Physics – Grade 9 – Advanced. Academic Year: 2022 - 2023 . . . Term 3
End of Term 3 Questions and Answers.

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Ministry of Education – Emirates Schools Establishment. **(LO): Learning Objective**

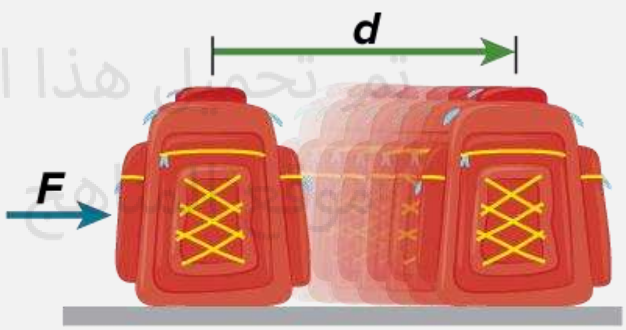
PART ONE – Multiple Choice Questions

LO – 1: Identify work as a scalar quantity measured in N.m or Joule (J). Part I– Question 1: **P188.**

When a force is applied through a displacement, **work** (W) is done on the system.

Work is the transfer of energy that occurs when a force is applied through a distance; equal to the product of the system's displacement and the force applied to the system in the direction of displacement. $\boldsymbol{W = F\,d}$.

The SI unit of work is called a Joule (J). One joule is equal to 1 N.m. One joule of work is done when a force of 1 N acts on a system over a displacement of 1 m.



LO – 2: Define energy as the ability of a system to do work or produce a change in itself or in the surrounding world, measured in Joules). Part I– Question 2:

Critical thinking (29). P198. Explain how to find the change in energy of a system if three agents exert forces on the system at once.

Answer:

Work = Change in Kinetic Energy.

$W = \Delta K.E$

$W_1 + W_2 + W_3 = \Delta E$

Since work is the change in kinetic energy, calculate the work done by each force. The work can be positive, negative, or zero, depending on the relative angles of the force and displacement of the object. The sum of the three works is the change in energy of the system.

LO – 3: Apply the relationship between power, the work done by a force, and the time interval in which that work is done. $\left(P = \frac{W}{t}\right)$ Part I– Question 3. **P196.**

Practice Problem 16:
What power does a pump develop to lift 35 L of water per minute from a depth of 110 m? (One liter of water has a mass of 1.00 kg.)

Solution:

$$P = \frac{W}{t} \implies P = \frac{mgh}{t} = \frac{(35)(9.8)(110)}{60} = 628.83 \approx 630\, watts \approx 0.630\, kW$$

Practice Problem 17:
An electric motor develops 65 kW of power as it lifts a loaded elevator 17.5 m in 35 s. How much force does the motor exert?

Solution:

$$P = \frac{W}{t} \implies P = \frac{F\, d}{t} \implies F = \frac{(P)(t)}{d} = \frac{(65000)(35)}{17.5} = 1.3 \times 10^5\, N$$

Practice Problem 18: CHALLENGE
A winch designed to be mounted on a truck, as shown in Figure 10, is advertised as being able to exert a 6.8×10^3 N force and to develop a power of 0.30 kW. How long would it take the truck and the winch to pull an object 15m?

$$P = \frac{W}{t} \implies t = \frac{W}{P}$$

$$t = \frac{(6.8 \times 10^3)(15)}{0.30 \times 1000}$$

$$t = 340\, s$$

$$t = 5.7\text{ min.}$$

LO – 4: State and explain the law of conservation of energy.
Get it Question, Page 210.
The law of conservation of energy states that in a closed system, energy is not created or destroyed, but rather, is conserved.

LO – 5: Define kinetic energy and apply the relationship between a particle's kinetic energy, mass, and speed ($KE = 0.5 \times m \times v^2$)
Translational kinetic energy the energy of a system due to the system's change in position.

Get it: Using the equation for translational kinetic energy, show why a car moving at 20 m/s has four times the translational kinetic energy of the same car moving at 10 m/s.

At $v = 10\ m/s$	At $v = 20\ m/s$	
$KE = 0.5\,(m)(10)^2$ $KE_1 = 50\ m$	$KE = 0.5\,(m)(20)^2$ $KE_2 = 200$ m	$KE_2 = (4)(KE_1)$

Q 20: If the work done on an object doubles its kinetic energy, does it double its speed? If not, by what ratio does it change the speed?

Kinetic energy is proportional to the square of the velocity, so doubling the energy doubles the square of the velocity. The velocity increases by a factor of the square root of 2, or 1.4

Mathematically: $W = \Delta KE$, assume that $KE_i = 0\,J$

$W_1 = 0.5 \times m \times v_1^2$ and $W_2 = (2)(W_1)$

$$0.5 \times m \times v_2^2 = (2)\,(0.5 \times m \times v_1^2)$$

$$v_2^2 = (2)\,(v_1^2) \implies v_2 = \sqrt{2}\,v_1$$

Question: Adult cheetahs, the fastest of the great cats, have a mass of about 70 kg and have been clocked to run at up to 32 m/s.

How many joules of kinetic energy does such a swift cheetah have?

$KE = 0.5 \times m \times v^2$

$KE = 0.5 \times 70 \times 32^2 = 35840\,J.$

LO – 6: Relate the rotational kinetic energy to the object's moment of inertia and it's angular velocity: ($KE_{rot} = 0.5 \times I \times \omega^2$)

Q 37: On a playground, some children push a merry-go round so that it turns twice as fast as it did before they pushed it. What are the relative changes in angular momentum and rotational kinetic energy of the merry-go-round?

Solution:

Angular momentum (L)	Rotational Kinetic Energy (KE_{rot})
$L = m\,r^2\,\omega$	$KE_{rot} = 0.5 \times I \times \omega^2$
L will be **doubled** because it is directly proportional to the angular velocity.	KE_{rot} will be **quadrable** because it is directly proportional to the square of the angular velocity.

PART TWO – Multiple Choice Questions

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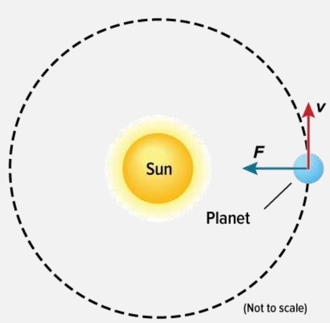
LO – 7: Recall that a perpendicular force (perpendicular to the direction of motion) does no work, but only changes the direction of motion of an object.

Calculate the work done by the force (F) shown in the figure?

Solution:	Figure (1)
Since the force (F) is **perpendicular** to the displacement, then the work done by that force is zero joule.	

LO – 8: Apply the relationship between a force F and the work done on a system by the force when the system undergoes a displacement d: ($W = Fd\cos\theta$) where θ is the angle between the force and the displacement.

Q 8: A rope is used to pull a metal box a distance of 15.0 m across the floor. The rope is held at an angle of 46.0° with the floor, and a force of 628 N is applied to the rope. How much work does the rope do on the box?

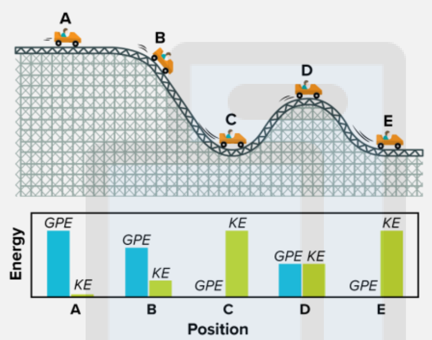
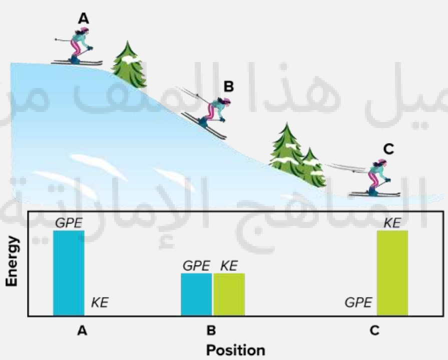
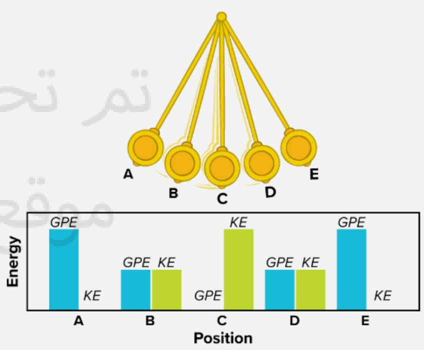
Solution:

$W = Fd\cos\theta$

$W = (628)(15.0)(\cos 46.0) = 6543.7\,J \approx 6.54 \times 10^3\,J$

LO – 9: Apply the law of conservation of mechanical energy to solve problems.

Figure 24: The conservation of mechanical energy is an important consideration in designing roller coaster, ski slopes, and the pendulum for the grandfather clocks.

<table>
<tr><th>Roller coaster</th><th>Skiing</th><th>Pendulum</th></tr>
<tr>
<td></td>
<td></td>
<td></td>
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KE + GPE = CONSTANT.

LO – 10: Relate the gravitational potential energy to the mass of the object and its height above or below a reference level. ($GPE = m\,g\,h$)

Q32: 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?

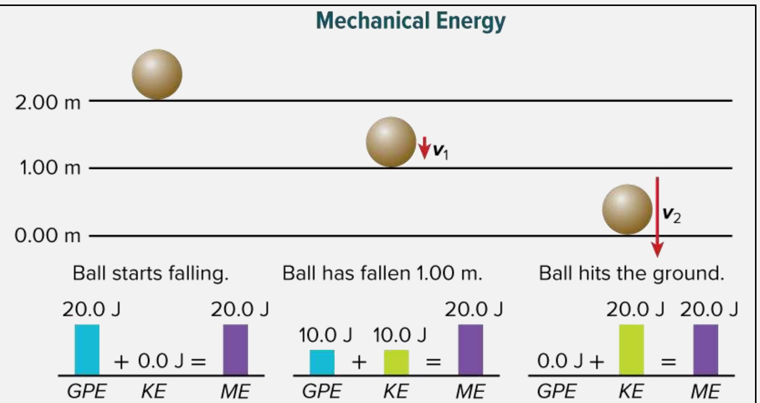
$GPE = m\,g\,h$

$GPE = (2.2)(9.8)(2.10 - 0.80) = 28.028\,J \approx 28\,J$

LO – 11: Define mechanical energy as the sum of all kinetic and potential energies of the system.

Figure 22: when a bowling ball is dropped, mechanical energy is conserved.

$m_{ball} = 1.02\,kg$



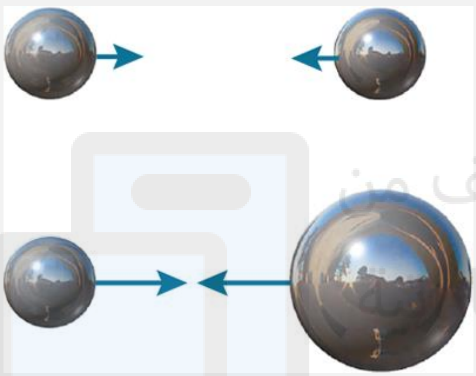
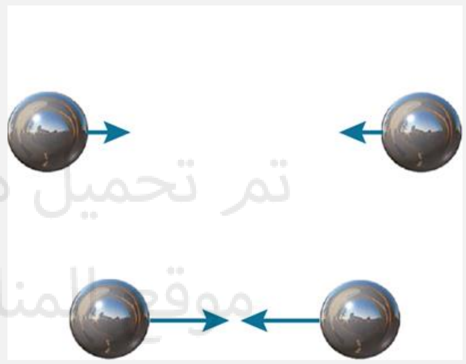
LO – 12: Define gravitational force as the force of attraction between two objects of given mass.

Page 168:

Law of Universal Gravitation:

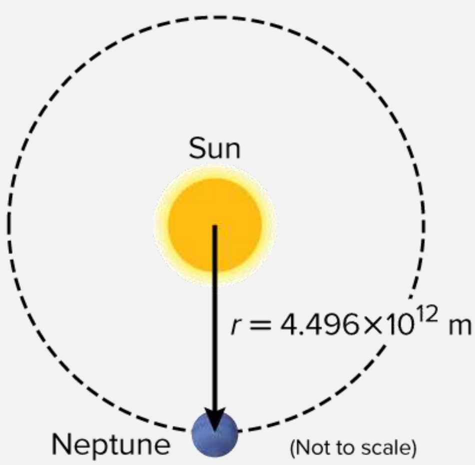
The gravitational force is equal to the universal gravitational constant, times the mass of object 1, times the mass of object 2, divided by the distance between the centers of the objects, squared.

$$F_g = \frac{G\, m_1 m_2}{r^2}$$

	
Gravitation between objects depends on the product of the masses of the objects.	The gravitational force between objects is inversely proportional to the square of the distance between the objects.

LO – 13: Calculate the orbital period of a planet orbiting the Sun.

Q 8, P 172: Neptune orbits the Sun at an average distance given in Figure 9, which allows gases, such methane, to condense and form an atmosphere. If the mass of the Sun is $1.99\times 10^{30}\ kg$, calculate the period of Neptune's orbit.

Solution:	Figure 9
$T = 2\pi\sqrt{\frac{r^3}{G\, m_s}}$ $T = 2\pi\sqrt{\frac{(4.496\times 10^{12})^3}{(6.67\times 10^{-11})(1.99\times 10^{30})}}$ $T = 5199120307\ s$ $T = \frac{5199120307}{3600\times 24\times 365} = 165\ years$	

LO – 14: Calculate the gravitational field strength for an object of mass m at a distance r from its center and specify the units for gravitational field.

Q 20, P 181: The mass of the Moon is $7.3 \times 10^{22}\ kg$ and its radius is 1738 km. What is the strength of the gravitational field on the surface of the Moon?

Solution:

$$\boldsymbol{g} = \frac{\boldsymbol{G\ m}}{\boldsymbol{r^2}}$$

$$\boldsymbol{g} = \frac{(6.67 \times 10^{-11})\ (7.3 \times 10^{22})}{(\mathbf{1738} \times \mathbf{1000})^2}$$

$$\boldsymbol{g} = 1.6\ m/s^2$$

LO – 15: Calculate the orbital period of a satellite.

Q 21, P 181: Two satellites are in circular orbits about Earth. One is 150 km above the surface, the other is 160 km.

a. Which satellite has the larger orbital period?
b. Which has the greater speed?

$M_{Earth} = 5.97 \times 10^{24} kg$ $\quad$ $R_{Earth} = 6.371 \times 10^{6} m$

Note that: $(r = h + R_{Earth})$

Solution: (The periodic time)

	Periodic time (T)
1^{st} satellite $(h = 150000\ m)$ $r_1 = (150 \times 10^3) + (6.371 \times 10^6)$ $r_1 = 6.521 \times 10^6\ m$	$T_1 = 2\pi\sqrt{\frac{r_1^3}{G\ m_E}}$ $T_1 = 2\pi\sqrt{\frac{(6.521 \times 10^6)^3}{(6.67 \times 10^{-11})(5.97 \times 10^{24})}}$ $T_1 = 5243\ s = 87.4\ minutes$
2^{nd} satellite $(h = 160000\ m)$ $r_2 = (160 \times 10^3) + (6.371 \times 10^6)$ $r_2 = 6.531 \times 10^6\ m$	$T_2 = 2\pi\sqrt{\frac{(6.531 \times 10^6)^3}{(6.67 \times 10^{-11})(5.97 \times 10^{24})}}$ $T_2 = 5255\ s = 87.6\ minutes$

OR, simply, the second satellite would have a greater periodic time as its height (160 km) is greater than the first satellite (150 km). $(T_2 > T_1)$

Solution: (The speed)

	Periodic time (T)
1st satellite $(h = 150000\ m)$ $r = (150 \times 10^3) + (6.371 \times 10^6)$ $r = 6.521 \times 10^6\ m$	$v_1 = \sqrt{\frac{G\ m_E}{r_1}}$ $v_1 = \sqrt{\frac{(6.67 \times 10^{-11})(5.97 \times 10^{24})}{(6.521 \times 10^6)}}$ $v_1 = 7814.4\ m/s = 7.8144\ km/s$
2nd satellite $(h = 160000\ m)$ $r = (160 \times 10^3) + (6.371 \times 10^6)$ $r = 6.531 \times 10^6\ m$	$v_2 = \sqrt{\frac{G\ m_E}{r_2}}$ $v_2 = \sqrt{\frac{(6.67 \times 10^{-11})(5.97 \times 10^{24})}{(6.531 \times 10^6)}}$ $v_2 = 7808.4\ m/s = 7.8084\ km/s$

OR, simply, the first satellite would have a greater speed as its height (150 km) is less than the second satellite (160 km). $(v_1 > v_2)$

LO – 16: Recall pressure as the perpendicular component of a force divided by the area of the surface to which it is applied (P = F/A).

Example 1, P 234: A child weights 364 N and sits on a three – legged stool, which weights 41 N. The bottoms of the stool's legs touch the ground over a total area of 19.3 cm^3.

a. What is the average pressure that the child and the stool exert on the ground?
b. How does the pressure change when the child leans over so that only two legs of the stool touch the floor?

Solution:

((a) $P = \frac{F}{A}$ $P = \frac{(364 + 41)}{19.3 \times 10^{-4}}$ $P = 209844\ Pa$ $P = 2.10 \times 10^2\ kPa$	((b) $P = \frac{F}{A}$ $P = \frac{(364 + 41)}{\left(\frac{19.3}{3}\right) \times 2 \times 10^{-4}}$ $P = 314766\ Pa$ $P = 3.14 \times 10^2\ kPa$	

PART THREE – Written part

LO – 17: Apply the law of conservation of energy to examples like roller coaster rides, ski slopes, inclined planes/ hills, and pendulums.

Q 47, P 217: A child jumps on a trampoline. Draw energy bar diagrams to show the forms of energy in the following situations.

a. The child is at the highest point.
b. The child is at the lowest point.

<table>
<tr><td>At highest point</td><td>At lowest point</td><td></td></tr>
<tr><td>All of the system's energy is gravitational potential energy.
$ME = GPE$</td><td>All of the system's energy is elastic potential energy.
$ME = EPE$</td><td rowspan="2">
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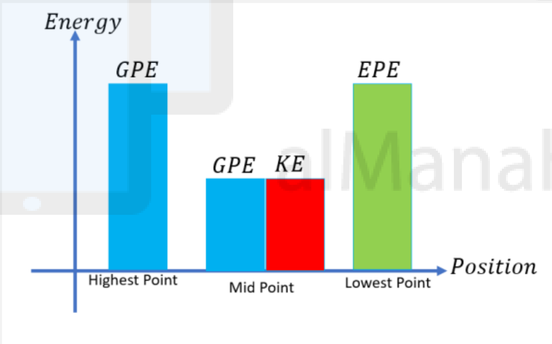
<tr><td colspan="2">
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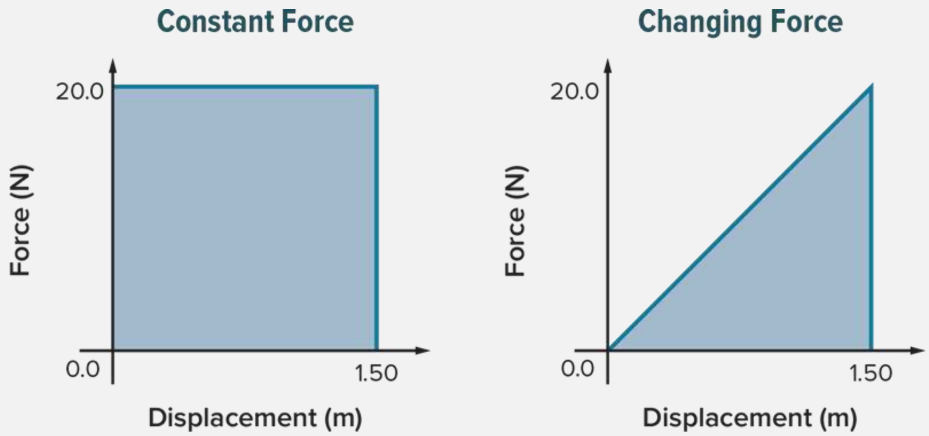
LO – 18: Determine graphically the work done by a force from the area of force versus displacement graph

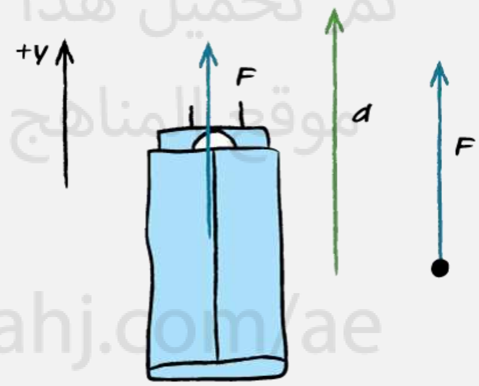
Figure 4, P 191: The area under a force – displacement graph is equal to the work.



Left Diagram:	Right diagram
Work = Bounded Area $W = Length \times width$ $W = 1.50 \times 20.0$ $W = 30.0\,J$	Work = Bounded Area $W = \frac{1}{2} \times Base \times Height$ $W = \frac{1}{2} \times 1.50 \times 20.0$ $W = 15.0\,J$

LO – 19: Apply the relationship between power, the work done by a force, and the time interval in which that work is done (P=W/t)

Example 3, P 197: An electric motor lifts an elevator 9.00 m in 15.0 s by exerting a force of $1.20 \times 10^4\,N$. What power does the motor produce in kW?

Solution:	
$P = \frac{W}{t}$ $P = \frac{Fd}{t}$ $P = \frac{(1.20 \times 10^4)(9.00)}{(15.0)}$ $P = 7200\,W$ $P = 7.20\,kW$	

LO – 20: Apply the law of universal gravitation to calculate the gravitational force or other unknown parameters.

Question 9, P 172: Predict the gravitational force between two 15-kg balls whose centers are 35 cm apart. What fraction is this of the weight of one ball?

Solution:

$$F = \frac{Gm_1m_2}{r^2}$$

$$F = \frac{(6.67 \times 10^{-11})(15)(15)}{(0.35)^2} = 1.22 \times 10^{-7} N$$

Comparison:

$$\frac{F}{Weight} = \frac{1.22 \times 10^{-7}}{15 \times 9.8} = 2.50 \times 10^{-9}$$

Means that the weight of one the balls is about 2000 million times greater than the gravitational force between the two balls.

Part 3 – Question 21. unannounced

Part 3 – Question 22. unannounced

THE END