we hear).



### Light Energy

Energy that travels as electromagnetic waves (what we see).



### Thermal Energy

The energy associated with the random motion of particles (often felt as heat).



### Chemical Energy

Energy stored in the bonds between atoms and molecules (such as in food, fuel, or fireworks).



## Key Notes

- 1 Energy is the **ability to cause change or do work.**
- 2 Work **transfers energy** between a system and its surroundings.
- 3 Energy can **change from one form to another.**
- 4 Energy exists in many forms, including **kinetic, sound, light, thermal, and chemical energy.**

## lesson 2

# The many Forms OF energy

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### WHAT IS TRANSLATIONAL KINETIC ENERGY?

**Translational kinetic energy** is the energy an object has because of its motion from one place to another.

### Formula for Translational Kinetic Energy

$$KE_{\text{trans}} = \frac{1}{2} mv^2$$

Translational kinetic energy is equal to one-half times the mass times the speed squared.

### Symbols and Units

| Symbol              | Quantity                     | SI Unit                 |
|---------------------|------------------------------|-------------------------|
| $KE_{\text{trans}}$ | Translational kinetic energy | J (joule)               |
| $m$                 | Mass                         | kg (kilogram)           |
| $v$                 | Speed (velocity)             | m/s (meters per second) |

$$1 \text{ J} = 1 \text{ kg} \cdot \text{m}^2/\text{s}^2$$

### Key Ideas and Proportionality

- ▶ Translational kinetic energy is proportional to **mass** ( $m$ ).
- ▶ Translational kinetic energy is proportional to the **square of speed** ( $v^2$ ).

2x

If the **mass doubles**, the translational kinetic energy **doubles** (2 times).

2x

If the **speed doubles**, the translational kinetic energy becomes **4 times** as large.

3x

If the **speed triples**, the translational kinetic energy becomes **9 times** as large.

### Real-World Example



A heavier bowling ball has more translational kinetic energy than a baseball moving at the same speed. A car moving at 20 m/s has four times the translational kinetic energy of the same car moving at 10 m/s.



### Important Reminder

**Kinetic energy is always positive** because it depends on the square of the speed ( $v^2$ ), and a squared quantity is always positive.



### Quick Notes

- 1 Translational kinetic energy depends on an object's mass and speed.
- 2 It is measured in joules (J).
- 3 It increases quickly with speed (proportional to  $v^2$ ).
- 4 It applies to objects that are moving from one place to another.

## lesson 2

The many forms  
of energy

اضغط هنا لحضور الشرح



## ? What is Rotational Kinetic Energy?

**Rotational kinetic energy** is the energy due to rotational motion.

## Main Formula

$$KE_{\text{rot}} = \frac{1}{2} I \omega^2$$

## Symbols and Units

| Symbol            | Meaning                                                     | SI Unit                      |
|-------------------|-------------------------------------------------------------|------------------------------|
| $KE_{\text{rot}}$ | Rotational kinetic energy (energy due to rotational motion) | J (joule)                    |
| $I$               | Moment of inertia (depends on how mass is distributed)      | $\text{kg} \cdot \text{m}^2$ |
| $\omega$          | Angular velocity (how fast the object rotates)              | rad/s                        |

## Key Concept

An object can rotate even if it does not change its position. For example, a spinning top can have rotational kinetic energy without moving from one place to another.

Rotational kinetic energy depends on how the **mass is distributed** in the object (moment of inertia) and **how fast** the object rotates (angular velocity).

## A Diver in Motion



## ↔ Translational vs. Rotational Motion

- **Translational motion** is motion from one place to another (the object's center of mass changes position).
- **Rotational motion** is spinning around an axis (the object can rotate without changing position).
- An object can have translational, rotational, or both types of motion.

## Key Notes

- 1  $KE_{\text{rot}}$  is always positive.
- 2 A larger angular velocity ( $\omega$ ) gives a much larger  $KE_{\text{rot}}$  (because it depends on  $\omega^2$ ).
- 3 The **mass distribution** of an object affects its moment of inertia ( $I$ ).
- 4 Some objects can have **both translational and rotational** kinetic energy at the same time.

lesson 2

# The many Forms OF energy

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## Translational vs. Rotational Kinetic Energy

| Feature         | Translational Kinetic Energy                                                         | Rotational Kinetic Energy                                                              |
|-----------------|--------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| Definition      | Energy due to a system changing position (motion from one place to another).         | Energy due to rotational motion (motion about an axis).                                |
| Equation        | $KE_{\text{trans}} = \frac{1}{2} mv^2$                                               | $KE_{\text{rot}} = \frac{1}{2} I\omega^2$                                              |
| Depends on      | Mass and the square of the speed.                                                    | Moment of inertia and the square of the angular speed.                                 |
| Symbols         | $m$ (mass), $v$ (speed)                                                              | $I$ (moment of inertia), $\omega$ (angular speed)                                      |
| SI units        | kilograms (kg), meters per second (m/s)                                              | kilograms·meters <sup>2</sup> (kg·m <sup>2</sup> ), radians per second (rad/s)         |
| Common examples | Moving car, thrown baseball, running person, falling object, diver's center of mass. | Spinning top, rotating wheel, ceiling fan, diver rotating in the air, planet spinning. |



# الآن...

## ابدأ حل الأسئلة



$E = mc^2$



### للتأكد من فهمك وتطبيق ما تعلمته



اقرأ السؤال  
جيداً



طبق ما تعلمته



تأكد من إجابتك

بالتدريب  
تصبح أقوى

مستقبلك يبدأ بخطوة اليوم ..





## MCQ

اختيار من متعدد

1



A limousine travels at a speed of 100 km/h. If its total mass, including the passengers, is 1900 kg, **what is its kinetic energy?**

- A  $2.64 \times 10^4 \text{ J}$
- B  $9.50 \times 10^6 \text{ J}$
- C  $1.47 \times 10^6 \text{ J}$
- D  $7.33 \times 10^5 \text{ J}$



## MCQ

اختيار من متعدد

2



A car with a mass of 1.25 ton has a total kinetic energy of 1000000 J. What is the speed of the car in km/h?

- A 144 km/h
- B 101.8 km/h
- C 40.0 km/h
- D 11.1 km/h

## MCQ

اختيار من متعدد

3



When a moving car's velocity triples, what happens to its **kinetic energy (K)**?

- A Increases by factor 9
- B Increases by factor 3
- C Decreases by factor  $\frac{1}{9}$
- D Decreases by factor  $\frac{1}{3}$





## MCQ

اختيار من متعدد

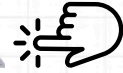
4



A bullet enters a wooden block with a kinetic energy of  $K_0$  and loses half its velocity as it goes out of the block. What is the **kinetic energy** of the bullet when it goes out?

- A  $K_0/4$
- B  $K_0/2$
- C  $2K_0$
- D  $4K_0$

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## MCQ

اختيار من متعدد

5



If the speed of a car increases by 20% while its mass remains constant, **The kinetic energy will increase by .....**

- A 40%
- B 44%
- C 20%
- D 144%

## MCQ

اختيار من متعدد

6

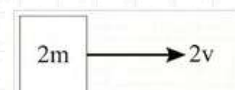


Which of the following figures represents the body that has the greatest kinetic energy?

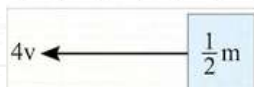
A



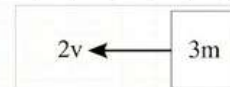
B



C



D





## MCQ

اختيار من متعدد

7



The table below lists the mass and speed of each of four objects.  
Which two objects have the **same kinetic energy**?

Data Table

| Objects | Mass (kg) | Speed (m/s) |
|---------|-----------|-------------|
| A       | 1.0       | 4.0         |
| B       | 2.0       | 2.0         |
| C       | 0.5       | 4.0         |
| D       | 4.0       | 1.0         |

- ☐ A A and D  
☐ B B and D  
☐ C A and C  
☐ D B and C

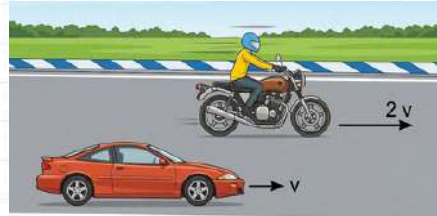
## MCQ

اختيار من متعدد

8



The opposite figure represents a car of mass  $m$  moving with velocity  $v$  and a motorcycle of mass  $m/4$  moving with velocity  $2v$ , so the **ratio between their kinetic energies**  $\left( \frac{(KE)_{\text{car}}}{(KE)_{\text{motorcycle}}} \right)$  is ...



- ☐ A  $\frac{1}{2}$   
☐ B  $\frac{1}{1}$   
☐ C  $\frac{1}{4}$   
☐ D  $\frac{2}{1}$





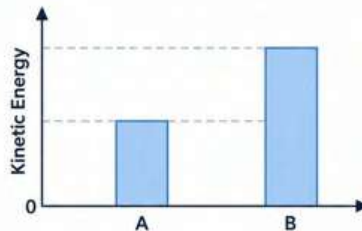
## MCQ

اختيار من متعدد

9



Two objects A and B have the same velocity. The graph shows that object B has **twice** the kinetic energy of object A. **Which statement is correct?**



- ☐ A  $m_B = \frac{1}{2}m_A$
- ☐ B  $m_B = m_A$
- ☐ C  $m_B = 2m_A$
- ☐ D  $m_B = 4m_A$

## MCQ

اختيار من متعدد

10



Does doubling the kinetic energy for a body cause the speed ( $v$ ) to double?  
**If not, by what ratio does the speed change?**

- ☐ A Yes, the speed doubles ( $v_2 / v_1 = 2$ )
- ☐ B No, the speed increases by a factor of  $\sqrt{2}$  ( $v_2 / v_1 = \sqrt{2}$ )
- ☐ C No, the speed increases by a factor of 4 ( $v_2 / v_1 = 4$ )
- ☐ D No, the speed remains constant ( $v_2 / v_1 = 1$ )

## MCQ

اختيار من متعدد

11



How much net-work is required to accelerate a 1000 kg car from 20 m/s to 30 m/s?

- ☐ A 100 000 J
- ☐ B 150 000 J
- ☐ C 200 000 J
- ☐ D 250000 J





## MCQ

اختيار من متعدد

12



Initially an object of mass 1.00 kg is moving to the left at 10.0 m/s.

If 150 J of work is done on the object, then how fast will it be moving?

- A 17.3 m/s
- B 20.0 m/s
- C 25.0 m/s
- D 27.3 m/s

## MCQ

اختيار من متعدد

13

A solid disk with a moment of inertia of  $2.5 \text{ kg}\cdot\text{m}^2$  rotates at a constant angular speed of 40 rad/s. What is the rotational kinetic energy of the disk?

- A 2000 J
- B 4000 J
- C 100 J
- D 50 J

## MCQ

اختيار من متعدد

14

What is the total work done to increase the angular speed of a wheel with a moment of inertia of  $4.0 \text{ kg}\cdot\text{m}^2$  from 10 rad/s to 30 rad/s?

- A 800 J
- B 1600 J
- C 1800 J
- D 3200 J





## MCQ

اختيار من متعدد

15



A flywheel has a rotational kinetic energy of 3200 J and a moment of inertia of  $4.0 \text{ kg}\cdot\text{m}^2$ . What is the angular speed of the flywheel?

- A 28.3 rad/s
- B 40.0 rad/s
- C 800 rad/s
- D 1600 rad/s

## MCQ

اختيار من متعدد

16



On a playground, some children push a merry-go-round so that it turns twice as fast as it did before they pushed it ( $\omega_2 = 2 \omega_1$ ). What is the relative change in the rotational kinetic energy ( $K_r$ ) of the merry-go-round?

- A rotational kinetic energy Remains unchanged ( $K_{r2} = K_{r1}$ )
- B rotational kinetic energy doubles ( $K_{r2} = 2 K_{r1}$ )
- C rotational kinetic energy Quadruples ( $K_{r2} = 4 K_{r1}$ )
- D rotational kinetic energy Increases by eight times ( $K_{r2} = 8 K_{r1}$ )

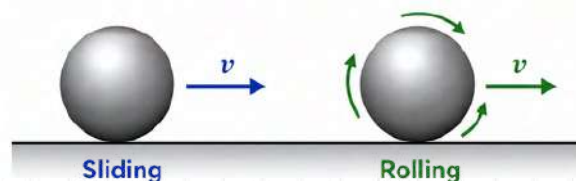
## MCQ

اختيار من متعدد

17



The same amount of work ( $W$ ) is done on two identical objects of equal mass, starting from rest. The first object moves purely by sliding without friction or rotation across a horizontal surface, while the second object rolls (combining translation and rotation). Which object attains the greater linear speed ( $v$ )?



- A The second object (rolling with rotation)
- B The first object (sliding without rotation)
- C Both objects attain the same linear speed
- D It cannot be determined without knowing the radius of each object





## Practice

18



A player kicks a stationary soccer ball with a mass of 0.45 kg, giving it a linear speed of 20 m/s while simultaneously rotating about its axis at an angular speed of 10 rad/s. If the moment of inertia of the ball is  $0.004 \text{ kg}\cdot\text{m}^2$ :



a

What is the ratio of the rotational kinetic energy to the translational kinetic energy of the ball?

الاجابة

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b

How much work did the player do on the ball?

الاجابة

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## lesson 2

# The many forms of energy

## Potential Energy

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### Definition

**Potential energy** is stored energy due to interactions between objects in a system.

2

### Introduction

Energy can exist in different forms, such as kinetic energy, thermal energy, chemical energy and potential energy. Potential energy is energy stored because of an object's position, configuration, or interactions with other objects. When the conditions of the system change, this stored energy can be transformed into other forms of energy, such as kinetic energy.

3

### Types of Potential Energy

a

#### Gravitational Potential Energy (GPE)

Energy stored due to the position of an object in a gravitational field, such as near Earth. The farther an object is raised above a chosen reference level, the greater its gravitational potential energy.



b

#### Elastic Potential Energy

Energy stored in objects that are stretched or compressed, such as a spring, rubber band or a bent object. This type of potential energy is due to the elastic forces between parts of the object, not gravity.



### Key Idea

Potential energy belongs to a **system**, not just a single isolated object.

This is because potential energy is stored due to interactions between two or more objects, such as an object and Earth, or parts of a compressed spring.

4

### Examples

#### Boulders on a Mountain (gravitational potential energy)

Boulders high up on a mountain have gravitational potential energy because they have been moved away from Earth's center against gravity. If the boulders fall, this stored energy can be transformed into kinetic energy as they move downward.



#### Compressed Spring (elastic potential energy)

A spring-loaded toy has potential energy because the spring is compressed (or stretched). The energy is stored due to the elastic forces within the spring, not because of gravity.



## Comparison Table

| Type of Potential Energy             | Cause                                                     | System                                       | Example                                               |
|--------------------------------------|-----------------------------------------------------------|----------------------------------------------|-------------------------------------------------------|
| Gravitational potential energy (GPE) | Position in a gravitational field (e.g., near Earth)      | Object and Earth                             | A boulder on a mountain, a ball held above the ground |
| Elastic potential energy             | Elastic forces due to stretching or compressing an object | Parts of the elastic object (e.g., a spring) | A compressed spring, a stretched rubber band          |

## lesson 2

# The many forms of energy

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### 1 What is Gravitational Potential Energy?

**Gravitational potential energy (GPE)** is the energy stored in an object–Earth system due to the object's position (height) relative to a reference level.

### 2 Main Formula

$$GPE = mgh$$

This formula gives the gravitational potential energy of an object of mass  $m$  at a height  $h$  above a reference level.

### 3 Symbols and Units

| Symbol | Quantity                       | SI Unit           |
|--------|--------------------------------|-------------------|
| $GPE$  | gravitational potential energy | J (joule)         |
| $m$    | mass                           | kg                |
| $g$    | gravitational field strength   | $m/s^2$ or $N/kg$ |
| $h$    | height above reference level   | m                 |

$$1 \text{ J} = 1 \text{ kg} \cdot \text{m}^2 / \text{s}^2$$

### 4 Work Done by Gravity

As an object moves, gravity can do work on it.

- **On the way up:** The displacement is upward, but the gravitational force is downward, so the work done by gravity is negative:

$$W_g = -mgh$$

Gravity slows the ball on the way up.

- **On the way down:** The force and displacement are in the same direction (downward), so the work done by gravity is positive:

$$W_g = +mgh$$

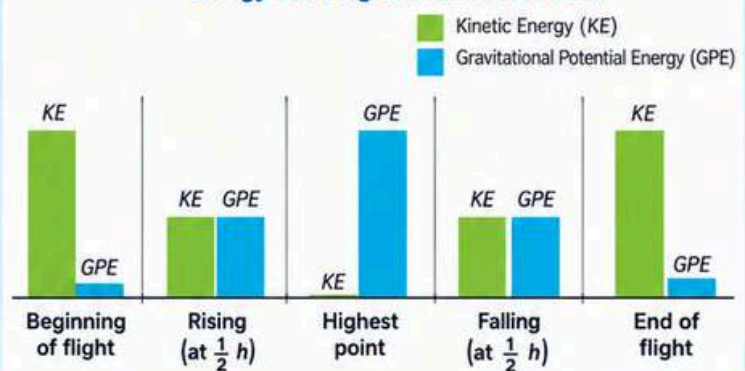
Gravity speeds up the ball on the way down.

### 5 Energy Transformation

Consider a ball that is tossed upward (or juggled).

- At the beginning of flight, the ball has a large kinetic energy (KE) and a small gravitational potential energy (GPE) (if the reference level is at the starting point).
- As the ball rises, KE decreases and GPE increases.
- At the highest point, the ball's speed is zero (KE is minimum) and GPE is maximum.
- As the ball falls, GPE changes back into KE.
- If no external work is done (ignoring air resistance), the total mechanical energy (KE + GPE) remains constant.

Energy Bar Diagram for a Tossed Ball



### 6 Picture Description



- The picture shows a ball being tossed upward and then falling back down.
- As the ball rises, its kinetic energy decreases and its gravitational potential energy increases.
- At the highest point, the ball's speed is zero and GPE is maximum.
- As the ball falls, GPE changes back into kinetic energy.

## REFERENCE LEVELS & ENERGY CHANGES

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### 1 Reference Level

The **reference level** is the height where gravitational potential energy (GPE) is defined to be zero.

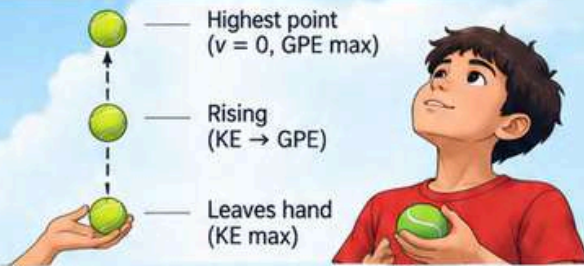
The choice of reference level is arbitrary. You can place the reference level at any height that is convenient for solving the problem.

### ★ Key Idea

Changing the reference level changes the numerical value of GPE, but it **does NOT change** the way the system's energy changes over time.

If no external work is done (e.g., air resistance is negligible), the total mechanical energy (KE + GPE) of the system remains constant.

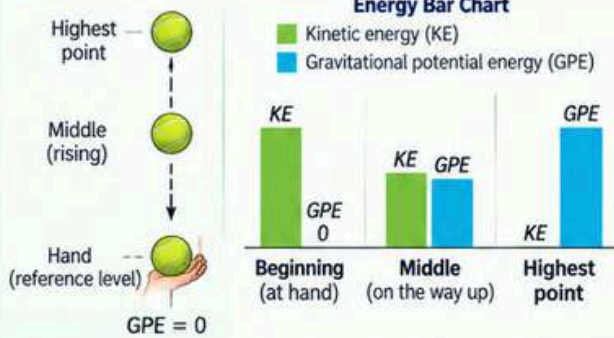
### 3 Example: Juggled Ball



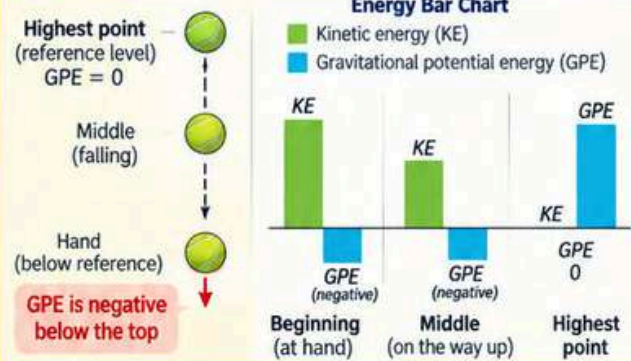
When the ball leaves the juggler's hand, it has kinetic energy. As the ball rises, its kinetic energy is transformed into gravitational potential energy. At the highest point, the ball's velocity is zero and its GPE is maximum. As the ball falls, its gravitational potential energy is transformed back into kinetic energy.

### 4 Two Reference Levels

#### a Reference Level at Juggler's Hand



#### b Reference Level at Highest Point



### 5 Comparison Table

| Feature                   | Reference at Juggler's Hand        | Reference at Highest Point                          | Notes                                           |
|---------------------------|------------------------------------|-----------------------------------------------------|-------------------------------------------------|
| Chosen zero point         | At the juggler's hand ( $h = 0$ m) | At the highest point ( $h = 0$ m)                   | Both choices are valid.                         |
| GPE at hand               | 0                                  | Negative                                            | Below the top, GPE is negative.                 |
| GPE at highest point      | Positive (maximum)                 | 0                                                   | Values depend on the reference level.           |
| Does total energy change? | No (constant, if no external work) | No (constant, if no external work)                  | Same for both reference levels.                 |
| Usefulness                | Often convenient for calculations  | Sometimes convenient, especially for falling motion | Choose the level that makes the problem easier. |

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التفكير  
هو مفتاح  
النجاح



## MCQ

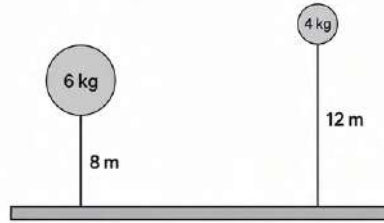
اختيار من متعدد

18



An object A with a mass of 6 kg is lifted vertically 8 m from the ground level; another object B with a mass of 4 kg is lifted 12 m up.

Which of the following statements is true?



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- I. Object A has greater potential energy since it is heavier
- II. Object B has greater potential energy since it is lifted to a higher position
- III. Two objects have the same potential energy

- A I only
- B II only
- C III only
- D I and II only

## MCQ

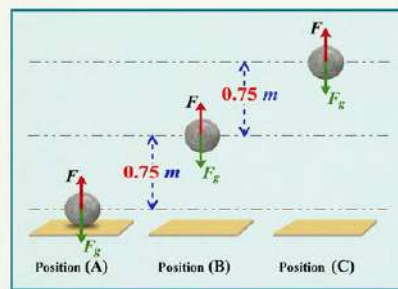
اختيار من متعدد

19



A weightlifter is lifting a marble ball of mass  $m$  from position (A) on the ground to position (B), and then to position (C) as shown in the figure.

Which row in the following table correctly represents the **gravitational potential energy (GPE)** stored in the ball at positions (A), (B), and (C), respectively?



|   | Position (A)                         | Position (B)                         | Position (C)                         |
|---|--------------------------------------|--------------------------------------|--------------------------------------|
| A | GPE = 0                              | GPE = $(+0.75 \text{ m}) \times F_g$ | GPE = $(+1.50 \text{ m}) \times F_g$ |
| B | GPE = 0                              | GPE = $(+0.75 \text{ m}) \times F_g$ | GPE = $(+0.75 \text{ m}) \times F_g$ |
| C | GPE = 0                              | GPE = $(-0.75 \text{ m}) \times F_g$ | GPE = $(-1.50 \text{ m}) \times F_g$ |
| D | GPE = $(+0.75 \text{ m}) \times F_g$ | GPE = $(+1.50 \text{ m}) \times F_g$ | GPE = $(+2.25 \text{ m}) \times F_g$ |





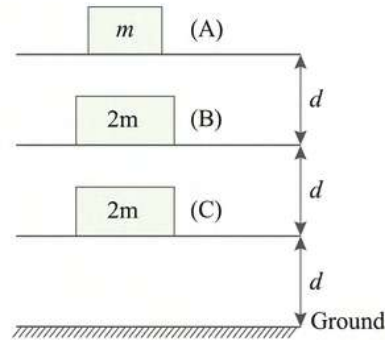
## MCQ

اختبار من متعدد

20



Three boxes (A, B and C) of different masses are placed on different shelves in a store as shown in the opposite figure. What is the correct order of these boxes according to their potential energies?



A  $A > B > C$

C  $B > A > C$

B  $C > B > A$

D  $B > C > A$

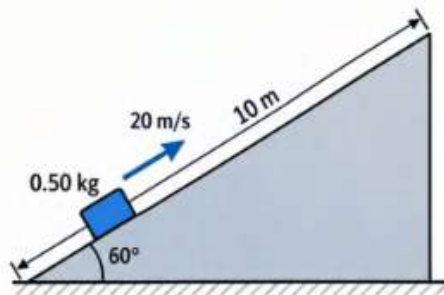
## MCQ

اختبار من متعدد

21



An object of mass 0.50 kg is fired with an initial speed of 20 m/s up an inclined plane that makes an angle of  $60^\circ$  with the horizontal and has a length of 10 m. Assuming the acceleration due to gravity is  $g = 10 \text{ m/s}^2$ , the potential energy of the object-Earth system (relative to the base of the incline) at the top of the inclined plane is:



A 50 J

B 43.3 J

C 25 J

D 18.75 J





## MCQ

اختيار من متعدد

22



When a ball moves upward after being tossed,  
what is the nature of the work done on it by gravity?

- A Zero work because gravity does not act on objects while they are moving upward.
- B Negative work ( $W_g = -mgh$ ) because the ball's displacement is in the opposite direction to the gravitational force (downward).
- C Positive work that leads to an increase in the ball's speed.
- D Positive work because the ball's displacement is in the same direction as the gravitational force.

## MCQ

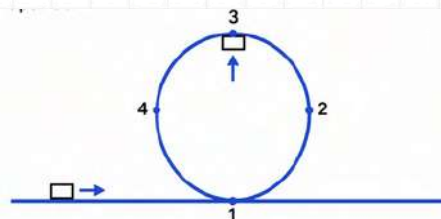
اختيار من متعدد

23



A rectangular block is moving along a frictionless path when it encounters the circular loop as shown. The block passes points 1, 2, 3, 4, 1 before returning to the horizontal track. At point 3:

- A its mechanical energy is a minimum
- B the velocity is zero
- C it is not accelerating
- D its speed is a minimum



## MCQ

اختيار من متعدد

24



What is the "Reference level" in the context of calculating gravitational potential energy?

- A It is always the ground or sea level and cannot be changed.
- B It is the maximum height a moving object can reach.
- C It is the position where the gravitational potential energy (GPE) is defined to be zero.
- D It is the point where the kinetic energy is at its highest possible level.





## MCQ

اختيار من متعدد

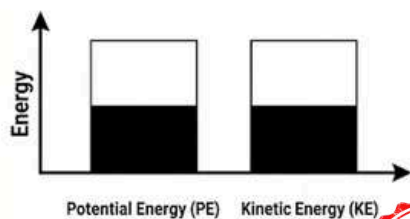
25



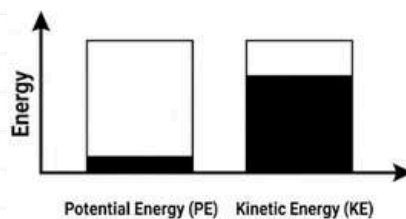
Considering the Energy Bar Diagrams for a tossed ball, when the ball reaches half of its maximum height ( $\frac{1}{2}h$ ) during its ascent or descent, what is the relationship between its energies?



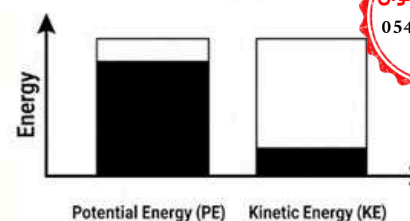
A



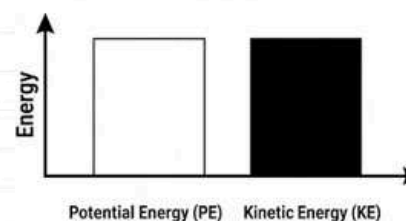
B



C



D



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A\*

## MCQ

اختيار من متعدد

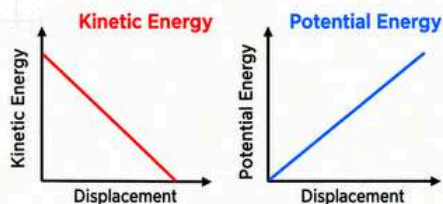
26



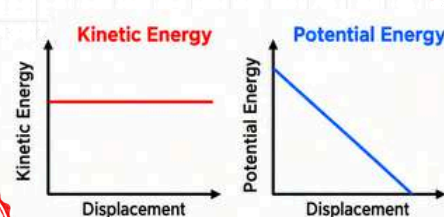
An object is thrown **vertically** upward.

Which pair of graphs best represents the object's kinetic energy and gravitational potential energy as functions of displacement **while it rises**?

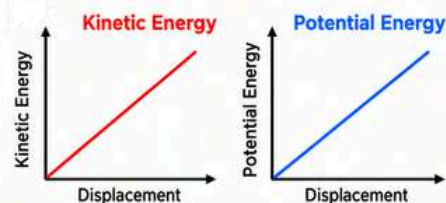
A



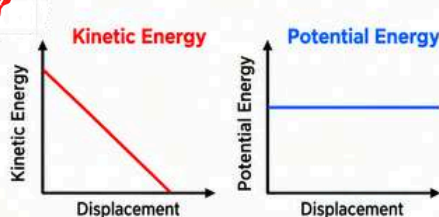
B



C



D



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A\*

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A\*





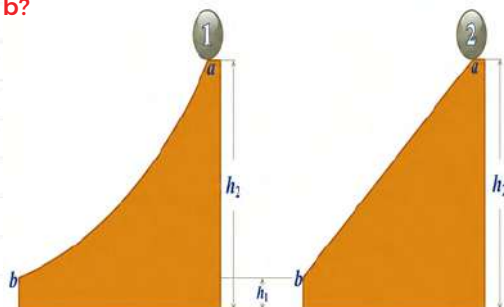
## MCQ

اختيار من متعدد

27



A student runs a race between two identical wooden balls ( $m_1 = m_2$ ), leaving them to slide on two different inclined frictionless surfaces from the same initial height to the same end point, as shown in the figure. Which of the following conclusions is correct regarding the change in gravitational potential energy ( $\Delta PE$ ) and the magnitude of the velocity ( $v$ ) of the two balls upon reaching point b?



- A The change in potential energy is equal ( $\Delta PE_1 = \Delta PE_2$ ) and the velocities are equal ( $v_1 = v_2$ ).
- B The change in potential energy is equal ( $\Delta PE_1 = \Delta PE_2$ ) and the velocity of the first ball is greater ( $v_1 > v_2$ ).
- C The change in potential energy for the first ball is greater ( $\Delta PE_1 > \Delta PE_2$ ) and the velocities are equal ( $v_1 = v_2$ ).
- D The change in potential energy for the first ball is greater ( $\Delta PE_1 > \Delta PE_2$ ) and the velocity of the first ball is greater ( $v_1 > v_2$ ).

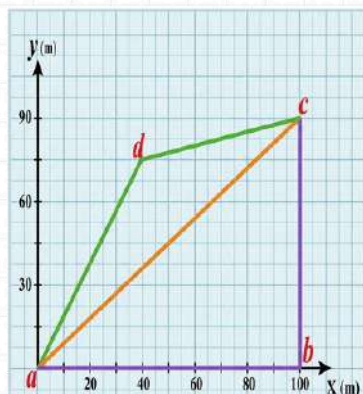
## MCQ

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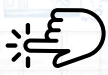
28



A 15.0 kg object is moved upward under the gravitational force from position a to position c, through three different paths as shown in the figure. Which of the following is correct?



- A  $(GPE)_{ac} = (GPE)_{abc} = (GPE)_{adc}$
- B  $(GPE)_{ac} < [(GPE)_{abc} = (GPE)_{adc}]$
- C  $[(GPE)_{ac} + (GPE)_{abc}] = (GPE)_{adc}$
- D  $(GPE)_{ac} = [(GPE)_{abc} - (GPE)_{adc}]$



## Practice

29



A boy lifts a **2.2-kg** book from his desk, which is **0.80 m** high, to a bookshelf that is **2.10 m** high. What is the **potential energy** of the book-Earth system relative to the desk when the book is on the shelf?

الحل



## Practice

30



If you slowly lower a **20.0-kg** bag of sand **1.20 m** from the trunk of a car to the driveway, how much work do you do?



الحل





## Practice

31



A 25.0-kg shell is shot from a cannon at Earth's surface. The reference level is Earth's surface.

- What is the shell-Earth system's gravitational potential energy when the shell's height is 425 m?
- What is the change in the system's potential energy when the shell falls to a height of 225 m?
- What motions and interactions does this system depend on?

الحل

## Practice

32



A worker picks up a 10.1-kg box from the floor and sets it on a table that is 1.1 m high. He slides the box 5.0 m along the table and then lowers it back to the floor. What were the changes in the box-Earth system's energy, and how did the system's total energy change? (Ignore friction.)

الحل



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## Elastic Potential Energy

### 1 Definition

**Elastic potential energy** is the stored energy due to an object's change in shape.

### 3 Symbols and Units

**EPE** = elastic potential energy

**KE** = kinetic energy

**GPE** = gravitational potential energy



Energy is measured in **joules (J)**.

### 2 Key Ideas / System Examples

- Elastic potential energy is stored in systems that include springs, rubber bands, trampolines, and a pulled bow.
- When a system is identified as the bow, the arrow and Earth, the energy of the system increases when the bow string is pulled.
- When the string and the arrow are released, the stored energy is changed into kinetic energy.
- A pole-vaulter with a flexible pole stores elastic potential energy when the pole bends. When the pole straightens, the elastic potential energy is transformed to gravitational potential energy and kinetic energy.

### 4 Pictures and Descriptions

#### Pulled Bow



The archer-bow-arrow system has maximum elastic potential energy before the string is released.

#### Released Arrow



When the string and arrow are released, the stored energy is completely transformed into kinetic energy.

#### Pole-Vaulter



When the pole-vaulter bends the flexible pole, some of the kinetic energy is transformed to elastic potential energy. When the pole straightens, it changes to gravitational potential energy and kinetic energy.

### 5 Comparison Table

| Situation                | Main Stored/Transformed Energy                               | What Happens                                                                                                                 |
|--------------------------|--------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| Pulled bow               | Elastic potential energy (EPE)                               | Energy is stored in the bow due to its change in shape.                                                                      |
| Released arrow           | Kinetic energy (KE)                                          | When the string and arrow are released, the stored energy is changed into kinetic energy.                                    |
| Bent pole (pole-vaulter) | Elastic potential energy (EPE)                               | When the pole bends, some of the pole-vaulter's kinetic energy is transformed to elastic potential energy.                   |
| Straightening pole       | Gravitational potential energy (GPE) and kinetic energy (KE) | When the pole straightens, the elastic potential energy is transformed to gravitational potential energy and kinetic energy. |

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## Other Forms Energy

### 1 Definition / Big Idea



Energy can be understood as a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system.

### 2 Main Energy Forms



#### Chemical energy

Stored in the chemical bonds in food and other substances.



#### Nuclear energy

Stored in the bonds inside the nucleus of an atom.



#### Thermal energy

Associated with temperature; it is the sum of the kinetic energy and potential energy of the particles in a system.



#### Electrical energy

Associated with charged particles.



#### Radiant energy

Transferred as electromagnetic waves, including light.



#### Mass as a form of energy (rest energy)

Mass is a form of energy that can be transformed into other forms of energy.

### 3 Symbols, Laws, and Units

| Quantity    | Symbol | Meaning                   | Unit          |
|-------------|--------|---------------------------|---------------|
| Energy      | $E$    | Energy of a system        | J (joule)     |
| Rest energy | $E_0$  | Mass energy (rest energy) | J (joule)     |
| Mass        | $m$    | Mass                      | kg (kilogram) |

Key equation:

$$E_0 = mc^2$$

Mass is a form of energy that can be transformed into other forms of energy.

### 4 Pictures and Descriptions

#### Food and the Body



When you eat, your body uses the energy from the chemical bonds in your food as an energy source.

#### Pole Vaulter



When the pole-vaulter bends the pole, some of the kinetic energy is transformed to elastic potential energy.

#### Cooking Pan



Thermal energy can be transferred, such as a stove transferring thermal energy to a pan.

#### Power Lines



Electrical energy can be transmitted through wires to your home, where appliances transform it into other forms of energy, such as light.

#### Power Plant



Power plants harness the energy of wind, water, fossil fuels, and atoms, and transform it into electrical energy.

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التفكير  
هو مفتاح  
النجاح

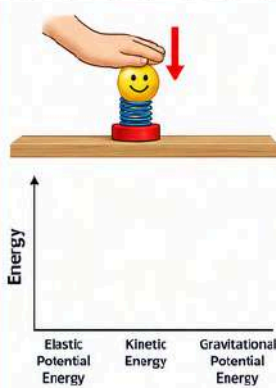


## Practice

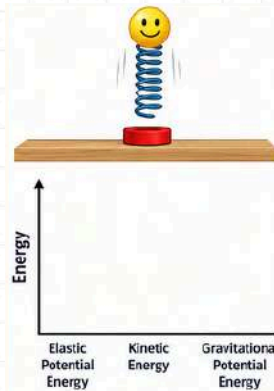
33

?? Draw bar graphs that show the forms of energy present in the following instances.  
Assume the system includes the spring toy and Earth

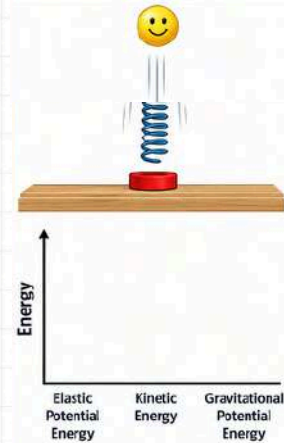
- a The toy is pushed down thereby compressing the spring.



- b The spring expands and the toy jumps.



- c The toy reaches the top of its flight.



- d Describe how energy manifests itself in different ways in this system.

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## MCQ

اختيار من متعدد

34



When you push down on the spring toy to compress the spring completely before releasing it, what is the primary form of energy stored in the system (toy + spring + Earth)?

- ☐ A Elastic potential energy
- ☐ B Kinetic energy (K)
- ☐ C Gravitational potential energy (GPE)
- ☐ D Thermal energy ( $E_{th}$ )

## MCQ

اختيار من متعدد

35



As the spring expands and the toy jumps upward, what primary energy transformation occurs within the system during launch?

- ☐ A Elastic potential energy ( $U_{es}$ ) converts into kinetic energy (K) and gravitational potential energy (GPE)
- ☐ B Gravitational potential energy (GPE) converts into elastic potential energy
- ☐ C Kinetic energy (K) converts entirely into elastic potential energy
- ☐ D Elastic potential energy remains constant with no transformation

## MCQ

اختيار من متعدد

36



When the toy reaches the top of its flight (maximum height), what is the primary form of energy present in the system at that instant (assuming air resistance is negligible)?

- ☐ A Gravitational potential energy (GPE)
- ☐ B Kinetic energy (K)
- ☐ C Elastic potential energy
- ☐ D Thermal energy ( $E_{th}$ )



## MCQ

اختيار من متعدد

37



What is the **amount of energy** produced from the complete conversion of a mass of 1 g into energy, given that the speed of light in a vacuum is  $c = 3 \times 10^8$  m/s?

- A  $9 \times 10^{10}$  J
- B  $9 \times 10^{13}$  J
- C  $9 \times 10^{16}$  J
- D  $3 \times 10^5$  J

## MCQ

اختيار من متعدد

38



In a nuclear reaction, an energy of  $4.5 \times 10^{14}$  J is released.

What is the mass defect that was completely converted into this energy? ( $c = 3 \times 10^8$  m/s)

- A  $2.5 \times 10^{-3}$  kg
- B  $5.0 \times 10^{-3}$  kg
- C  $1.5 \times 10^{-2}$  kg
- D  $9.0 \times 10^{-3}$  kg



## lesson 3

# CONSERVATION OF ENERGY

اضغط هنا لحضور الشرح



### 1. Definition

The law of conservation of energy states that **energy cannot be created or destroyed**. It can only be **transferred or transformed** from one form to another. In an isolated system, the **total energy remains constant**.



### 2. Focus Question

**Can energy be lost?**

**No.** Energy may change form or leave the system, but the **total energy is conserved**.

Energy is never lost – it just goes somewhere else or changes form!



### 3. Mechanical Energy

**Mechanical energy** is the energy associated with the motion and position of objects. It is the sum of the **kinetic energy** and **potential energy** of a system.



### 4. Main Formula

$$ME = KE + PE$$

The mechanical energy of a system is equal to the sum of its kinetic energy (KE) and potential energy (PE).



### 5. Symbols and Units

| Symbol | Quantity          | Meaning                              | SI Unit   |
|--------|-------------------|--------------------------------------|-----------|
| KE     | Kinetic energy    | Energy of motion                     | joule (J) |
| PE     | Potential energy  | Energy due to position (e.g. height) | joule (J) |
| ME     | Mechanical energy | Sum of KE and PE                     | joule (J) |

Energy is measured in **joules (J)** in the SI system.



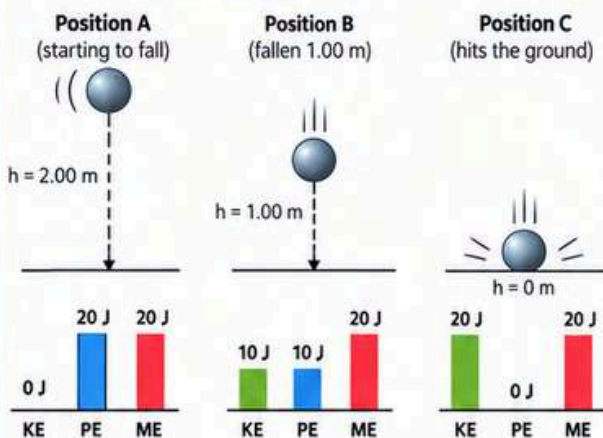
### 6. Kinetic, Potential and Mechanical Energy

| Type of energy                | Meaning                                                     | Depends on                           | Example                      |
|-------------------------------|-------------------------------------------------------------|--------------------------------------|------------------------------|
| <b>Kinetic Energy (KE)</b>    | Energy an object has because it is moving.                  | Mass (m) and speed (v)               | A rolling ball               |
| <b>Potential Energy (PE)</b>  | Energy an object has because of its position (e.g. height). | Mass (m), gravity (g) and height (h) | A ball held above the ground |
| <b>Mechanical Energy (ME)</b> | Total of KE and PE.                                         | Both KE and PE (of the system)       | A moving or falling object   |



### 7. Example: Falling Bowling Ball

A 10.0-N bowling ball is dropped from a height of 2.00 m. As it falls (neglecting air resistance), its gravitational potential energy (GPE) decreases while its kinetic energy (KE) increases. The total mechanical energy remains constant.



The total mechanical energy stays at **20 J** throughout the fall (as long as air resistance is negligible).



### 8. Important Notes / Reminders

- **Energy cannot be created or destroyed.** It can only be **transferred or transformed**.
- In a **closed and isolated system**, the total energy remains **constant**.
- **Mechanical energy** is the sum of **kinetic and potential energy** ( $ME = KE + PE$ ).
- If **external forces do work** on the system (e.g. friction), mechanical energy can be transformed into other forms of energy (thermal energy, sound, etc.). The total energy of the larger system (including the surroundings) is still conserved.
- The **path** an object takes **does not matter**. Only the initial and final states (positions and speeds) determine the change in mechanical energy, if no non-conservative forces (like friction) do work.

### lesson 3

## Conservation of Mechanical Energy



#### 1. Definition

The law of conservation of mechanical energy states that the **total mechanical energy** of a closed and isolated system **remains constant**, provided that only conservative forces (such as gravity) do work. Mechanical energy can be transferred between kinetic and potential energy, but it is not lost.



#### 2. Main Law / Formula

$$KE_i + PE_i = KE_f + PE_f$$

$$ME = KE + PE$$

$KE_i, PE_i$  : kinetic and potential energy at the start (initial)

$KE_f, PE_f$  : kinetic and potential energy at the end (final)

$ME$  : total mechanical energy (sum of KE and PE)

## Energy Paths and Non-Conservative Forces



#### 1. Path Does Not Matter (No Friction)

If friction does not affect the system, the path an object takes **does not matter**. Only the **change in height matters** for gravitational potential energy (PE).

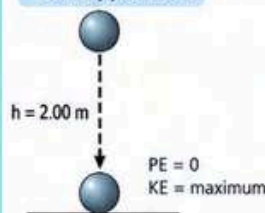
An object that starts and ends at the same heights has the same change in PE, regardless of the path it follows.



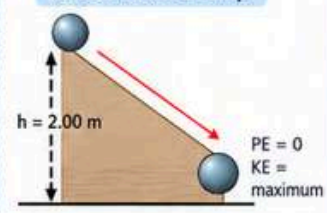
#### 2. Dropped Ball vs Ramp

**Both reach the same final mechanical energy** (if friction is neglected).

##### A. Dropped ball



##### B. Ball down a ramp



Both balls start with the same gravitational potential energy ( $mgh$ ) and can have the same final kinetic energy if friction is negligible.



#### What Changes When Friction Is Present?

When friction is present, it does work on the system. Some of the mechanical energy (KE and/or PE) is transformed into **thermal energy** (internal energy) and **sound energy**.

As a result, the **mechanical energy** of the object **decreases**, even though the total energy of the larger system remains constant.



#### Frictionless vs With Friction

| Feature                                | Frictionless Motion                         | Motion with Friction                                          |
|----------------------------------------|---------------------------------------------|---------------------------------------------------------------|
| <b>Mechanical energy (ME)</b>          | Remains constant ( $ME = KE + PE$ )         | Decreases over time                                           |
| <b>Energy transformation</b>           | Only between KE and PE                      | Some mechanical energy $\rightarrow$ thermal energy and sound |
| <b>Path</b>                            | Does not matter (only the change in height) | Path matters (longer path = more energy lost to friction)     |
| <b>Total energy (of larger system)</b> | Conserved                                   | Conserved                                                     |

lesson 3

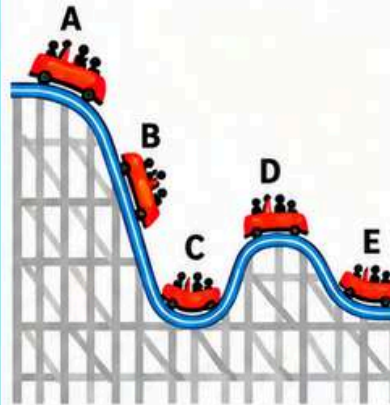
# Applications of Conservation of Energy



## 1 Overview

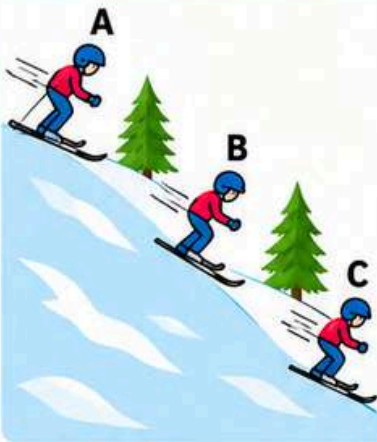
The law of conservation of energy applies to **real moving objects** such as roller coasters, skiers and pendulums. Energy may change between gravitational potential energy (GPE), kinetic energy (KE) and other forms, but the **total energy** of a closed system **remains constant**.

## 2 Roller Coaster Example



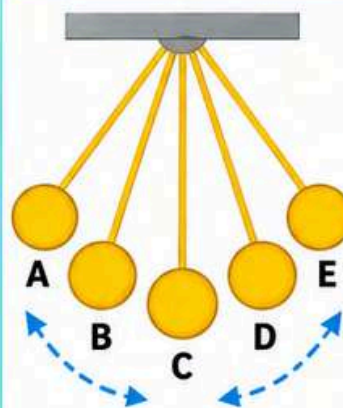
At the top of the first hill (A), the car has maximum gravitational potential energy and little kinetic energy. At the bottom (C), KE is maximum and GPE is minimum. As the car climbs the next hill (D), KE is converted back into GPE.

## 3 Skiing Down a Slope



At the top of the slope (A), the skier has maximum gravitational potential energy. As the skier moves downhill, GPE is transformed into kinetic energy and their speed increases. At the bottom (C), the skier has maximum KE and minimum GPE.

## 4 Pendulum Example



At the ends of the swing (A and E), the pendulum bob is highest, so GPE is maximum and KE is zero. As the bob swings downward, GPE is converted to KE. At the lowest point (C), KE is maximum and GPE is minimum. The bob then swings back up, converting KE to GPE.

## 5 Comparison of Applications

| System              | Where GPE is greatest                         | Where KE is greatest                  | Total mechanical energy   | Notes                                               |
|---------------------|-----------------------------------------------|---------------------------------------|---------------------------|-----------------------------------------------------|
| Roller coaster      | Top of highest hill (e.g. point A)            | Bottom of lowest point (e.g. point C) | Constant (if no friction) | Energy changes between GPE and KE as the car moves. |
| Skiing down a slope | Top of the slope (e.g. point A)               | Bottom of the slope (e.g. point C)    | Constant (if no friction) | GPE is transformed into KE as the skier speeds up.  |
| Pendulum            | Highest points of swing (e.g. points A and E) | Lowest point (e.g. point C)           | Constant (if no friction) | KE and GPE continuously exchange during the swing.  |



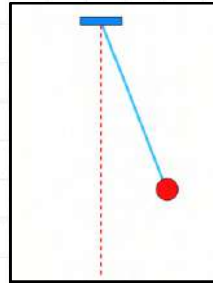
## MCQ

اختيار من متعدد

39



Assuming friction and air resistance are negligible, which of the following is **correct** about the **total mechanical energy of the pendulum as it oscillates**?



- ☐ A Total energy is constant throughout the pendulum's motion
- ☐ B Total energy is maximum when the pendulum bob is at its lowest position
- ☐ C Total energy is maximum when the pendulum bob is at its maximum height
- ☐ D Total energy is minimum when the pendulum bob is somewhere between its lowest and highest positions.

## MCQ

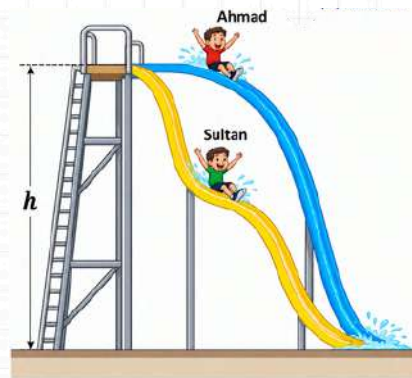
اختيار من متعدد

40



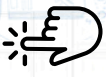
Ahmad and Sultan start from rest at the same time at height ( $h$ ) at the top of two differently configured water slides. The slides are nearly frictionless.

Which statement is **true** about Ahmad and Sultan in the given position?



- ☐ A Ahmad has less potential energy than Sultan
- ☐ B Both have the same kinetic energy
- ☐ C Both have the same potential energy
- ☐ D Sultan has greater kinetic energy than Ahmad



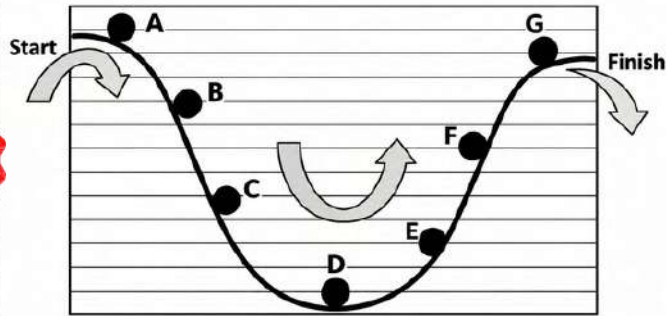


## MCQ

اختبار من متعدد

41

?? use the graph below to answer the following questions :



?? Which sequence correctly shows a resulting increase in potential energy?

A C, D, E, F

C B, F, E, C

B D, E, B, F

D A, G, F, C

?? Which sequence correctly shows a resulting increase in kinetic energy?

A E, F, B, G

C B, F, E, C

B D, E, B, F

D A, B, C, D

?? Which sequence correctly shows a resulting decrease in kinetic energy?

A E, F, B, G

C B, F, E, C

B D, E, F, G

D A, G, F, C

?? Which sequence correctly shows a resulting decrease in potential energy?

A E, F, B, G

C A, B, C, D

B D, E, B, F

D A, G, F, C



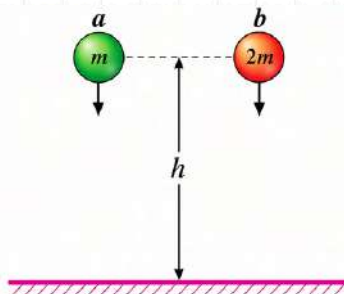
## MCQ

اختيار من متعدد

42



Two balls **a** and **b** of the same volume and of masses  $m$  and  $2m$  respectively have fallen from a height  $h$  above the ground as shown in the opposite figure, so which physical quantity will not be equal for the two balls at the halfway point of their path till the ground?



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- ☐ A Potential energy
- ☐ B Kinetic energy
- ☐ C Mechanical energy
- ☐ D All the previous

## MCQ

اختيار من متعدد

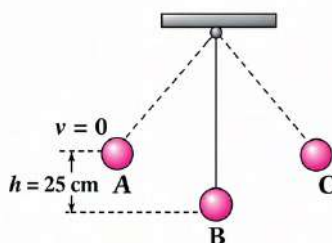
43



The diagram illustrates a ball hung by a thread that swings freely in a vertical plane.

The maximum speed reached by the ball during oscillation equals .....

$$(g = 9.8 \text{ m/s}^2)$$



للتفوق عنوان

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- ☐ A 1.1 m/s
- ☐ B 2.2 m/s
- ☐ C 3.3 m/s
- ☐ D 4.4 m/s





## MCQ

اختيار من متعدد

44



An object is projected from the ground vertically upward at velocity 10 m/s, so the maximum height reached by the object will be .....

- A 0.5 m
- B 1 m
- C 5 m
- D 10 m

## MCQ

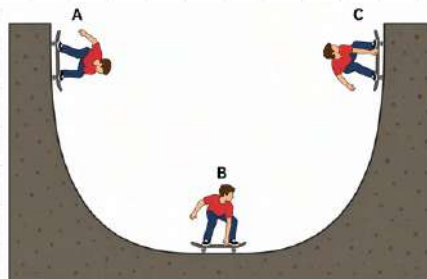
اختيار من متعدد

45



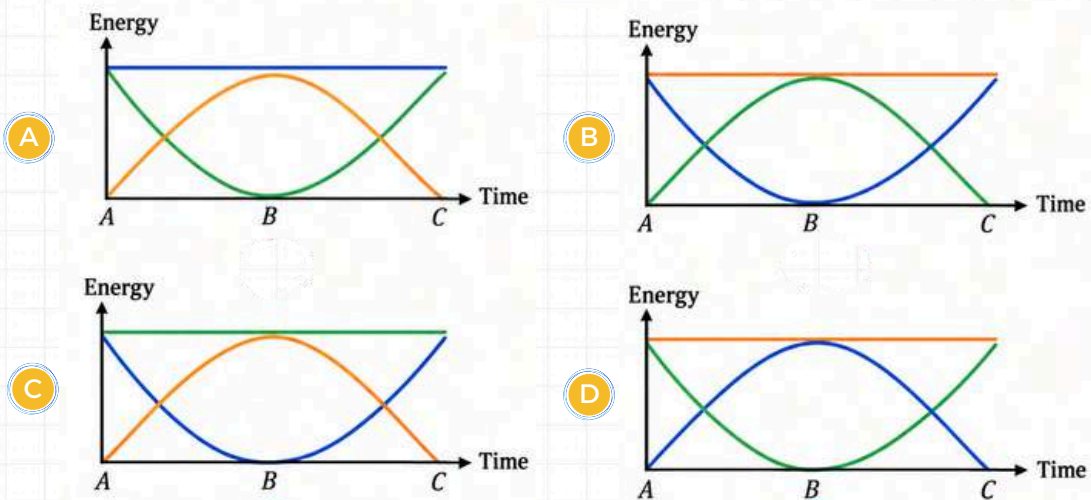
A skater slides down a U-shaped ramp, as shown in the figure.

Which graph correctly describes the change in **mechanical energy** (blue), **potential energy** (green), and **kinetic energy** (orange) over time



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## MCQ

اختيار من متعدد

46



A ball is dropped from a point a above the ground as shown in the figure.

Assuming that air resistance is negligible. Which of the following expressions correctly describes the kinetic energy of the ball when it is at point b ( $K_b$ ) in terms of its gravitational potential energy at point a  $U_{G_a}$ ?

- A  $(K_b) = \frac{3}{4} (U_{G_a})$
- B  $(K_b) = \frac{4}{3} (U_{G_a})$
- C  $(K_b) = \frac{1}{4} (U_{G_a})$
- D  $(K_b) = \frac{1}{3} (U_{G_a})$



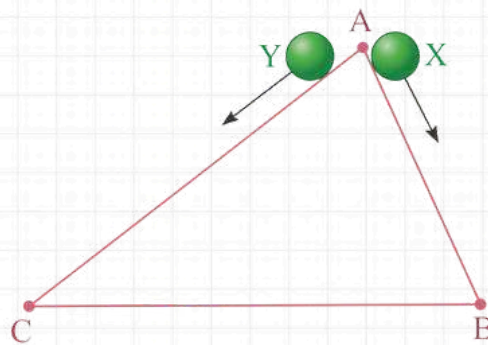
## MCQ

اختيار من متعدد

47



In the opposite figure, two identical balls (X, Y) descend together from the same level, one over incline (AB) and the other over (AC). Which of the following sentences describes what happens to the two balls at points (B and C) by neglecting the friction?



- A The mechanical energy of ball (X) is greater
- B The speed of ball (X) will be greater
- C The mechanical energy of ball (Y) is greater
- D The speeds of the two balls will be equal





## MCQ

اختيار من متعدد

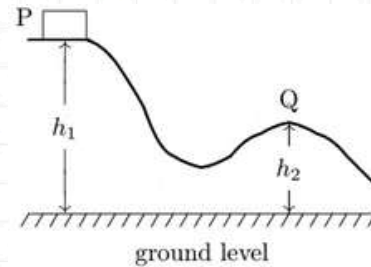
48



A block is released from rest at point P and slides along the frictionless track shown.

At point Q, its speed is:

- ☐ A  $2g\sqrt{h_1 - h_2}$
- ☐ B  $2g(h_1 - h_2)$
- ☐ C  $(h_1 - h_2)/2g$
- ☐ D  $\sqrt{2g(h_1 - h_2)}$



## MCQ

اختيار من متعدد

49



For a block of mass  $m$  to slide without friction up the rise of height  $h$  shown, it must have a minimum initial kinetic energy of:

- ☐ A  $gh$
- ☐ B  $mgh$
- ☐ C  $gh/2$
- ☐ D  $mgh/2$



## MCQ

اختيار من متعدد

50

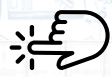


A 2.0 kg object is released from rest from a height of 3.0 m above Earth's surface.

How much kinetic energy does the object have when it reaches a height of 1.0 m?

- ☐ A 2.5 J
- ☐ B 10 J
- ☐ C 20 J
- ☐ D 40 J





## MCQ

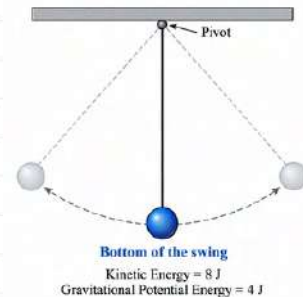
اختيار من متعدد

51



A pendulum swings in a vertical plane. At the bottom of the swing, the kinetic energy is 8 J and the gravitational potential energy is 4 J. At the highest position of the swing, the kinetic and gravitational potential energies are \_\_\_\_.

- A kinetic energy = 0 J gravitational potential energy = 4 J
- B kinetic energy = 12 J gravitational potential energy = 0 J
- C kinetic energy = 0 J gravitational potential energy = 12 J
- D kinetic energy = 4 J gravitational potential energy = 8 J



## MCQ

اختيار من متعدد

52



A ball of mass  $m$  is thrown vertically into the air with an initial speed  $v$ . Which of the following equations correctly describes the **maximum height,  $h$ , of the ball?**

- A  $h = \sqrt{\frac{v}{2g}}$
- B  $h = \frac{2g}{v^2}$
- C  $h = \frac{v^2}{2g}$
- D  $h = \frac{mv^2}{g}$

## MCQ

اختيار من متعدد

53



A stone is thrown up in the air and it reaches a maximum height of 10.0 m. **What is the initial speed of the stone?**

- A 10.0 m/s
- B 12.0 m/s
- C 14.0 m/s
- D 19.0 m/s





## MCQ

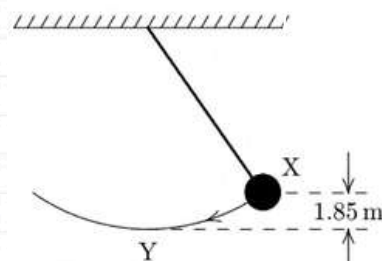
اختيار من متعدد

54



A simple pendulum consists of a 2.0-kg mass attached to a string. It is released from rest at X as shown. Its speed at the lowest point Y is about:

- A 0.90 m/s
- B 3.6 m/s
- C 6.3 m/s
- D 6.0 m/s



## Practice

55



Your friend wants to solve the world's energy problems by inventing a device that will deliver **ten times more energy** than put into the device. **Can this device work? Explain.**




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## MCQ

اختيار من متعدد

56



Suppose that the bike rider pedaled up the hill and never came to a stop. In what system is energy conserved? From what form of energy did the bike gain mechanical energy?

- A The system (bike + rider + Earth), and mechanical energy (M.E) was gained from chemical energy ( $E_{\text{chem}}$ ) stored in the rider's body
- B The system (bike only), and mechanical energy (M.E) was gained from gravitational potential energy (GPE)
- C The system (bike + hill only), and mechanical energy (M.E) was gained from thermal energy ( $E_{\text{th}}$ )
- D The system (rider + Earth only), and mechanical energy (M.E) was gained from rotational kinetic energy ( $K_{\text{rot}}$ ) of the wheels





## MCQ

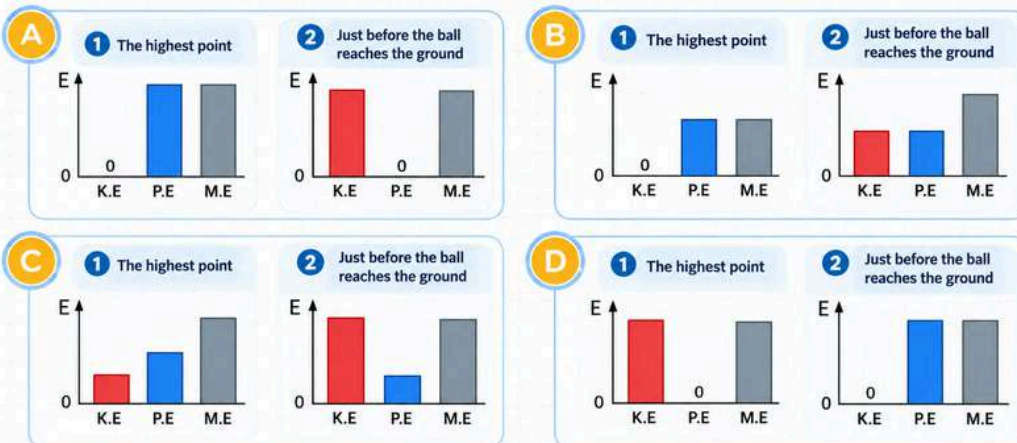
اختيار من متعدد

57



A ball is thrown **vertically upward**. Neglect air resistance and take the gravitational potential energy at the ground as zero. Which option correctly shows the energy bar diagrams at:

- 1 The highest point.
- 2 Just before the ball reaches the ground.



## Practice

58



A bike rider approaches a hill at a speed of 8.5 m/s. The combined mass of the bike and the rider is 85.0 kg. Choose a suitable system. **Find the initial kinetic energy of the system.** The rider coasts up the hill. Assuming friction is negligible, **at what height will the bike come to rest?**




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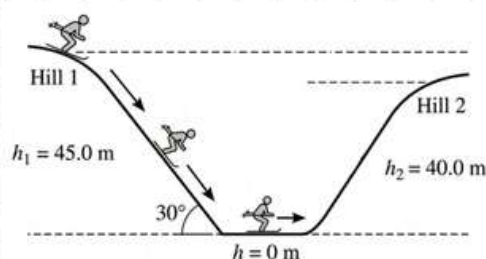


## Practice

59



A skier starts from rest at the top of a hill that is 45.0 m high, skis down a  $30^\circ$  incline into a valley, and continues up a hill that is 40.0 m high. The heights of both hills are measured from the valley floor. Assume that friction is negligible and ignore the effect of the ski poles.



- How fast is the skier moving at the bottom of the valley?
- What is the skier's speed at the top of the second hill?
- Do the angles of the hills affect your answers?

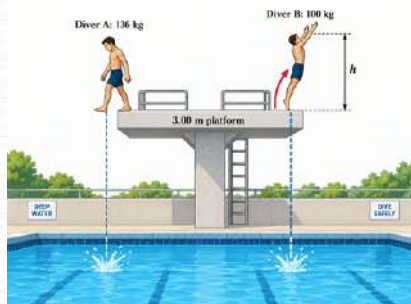
الحل

## Practice

60



In a belly-flop diving contest, the winner is the diver who makes the biggest splash upon hitting the water. The size of the splash depends not only on the diver's style, but also on the amount of kinetic energy the diver has. Consider a contest in which each diver jumps from a 3.00-m platform. One diver has a mass of 136 kg and simply steps off the platform. Another diver has a mass of 100 kg and leaps upward from the platform. How high would the second diver have to leap to make a competitive splash?



الحل



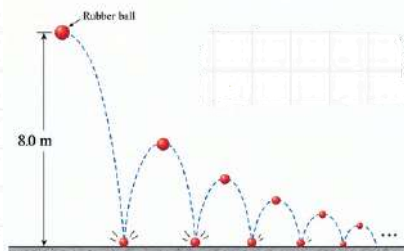


## Practice

61



A rubber ball drops from a height of 8.0 m onto a concrete floor and bounces repeatedly. Each time it hits the floor, the ball-Earth system loses  $\frac{1}{5}$  of its ME. How many times will the ball bounce before it bounces back up to a height of only 4.0 m?



الحل

## Practice

62



In Figure, a child slides down a playground slide. At the bottom, she is moving at 3.0 m/s. How much energy was transformed by friction as she slid down the slide?



الحل





# Collisions and Conservation Laws



## Key Concepts

- A **collision** is an interaction between two objects during a short time interval.
- **Momentum** is always conserved in a closed, isolated system.
- **Kinetic energy** may be conserved, decrease, or increase, depending on the type of collision.
- The details of a collision can be complex, but the strategy is to find the motion of the objects just before and just after the collision.
- You cannot predict whether kinetic energy is conserved. In all cases except case 1, there is a change in the amount of kinetic energy.



## Momentum

- **Definition:** A measure of the quantity of motion of an object.
- **Formula:**  $p = mv$
- **Symbols:**  $p$  : momentum (kg·m/s)     $m$  : mass (kg)     $v$  : velocity (m/s)
- **Unit:** kilogram meter per second (kg·m/s)



## Law of Conservation of Momentum

In a closed, isolated system, the total momentum before a collision equals the total momentum after the collision.

$$p_{total} \text{ (before)} = p_{total} \text{ (after)}$$





# Collisions and Conservation Laws

## 1 Elastic Collision

An elastic collision is a collision in which the kinetic energy of the system before and after the collision was the same.



### Note

Collisions between hard objects, such as those made of steel or hard plastic, often are called nearly elastic collisions.

## 2 Case 1: Elastic Collision

$$KE_f = KE_i$$

Before collision



1.00 kg 1.00 kg

$$v_{Ai} = 1.00 \text{ m/s}$$

$$v_{Bi} = 0.00 \text{ m/s}$$

$$KE_i = 0.50 \text{ J}$$

After collision



1.00 kg 1.00 kg

$$v_{Af} = 0.00 \text{ m/s}$$

$$v_{Bf} = 1.00 \text{ m/s}$$

$$KE_f = 0.50 \text{ J}$$

## 3 Perfectly Inelastic Collision

A perfectly inelastic collision is a collision in which colliding objects stick together after colliding.



### Note

Objects made of soft, sticky materials, such as clay, act in this way.

## 4 Case 2: Perfectly Inelastic Collision

$$KE_f < KE_i$$

Before collision



1.00 kg 1.00 kg

$$v_{Ai} = 1.00 \text{ m/s}$$

$$v_{Bi} = 0.00 \text{ m/s}$$

$$KE_i = 0.50 \text{ J}$$

After collision



1.00 kg 1.00 kg

$$v_{Af} = v_{Bf} = 0.50 \text{ m/s}$$

$$KE_f = 0.25 \text{ J}$$

## 5 Comparison of Collision Types

| Collision type                | What happens after collision          | Kinetic energy result     |
|-------------------------------|---------------------------------------|---------------------------|
| Elastic collision             | Objects separate (change velocities). | $KE_f = KE_i$ (same)      |
| Perfectly inelastic collision | Objects stick together.               | $KE_f < KE_i$ (decreases) |

## 6 Symbols and Units

| Symbol | Quantity       | Unit |
|--------|----------------|------|
| $v$    | velocity       | m/s  |
| $KE$   | kinetic energy | J    |

## 7 Get It?



Compare and contrast elastic collisions and inelastic collisions.





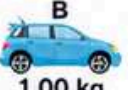
# Collisions and Conservation Laws

## 1 Inelastic Collision

In cases 2 and 3, the kinetic energy decreased. Some of it may have been transformed to thermal energy and other forms of energy.

## 2 Case 3: Inelastic Collision

Kinetic energy decreases ( $KE_f < KE_i$ ).

| Before collision                                                                                          |                                                                                    | After collision                                                                                           |                                                                                     |
|-----------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|                          |  |                        |  |
| 1.00 kg                                                                                                   | 1.00 kg                                                                            | 1.00 kg                                                                                                   | 1.00 kg                                                                             |
| $v_{Ai} = 1.00 \text{ m/s}$                                                                               | $v_{Bi} = 0.00 \text{ m/s}$                                                        | $v_{Af} = 0.25 \text{ m/s}$                                                                               | $v_{Bf} = 0.75 \text{ m/s}$                                                         |
| $KE_i = KE_{Ai} + KE_{Bi}$                                                                                |                                                                                    | $KE_f = KE_{Af} + KE_{Bf}$                                                                                |                                                                                     |
| $= \frac{1}{2} (1.00 \text{ kg})(1.00 \text{ m/s})^2 + \frac{1}{2} (1.00 \text{ kg})(0.00 \text{ m/s})^2$ |                                                                                    | $= \frac{1}{2} (1.00 \text{ kg})(0.25 \text{ m/s})^2 + \frac{1}{2} (1.00 \text{ kg})(0.75 \text{ m/s})^2$ |                                                                                     |
| $= 0.50 \text{ J}$                                                                                        |                                                                                    | $= 0.31 \text{ J}$                                                                                        |                                                                                     |

$$KE_f < KE_i \quad (0.31 \text{ J} < 0.50 \text{ J})$$

The objects do not stick together.

## 3 Superelastic Collision

In case 4, the kinetic energy of the system increased. If energy in the system is conserved, then one or more other forms of energy must have decreased. Perhaps potential energy from a compressed spring was released during the collision, adding kinetic energy to the system. This kind of collision is called a superelastic or explosive collision.

## 4 Case 4: Superelastic Collision

Kinetic energy increases ( $KE_f > KE_i$ ).

| Before collision                                                                                          |                                                                                      | After collision                                                                                           |                                                                                       |
|-----------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|                        |  |                      |  |
| 1.00 kg                                                                                                   | 1.00 kg                                                                              | 1.00 kg                                                                                                   | 1.00 kg                                                                               |
| $v_{Ai} = 1.00 \text{ m/s}$                                                                               | $v_{Bi} = 0.00 \text{ m/s}$                                                          | $v_{Af} = 0.20 \text{ m/s}$                                                                               | $v_{Bf} = 1.20 \text{ m/s}$                                                           |
| $KE_i = KE_{Ai} + KE_{Bi}$                                                                                |                                                                                      | $KE_f = KE_{Af} + KE_{Bf}$                                                                                |                                                                                       |
| $= \frac{1}{2} (1.00 \text{ kg})(1.00 \text{ m/s})^2 + \frac{1}{2} (1.00 \text{ kg})(0.00 \text{ m/s})^2$ |                                                                                      | $= \frac{1}{2} (1.00 \text{ kg})(0.20 \text{ m/s})^2 + \frac{1}{2} (1.00 \text{ kg})(1.20 \text{ m/s})^2$ |                                                                                       |
| $= 0.50 \text{ J}$                                                                                        |                                                                                      | $= 0.74 \text{ J}$                                                                                        |                                                                                       |

$$KE_f > KE_i \quad (0.74 \text{ J} > 0.50 \text{ J})$$

## 5 Comparison of the Cases

| Case | What happens                  | Kinetic energy change       |
|------|-------------------------------|-----------------------------|
| 1    | Elastic collision             | No change ( $KE_f = KE_i$ ) |
| 2    | Perfectly inelastic collision | Decreases ( $KE_f < KE_i$ ) |
| 3    | Inelastic collision           | Decreases ( $KE_f < KE_i$ ) |
| 4    | Superelastic collision        | Increases ( $KE_f > KE_i$ ) |

## 6 Symbols and Units

| Symbol | Quantity       | Unit |
|--------|----------------|------|
| $m$    | mass           | kg   |
| $v$    | velocity       | m/s  |
| $KE$   | kinetic energy | J    |

## 7 Important Note



Momentum is conserved in all four cases in a closed, isolated system.





# Collisions and Conservation Laws

## Comparison of Collision Types

| Type of Collision             | What happens after the collision | Kinetic energy relation | Key note                                                           |
|-------------------------------|----------------------------------|-------------------------|--------------------------------------------------------------------|
| Elastic collision             | Objects do not stick together.   | $KE_f = KE_i$           | Kinetic energy does not change.                                    |
| Perfectly inelastic collision | Objects stick together.          | $KE_f < KE_i$           | Kinetic energy decreases.                                          |
| Inelastic collision           | Objects do not stick together.   | $KE_f < KE_i$           | Kinetic energy decreases.                                          |
| Superelastic collision        | Objects do not stick together.   | $KE_f > KE_i$           | Kinetic energy increases because another form of energy decreases. |

## Collision Cases

### Case 1: Elastic Collision

$$KE_f = KE_i$$



### Case 2: Perfectly Inelastic Collision

$$KE_f < KE_i$$



### Case 3: Inelastic Collision

$$KE_f < KE_i$$



### Case 4: Superelastic Collision

$$KE_f > KE_i$$





## MCQ

اختيار من متعدد

63



An inelastic collision is one in which:

- ☐ A Momentum is not conserved but kinetic energy is conserved
- ☐ B Total mass is not conserved but momentum is conserved
- ☐ C Neither kinetic energy nor momentum is conserved
- ☐ D Momentum is conserved but kinetic energy is not conserved

## MCQ

اختيار من متعدد

64



Blocks A and B are moving toward each other. A has a mass of 2.0 kg and a velocity of 50 m/s, while B has a mass of 4.0 kg and a velocity of -25 m/s. They suffer a perfectly inelastic collision. The kinetic energy lost during the collision is:

- ☐ A 0 J
- ☐ B 1250 J
- ☐ C 3750 J
- ☐ D 5000 J

## MCQ

اختيار من متعدد

65



Suppose a glob of chewing gum and a small, rubber ball collide head-on in midair and then rebound apart. Would you expect kinetic energy (K) to be conserved? If not, what happens to the energy?

- ☐ A No, kinetic energy (K.E) is not conserved ( $KE_i \neq KE_f$ ). Some of it is converted into thermal energy ( $E_{th}$ ) and work done in deforming the gum.
- ☐ B Yes, kinetic energy (KE) is perfectly conserved ( $KE_i = KE_f$ ) because the objects bounce apart.
- ☐ C No, kinetic energy (KE) is not conserved. It is completely converted into gravitational potential energy (GPE).
- ☐ D Yes, kinetic energy (KE) is conserved, but the total momentum (P) of the system is lost.





## Practice

66



A 110-kg football linebacker has a head-on collision with a 150-kg defensive end. After they collide, they come to a complete stop. Before the collision, which player had the greater velocity, momentum and which player had the greater kinetic energy?

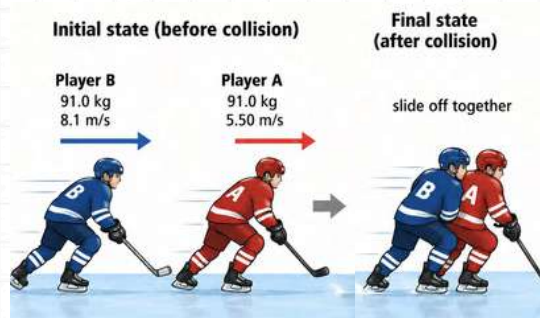
الحل

## Practice

67



A 91.0-kg hockey player is skating on ice at 5.50 m/s. Another hockey player of equal mass, moving at 8.1 m/s in the same direction, hits him from behind. They slide off together:



- What are the total mechanical energy and momentum of the system before the collision?
- What is the velocity of the two hockey players after the collision?
- How much was the system's kinetic energy decreased in the collision?

الحل





## Practice

68



An 8.00-g bullet is fired horizontally into a 9.00-kg block of wood on an air table and is embedded in it. After the collision, the block and bullet slide along the frictionless surface together with a speed of 10.0 cm/s. Find the initial speed of the bullet.

الحل

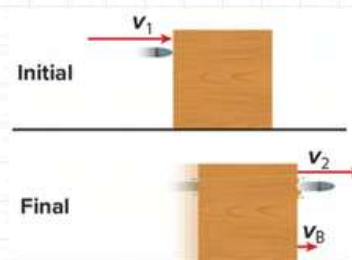
## Practice

69



A bullet of mass  $m$ , moving at speed  $v_1$ , goes through a motionless wooden block and exits with speed  $v_2$ . After the collision, the block, which has mass  $m_B$ , is moving:

- What is the final speed ( $v_B$ ) of the block?
- What was the change in the bullet's mechanical energy?
- How much energy was lost to friction inside the block?



الحل





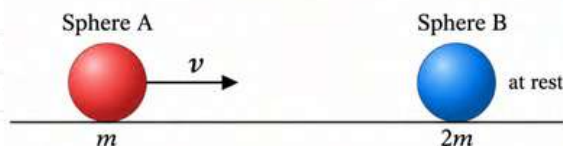
## MCQ

اختيار من متعدد

70



Sphere A has mass  $m$  and is moving with velocity  $v$ . It makes a head-on elastic collision with a stationary sphere B of mass  $2m$ . After the collision their speeds ( $v_A$  and  $v_B$ ) are:



- (A)  $v_A = 0, v_B = v/2$
- (B)  $v_A = -v/3, v_B = 2v/3$
- (C)  $v_A = -v, v_B = v$
- (D)  $v_A = -2v/3, v_B = v/3$

اضغط هنا لحضور الشرح



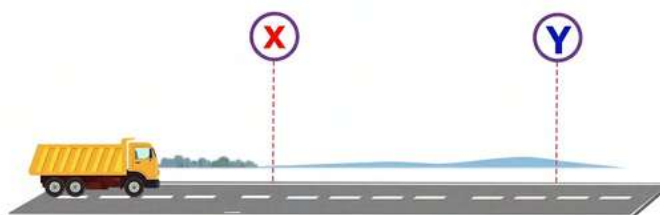
## MCQ

اختيار من متعدد

71



A group of students in grade 12 advanced investigating the principle of conservation of momentum using a small toy truck moving with constant velocity on a frictionless surface. As the truck passes position (X) an amount of sand is dropped into it. At position (Y), a trapdoor at the back of the truck opens and the sand falls out. How does the velocity of the truck change at position (X) and at position (Y)?



|     |                          |                          |
|-----|--------------------------|--------------------------|
| (A) | at (X)<br>Decreases      | at (Y)<br>Increases      |
| (B) | at (X)<br>Decreases      | at (Y)<br>Stays the same |
| (C) | at (X)<br>Stays the same | at (Y)<br>Stays the same |
| (D) | at (X)<br>Stays the same | at (Y)<br>Increases      |





## MCQ

اختيار من متعدد

72

Two balls (a) and (b) have the same kinetic energy, and the momentum of ball (b) equals half of the momentum of ball (a). If the mass of ball (a) equals 6 kg, **what is the mass of ball (b)?**



اضغط هنا لحضور الشرح



- A 1.5 kg
- B 3 kg
- C 2 kg
- D 0.75 kg

## MCQ

اختيار من متعدد

73

Two identical balls with equal masses moving along a straight line with velocities  $\vec{v}_{(1,x)}$  and  $\vec{v}_{(2,x)}$ , undergo a totally elastic collision. After collision their velocities are  $\vec{v}_{f(1,x)}$  and  $\vec{v}_{f(2,x)}$ . Which of the following table rows for the balls before and after the collision?

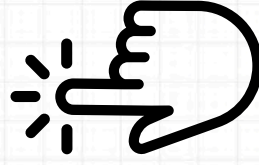
اضغط هنا لحضور الشرح



|   | Before/قبل              |                         | After/بعد               |                         |
|---|-------------------------|-------------------------|-------------------------|-------------------------|
|   | $(\vec{v}_{i(1,x)})m/s$ | $(\vec{v}_{i(2,x)})m/s$ | $(\vec{v}_{f(1,x)})m/s$ | $(\vec{v}_{f(2,x)})m/s$ |
| A | 2                       | -5                      | -5                      | 2                       |
| B | 3                       | -3                      | 0                       | 6                       |
| C | 3                       | -2                      | 1                       | 6                       |
| D | 5                       | -2                      | -5                      | 5                       |



اضغط هنا لحضور الشرح



يمكنك التسجيل في

**الفصل الدراسي الأول**

**للحصول على المذكرة كاملة**

A+

**الفيزياء للصف 12 (متقدم - عام)**  
(لغة المنهج : انجليزي - عربي )  
**الاشتراك يشمل :**

- 2 حصتين اسبوعيا
- الحصص اونلاين من خلال zoom
- مراجعة بعد الانتهاء من كل وحدة
- مذكرة شرح المنهج
- مذكرة المراجعة الشاملة للهيكل وأسئلة التوقعات
- شرح المنهج كاملا + المراجعة الشاملة للهيكل
- توفير تسجيل الحصص
- مدة الحصة ساعة إلى ساعة ونصف
- اختبارات محاكاة

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اضغط هنا للتواصل واتساب

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