

## حل مراجعة نهائية وفق الهيكل الوزاري منهج انسباير



### تم تحميل هذا الملف من موقع المناهج الإماراتية

موقع المناهج ← المناهج الإماراتية ← الصف التاسع المتقدم ← فيزياء ← الفصل الثالث ← ملفات متنوعة ← الملف

تاريخ إضافة الملف على موقع المناهج: 18:59:07 2025-05-24

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

المزيد من مادة  
فيزياء:

إعداد: School Bedaa Al

### التواصل الاجتماعي بحسب الصف التاسع المتقدم



صفحة المناهج  
الإماراتية على  
فيسبوك

الرياضيات

اللغة الانجليزية

اللغة العربية

التربية الاسلامية

المواد على تلغرام

### المزيد من الملفات بحسب الصف التاسع المتقدم والمادة فيزياء في الفصل الثالث

مراجعة وحدة حالات المادة والضغط وفق الهيكل الوزاري منهج انسباير

1

أسئلة الامتحان النهائي القسم الالكتروني منهج بريدج مع الإجابات

2

مراجعة نهائية وفق الهيكل الوزاري منهج انسباير

3

الدليل الشامل في شرح مسائل قانون الديناميكا الأول

4

حل أسئلة وزارية سابقة موزعة حسب الدروس

5



Grade 9 – Advanced. AY: 2024 – 2025 . . . T 3.

**End of Term 3** Final Summative Assessment Preparation.

## Contents.

[Unit – 3] Momentum and Energy.	Lessons.
Module 10: Energy and its Conservation.	Lesson – 1: Work and Energy Lesson – 2: The Many Forms of Energy Lesson – 3: Conservation of Energy Lesson – 4: Machines (For Enrichment)
[Unit – 2] Mechanics in Two Dimension.	
Module 7: Gravitation	Lesson – 1: Planetary Motion and Gravitation Lesson – 2: Using the Law of Universal Gravitation
Module 12: States of Matter.	Lesson – 1: Properties of Fluids Lesson – 2: Forces within Liquids (For Enrichment) Lesson – 3: Fluids at Rest and in Motion Lesson – 4: Solids (For Enrichment)

You may use the following equations:

$g = 9.8 \text{ m/s}^2$		
Module (10) Energy and It's Conservation	Module (7) Gravitation	Module (12) States of Matter
$W = Fd\cos(\theta)$ $W = \Delta E$ $P = \frac{\Delta E}{t} = \frac{W}{t}, P = Fv$ $KE_{trans} = \frac{1}{2}mv^2$ $GPE = mgh$ $MK = KE + PE$ $(KE)_i + (PE)_i = (KE)_f + (PE)_f$	$\left(\frac{T_A}{T_B}\right)^2 = \left(\frac{r_A}{r_B}\right)^3$ $F_G = \frac{Gm_1 \times m_2}{r^2}$ $T = \sqrt{\left(\frac{4\pi^2}{G \times m_E}\right)r^3} = 2\pi\sqrt{\left(\frac{r^3}{G \times m_E}\right)}$ $v = \sqrt{\left(\frac{Gm_E}{r}\right)}$ $a = g\left(\frac{r_b}{r}\right)^2$ $g = \frac{Gm}{r^2}$ $G = 6.67 \times 10^{-11} \frac{\text{N} \cdot \text{m}^2}{\text{kg}^2}$	$P = \frac{F}{A}$ $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $P_1V_1 = P_2V_2, T \text{ constant}$ $\frac{V_1}{T_1} = \frac{V_2}{T_2}, P \text{ constant}$ $PV = nRT$ $\frac{F_2}{A_2} = \frac{F_1}{A_1}$ $P = \rho hg$ $F_{buoyant} = (F_{bottom} - F_{top})$ $F_{buoyant} = \rho_{(fluid)}Vg$ $R = 8.31 \text{ Pa} \cdot \frac{\text{m}^3}{\text{mol} \cdot \text{K}}$

## PART ONE – MULTIPLE CHOICE QUESTIONS (MCQ)

LO – 1.

Explain Kepler's Second Law which states that an imaginary line from the Sun to a planet sweeps out equal areas in equal time intervals.

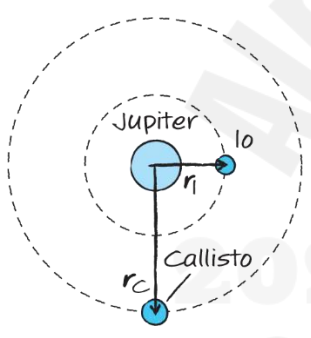
LO – 2:

Explain Kepler's Third Law which states that the square of the ratio of the periods of any two planets revolving about the Sun is equal to the cube of the ratio of their average distances from the Sun and write it in equation form:

$$\left(\frac{T_A}{T_B}\right)^2 = \left(\frac{r_A}{r_B}\right)^3$$

### EXAMPLE Problem 1

Galileo measured the orbital radii of Jupiter's moons using the diameter of Jupiter as a unit of measure. He found that Io, the closest moon to Jupiter, has a period of 1.8 days and is 4.2 units from the center of Jupiter. Callisto, the fourth moon from Jupiter, has a period of 16.7 days. Using the same units that Galileo used, predict Callisto's distance from Jupiter.

	$\left(\frac{T_c}{T_1}\right)^2 = \left(\frac{r_c}{r_1}\right)^3$ $\left(\frac{16.7}{1.8}\right)^2 = \left(\frac{r_c}{4.2}\right)^3$ $r_c = 18.54436362 \text{ units}$ $r_c \approx 19 \text{ units}$
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**Q 1.** If Ganymede, one of Jupiter's moons, has a period of 32 days, how many units is its orbital radius? Use the information given in Example Problem 1.

$$\left(\frac{T_G}{T_1}\right)^2 = \left(\frac{r_G}{r_1}\right)^3$$

$$\left(\frac{32}{1.8}\right)^2 = \left(\frac{r_G}{4.2}\right)^3$$

$$r_G = 28.60888548 \text{ units}$$

$$r_c \approx 29 \text{ units}$$

**Q 2.** An asteroid revolves around the Sun with a mean orbital radius twice that of Earth's. Predict the period of the asteroid in Earth years.

$$\left(\frac{T_A}{T_E}\right)^2 = \left(\frac{r_A}{r_E}\right)^3$$

$$\left(\frac{T_A}{1.00}\right)^2 = \left(\frac{2r_E}{r_E}\right)^3$$

$$\left(\frac{T_A}{1.00}\right)^2 = (2)^3$$

$$T_A = 2.8 \text{ years}$$

**Q 3.** Venus has a period of revolution of 225 Earth days. Find the distance between the Sun and Venus as a multiple of Earth's average distance from the Sun.

$$\left(\frac{T_V}{T_E}\right)^2 = \left(\frac{r_V}{r_E}\right)^3$$

$$\left(\frac{225}{365.25}\right)^2 = \left(\frac{r_V}{r_E}\right)^3$$

$$\frac{r_V}{r_E} = \sqrt[3]{\left(\frac{225}{365.25}\right)^2}$$

$$\frac{r_V}{r_E} = 0.724$$

$$r_V = 0.724 r_E$$

**Q 4.** Uranus requires 84 years to circle the Sun. Find Uranus's average distance from the Sun as a multiple of Earth's average distance from the Sun.

$$\left(\frac{T_V}{T_E}\right)^2 = \left(\frac{r_V}{r_E}\right)^3$$

$$\left(\frac{225}{365.25}\right)^2 = \left(\frac{r_V}{r_E}\right)^3$$

$$\frac{r_V}{r_E} = \sqrt[3]{\left(\frac{225}{365.25}\right)^2}$$

$$\frac{r_V}{r_E} = 0.724$$

$$r_V = 0.724 r_E$$

**Q 5.** From Table 1 you can find that, on average, Mars is 1.52 times as far from the Sun as Earth is. Predict the time required for Mars to orbit the Sun in Earth days.

$$r_M = 1.52\,r_E$$

Table 1 Solar System Data			
Name	Average Radius (m)	Mass (kg)	Average Distance from the Sun (m)
Sun	$6.96 \times 10^8$	$1.99 \times 10^{30}$	—
Mercury	$2.44 \times 10^6$	$3.30 \times 10^{23}$	$5.79 \times 10^{10}$
Venus	$6.05 \times 10^6$	$4.87 \times 10^{24}$	$1.08 \times 10^{11}$
Earth	$6.38 \times 10^6$	$5.97 \times 10^{24}$	$1.50 \times 10^{11}$
Mars	$3.40 \times 10^6$	$6.42 \times 10^{23}$	$2.28 \times 10^{11}$
Jupiter	$7.15 \times 10^7$	$1.90 \times 10^{27}$	$7.79 \times 10^{11}$
Saturn	$6.03 \times 10^7$	$5.68 \times 10^{26}$	$1.43 \times 10^{12}$
Uranus	$2.56 \times 10^7$	$8.68 \times 10^{25}$	$2.87 \times 10^{12}$
Neptune	$2.48 \times 10^7$	$1.02 \times 10^{26}$	$4.50 \times 10^{12}$

$$\left(\frac{T_M}{T_E}\right)^2 = \left(\frac{r_M}{r_E}\right)^3$$

$$\left(\frac{T_M}{365.25}\right)^2 = \left(\frac{1.52r_E}{r_E}\right)^3$$

$$\left(\frac{T_M}{365.25}\right)^2 = (1.52)^3$$

$$T_M = 684.5 \text{ days}$$

**Q 6.** The Moon has a period of 27.3 days and a mean distance of  $3.9 \times 10^5$  km from its center to the center of Earth.

- Use Kepler's laws to find the period of a satellite in orbit  $6.70 \times 10^3$  km from the center of Earth.
- How far above Earth's surface is this satellite?

$\left(\frac{T_M}{T_S}\right)^2 = \left(\frac{r_M}{r_S}\right)^3$ $\left(\frac{27.3}{T_S}\right)^2 = \left(\frac{3.9 \times 10^8}{6.70 \times 10^6}\right)^3$ $T_S = 0.0614720845 \text{ days}$ $T_S = 89 \text{ minutes}$	<p>Distance of Satellite from Earth's Surface:</p> $d = 6.70 \times 10^3 \text{ km} - r_{\text{Earth}}$ $d = 6.70 \times 10^6 - 6.38 \times 10^6$ $d = 6.70 \times 10^6 \text{ m} - 6.38 \times 10^6$ $d = 320000 \text{ m}$ $d = 320 \text{ km}$
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**Q 7.** Using the data in the previous problem for the period and radius of revolution of the Moon, predict what the mean distance from Earth's center would be for an artificial satellite that has a period of exactly 1.00 day.

$$\left(\frac{T_M}{T_S}\right)^2 = \left(\frac{r_M}{r_S}\right)^3$$

$$\left(\frac{27.3}{1.00}\right)^2 = \left(\frac{3.9 \times 10^8}{r_S}\right)^3$$

$$r_S = 43015288.73 \text{ m}$$

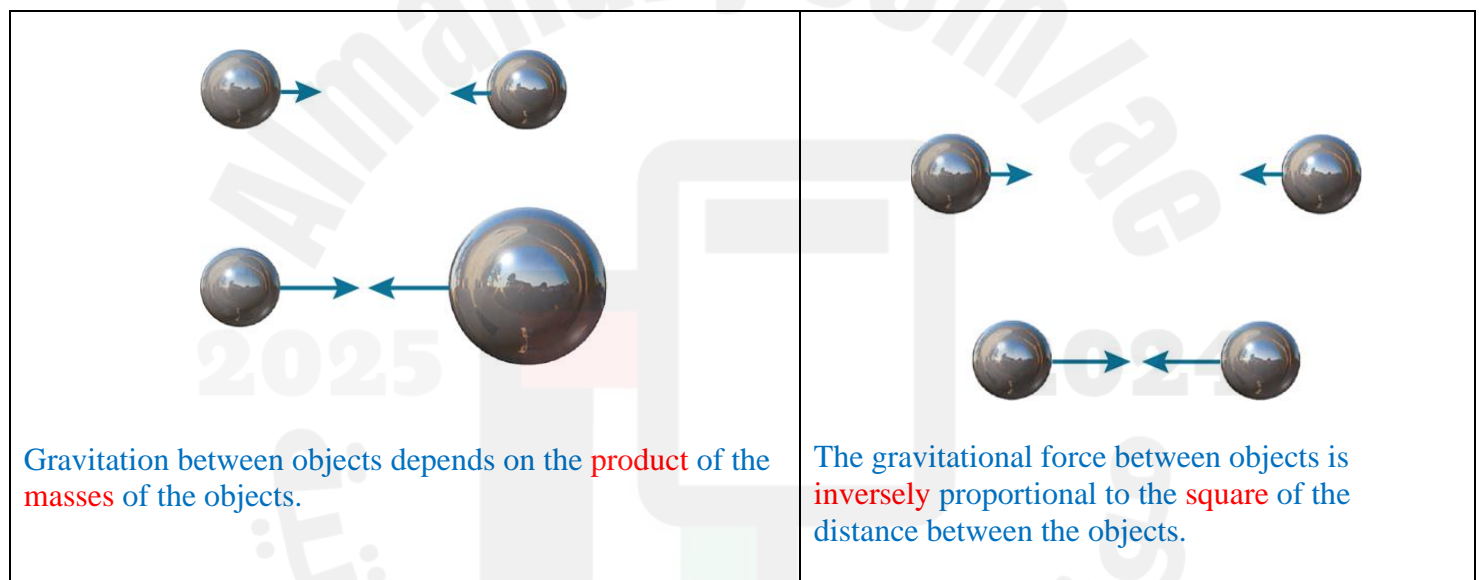
$$r_S = 4.3 \times 10^4 \text{ km}$$

**LO – 3:**

Explore the gravitational force between objects and the parameters affecting that force and explain the insignificance of such force between objects.

Figure 5

Mass and distance affect the magnitude of the gravitational force between objects.



**LO – 4:**

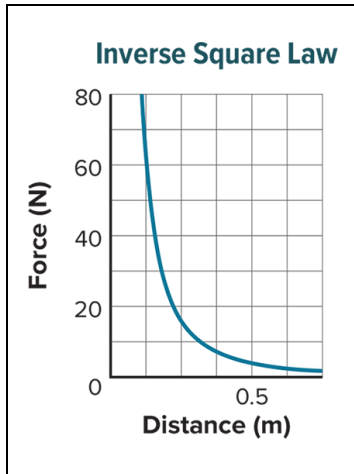
Define gravitational force as the force of attraction between two or more objects with given masses, with an explanation of the law of universal gravitation as a form of Newton's second law, and write it in the form of an equation:

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



Figure 6

This is a graphical representation of the inverse square relationship.



**Q 9.** 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?

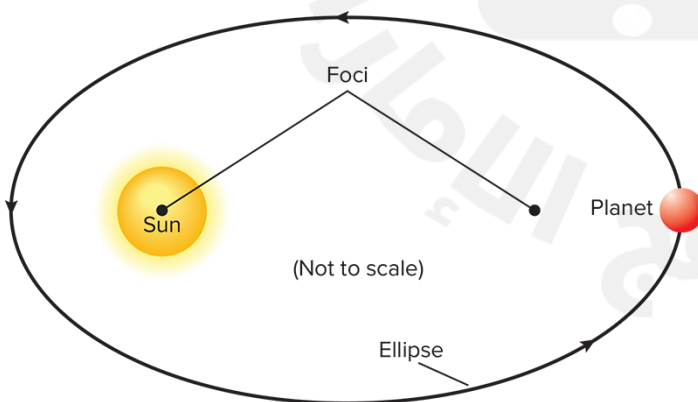
$F_g = \frac{G m_1 m_2}{r^2}$	$\frac{F_g}{\text{Weight}} = \frac{1.2 \times 10^{-7}}{15 \times 9.8}$
$F_g = \frac{6.67 \times 10^{-11} \times 15 \times 15}{(0.35)^2}$	$\frac{F_g}{\text{Weight}} = 0.82 \times 10^{-9}$
$F_g = 1.2 \times 10^{-7} \text{ N}$	$\frac{F_g}{\text{Weight}} = 0.82 \text{ parts per billion}$

**LO – 5:**

Explain Kepler's First Law which states that the planets follow elliptical paths with the sun at one focus.

Figure 2

The orbit of each planet is an ellipse, with the Sun at one focus.





### Get It?

Describe the common feature that Kepler's first law found concerning the paths of orbiting objects around the Sun.

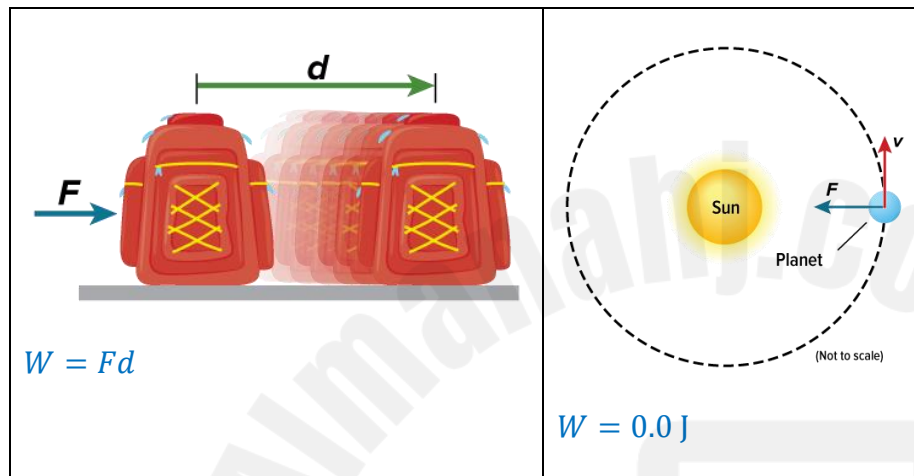
The paths of the planets are ellipses with the Sun at one focus.

### LO – 6:

1. Show that work is done when a force is applied through a displacement.
2. Recall that a perpendicular force (perpendicular to the direction of motion) does no work but only changes the direction of motion of an object.

Figure 1

Work is done when a force is applied through a displacement.



Identify another example of when a force does work on an object.

when you push a saltshaker across a tabletop.

Pushing a broken car.



### LO – 7:

1. Determine the mechanical work done on a body by a constant force divided by a displacement as the dot product of the force vector and the displacement vector and explain that the work done by a variable force is represented by the area under the force-displacement graph.
2. Illustrate when work is positive, negative or zero with suitable examples.

**EXAMPLE Problem 1**

A hockey player uses a stick to apply a constant 4.50 N force forward to a 105 g puck sliding on ice over a displacement of 0.150 m forward. How much work does the stick do on the puck? Assume friction is negligible.

$W = F d$ $W = 4.50 \times 0.150$ $W = 0.675 \text{ J}$	
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**Q 1.** Refer to Example Problem 1 to solve the following problem.

a. If the hockey player exerted twice as much force (9.00 N) on the puck over the same distance, how would the amount of work the stick did on the puck be affected?

$$W = F d$$

$$W = 9.00 \times 0.150$$

$$W = 1.35 \text{ J}$$

b. If the player exerted a 9.00-N force, but the stick was in contact with the puck for only half the distance (0.075 m,) how much work does the stick do on the puck?

$$W = F d$$

$$W = 9.00 \times 0.075$$

$$W = 0.675 \text{ J}$$

**Q 2.** Together, two students exert a force of 825 N in pushing a car a distance of 35 m.

a. How much work do the students do on the car?

b. If their force is doubled, how much work must they do on the car to push it the same distance?

[a]	[b]
$W = F d$	$W = F d$
$W = 835 \times 35$	$W = (2 \times 835) \times 35$
$W = 29225 \text{ J}$	$W = 58450 \text{ J}$

**Q 3.** A rock climber wears a 7.5-kg backpack while scaling a cliff. After 30.0 min, the climber is 8.2 m above the starting point.

a. How much work does the climber do on the backpack?

b. If the climber weighs 645 N, how much work does she do lifting herself and the backpack?

[a]	[b]
$W = F_g d$	$W = F_g d$
$W = m_{\text{backpack}} \times g \times h$	$W = (645 + (7.5 \times 9.8)) \times 8.2$
$W = 7.5 \times 9.8 \times 8.2$	$W = 5891.7 \text{ J}$
$W = 602.7 \text{ J}$	

**Q 4.** Marisol pushes a 3.0-kg box 7.0 m across the floor with a force of 12 N. She then lifts the box to a shelf 1 m above the ground. How much work does Marisol do on the box?

$$W = W_{\text{horizontal}} + W_{\text{vertical}}$$

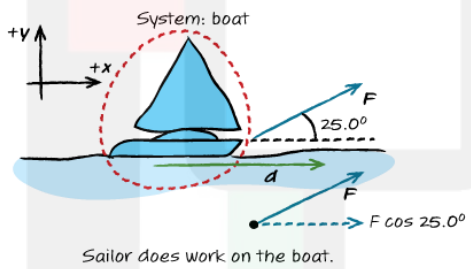
$$W = (F d) + (F_g h)$$

$$W = (12 \times 7) + (3.0 \times 9.8 \times 1.0)$$

$$W = 113.4 \text{ J}$$

#### EXAMPLE Problem 2.

A sailor pulls a boat a distance of 30.0 m along a dock using a rope that makes a  $25.0^\circ$  angle with the horizontal. How much work does the rope do on the boat if its tension is 255 N?

$W = F d \cos \theta$ $W = 255 \times 30 \times \cos 25^\circ$ $W = 6933.254571 \text{ J}$ $W = 6.93 \times 10^3 \text{ J}$	
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**Q 5.** If the sailor in Example Problem 2 pulls with the same force through the same displacement but at an angle of  $50.0^\circ$ , how much work is done on the boat by the rope?

$$W = F d \cos \theta$$

$$W = 255 \times 30 \times \cos 50^\circ$$

$$W = 4917.325214 \text{ J}$$

$$W = 4.92 \times 10^3 \text{ J}$$

**Q 6.** Two people **lift** a heavy box a distance of 15 m. They use ropes, each of which makes an angle of  $15^\circ$  with the vertical. Each person exerts a force of 225 N. Calculate the work done by the ropes.

		$W_{\text{total}} = F_{\text{net}} d$ $W_t = (2 \times F_T \times \cos 15^\circ) \times 15$ $W_t = (2 \times 225 \times \cos 15^\circ) \times 15$ $W_t = 6519.999327 \text{ J}$ $W_t = 6.5 \times 10^3 \text{ J}$
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**Q 7.** An airplane passenger carries a 215-N suitcase up the stairs, a displacement of 4.20 m horizontally.

- How much work does the passenger do on the suitcase?
- The same passenger carries the same suitcase back down the same set of stairs. How much work does the passenger do on the suitcase to carry it down the stairs?

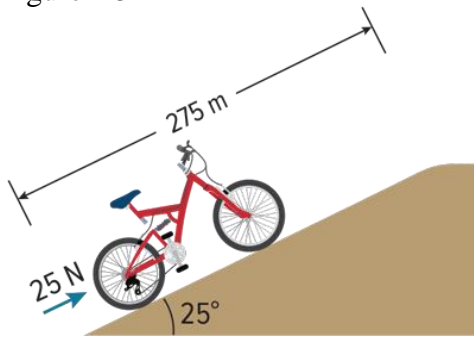
<p>[a]</p> $W = F d \cos \theta$ $W = 215 \times 4.20 \times \cos 0.0^\circ$ $W = 903 \text{ J}$	<p>[b]</p> $W = F d \cos \theta$ $W = 215 \times 4.20 \times \cos 180^\circ$ $W = -903 \text{ J}$
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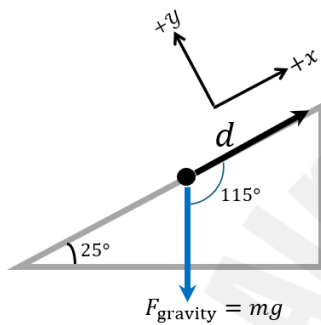
**Q 8.** A rope is used to pull a metal box a distance of 15.0 m across the floor. The rope is held at an angle of  $46.0^\circ$  with the floor, and a force of 628 N is applied to the rope. How much work does the rope do on the box?

	$W = F d \cos \theta$ $W = 628 \times 15.0 \times \cos 46.0^\circ$ $W = 6543.68185 \text{ J}$ $W = 6.54 \times 10^3 \text{ J}$
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**Q 9.** A bicycle rider pushes a 13-kg bicycle up a steep hill. The incline is  $25^\circ$  and the hill is 275 m long, as shown in Figure 5. The rider pushes the bike parallel to the road with a force of 25 N

- How much work does the rider do on the bike?
- How much work is done by the force of gravity on the bike?

<p>Figure – 5</p> 	<p>[a]</p> $W = F d$ $W = 25 \times 275$ $W = 6875 \text{ J}$ $W = 6.9 \times 10^3 \text{ J}$	<p>[b]</p> $W = F d \cos \theta$ $W = (13 \times 9.8) \times 275 \times \cos 115^\circ$ $W = -14806.4308 \text{ J}$ $W = -1.5 \times 10^4 \text{ J}$
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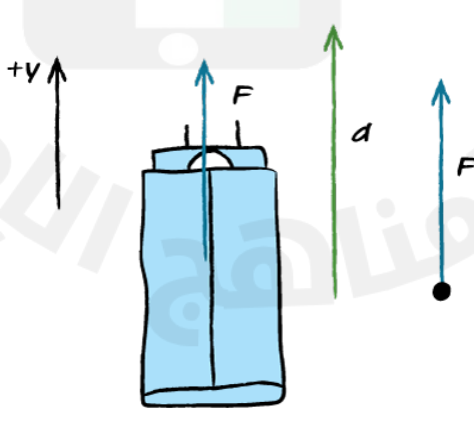
**LO – 8:**

Apply the relationship between power, the work done by a force, and the time interval in which that work is

done:  $P = \frac{W}{t}$

### Example Problem – 3.

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?

$P = \frac{W}{t}$ $P = \frac{Fd}{t}$ $P = \frac{(1.20 \times 10^4) (9.00)}{(15.0)}$ $P = 7200 \text{ W}$ $P = 7.20 \text{ kW}$	
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**Q 14.** A cable attached to a motor lifts a 575-N box up a distance of 20.0 m. The box moves with a constant velocity and the job is done in 10.0 s. What power is developed by the motor in W and kW?

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

$$P = \frac{Fd}{t}$$

$$P = \frac{(575)(20.0)}{(10.0)}$$

$$P = 1150 \text{ W}$$

$$P = 1.15 \text{ kW}$$

**Q 15.** You push a wheelbarrow a distance of 60.0 m at a constant speed for 25.0 s by exerting a 145-N force horizontally.

a. What power do you develop?

b. If you move the wheelbarrow twice as fast, how much power is developed?

$P = \frac{W}{t}$	$v = \frac{d}{t}$	$P = \frac{W}{t}$
$P = \frac{Fd}{t}$	$v = \frac{60.0}{25.0}$	$P = \frac{Fd}{t}$
$P = \frac{(145)(60.0)}{(25.0)}$	$v = 2.4 \text{ m/s}$	$P = Fv$
$P = 348 \text{ W}$	$v_{\text{new}} = 4.8 \text{ m/s}$	$P = 145 \times 4.8$
		$P = 696 \text{ W}$

**Q 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.)

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

$$P = \frac{Fd}{t}$$

$$P = \frac{(mg)d}{t}$$

$$P = \frac{(35 \times 9.8)(110)}{60}$$

$$P = 630 \text{ W}$$

$$P = 0.63 \text{ kW}$$

**Q 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?

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


$$P = \frac{Fd}{t}$$

$$65 \times 1000 = \frac{(F)(17.5)}{35}$$

$$F = 130000 \text{ N}$$

$$F = 130 \text{ kN}$$

**Q 18.** A winch designed to be mounted on a truck, as shown in Figure 10, is advertised as being able to exert a  $6.8 \times 10^3 \text{ N}$  force and to develop a power of 0.30 kW. How long would it take the truck and the winch to pull an object 15 m?

<p>Figure – 10</p> 	$P = \frac{W}{t}$ $P = \frac{Fd}{t}$ $0.30 \times 1000 = \frac{(6.8 \times 10^3)(15)}{t}$ $t = 340 \text{ s}$ $t = 5.7 \text{ minutes}$
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**Q 25.** Does the work required to lift a book to a shelf depend on how fast you raise it? Does the power required to lift it depend on how fast you raise it? Explain.

No, work is not a function of time. However, power is a function of time, so the power required to lift the book does depend on how fast you raise it.

**Q 26.** An elevator lifts a total mass of  $1.1 \times 10^3 \text{ kg}$  a distance of 40.0 m in 12.5 s. How much power does the elevator deliver?

$P = \frac{W}{t}$	$P = \frac{1.1 \times 10^3 \times 9.8 \times 40.0}{12.5}$
$P = \frac{Fd}{t}$	$P = 34496 \text{ W}$
$P = \frac{mgd}{t}$	$P = 3.4 \times 10^4 \text{ W}$



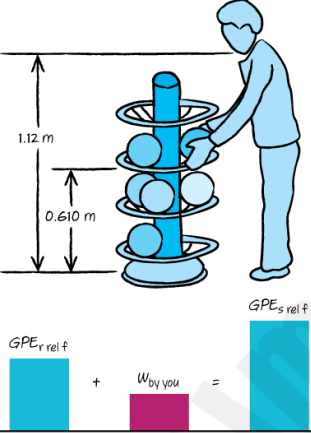
LO – 9:

1. 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.
2. Determine the international unit by which all types and forms of energy are measured.

LO – 10:

1. Calculate the work done by the gravitational force when an object is lifted or lowered from a reference level.
2. Discuss energy transformations in situations where an object moves vertically upward or downward.

**Example Problem – 4:**

 <p>The diagram shows a person lifting a bowling ball from a storage rack to their shoulder. The rack is 0.610 m above the floor, and the person's shoulder is 1.12 m above the floor. Below the diagram is a bar chart illustrating the energy conservation equation: <math>GPE_{r \text{ rel } f} + W_{\text{by you}} = GPE_{s \text{ rel } f}</math>.</p>	<p>You lift a 7.30 – kg bowling ball from the storage rack and hold it up to your shoulder. The storage rack is 0.610 m above the floor and your shoulder is 1.12 m above the floor.</p> <p>[a] When the bowling ball is at your shoulder, what is the ball – Earth system’s gravitational potential energy relative to the floor?</p> <p>[b] When the bowling ball is at your shoulder, what is the ball – Earth system’s gravitational potential energy relative to the rack?</p> <p>[c] How much work was done by the gravity as you lifted the ball from the rack to shoulder level?</p>
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**Solutions:**

[a]  $GPE = mgh \Rightarrow GPE = (7.30)(9.81)(1.12) = 80.20656 \approx 80.2 \text{ J}$

[b]  $GPE = mgh \Rightarrow GPE = (7.30)(9.81)(1.12 - 0.610) = 36.52263 \approx 36.5 \text{ J}$

[c]  $W = -mgh \Rightarrow W = -(7.30)(9.81)(1.12 - 0.610) = -36.52263 \approx -36.5 \text{ J}$

**Q 30.** In Example Problem 4, what is the potential energy of the ball-Earth system when the bowling ball is on the floor? Use the rack as your reference level.

$$GPE = mgh$$

$$GPE = 7.30 \times 9.8 \times (-0.610)$$

$$GPE = -44 \text{ J}$$

**Q 31.** 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?

$$GPE = mgh$$

$$GPE = 20.0 \times 9.8 \times (-1.20)$$

$$GPE = -235.2 \text{ J}$$

$$GPE = -2.4 \times 10^2 \text{ J}$$

**Q 32.** 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?

$$GPE = mgh$$

$$GPE = (2.2)(9.8)(2.10 - 0.80)$$

$$GPE = 28.028 \text{ J}$$

$$GPE = 28 \text{ J}$$

**Q 33.** You are walking around an old building and notice that it is falling apart. If a 6.7 m brick falls to the ground from the building's chimney, which is 1.8-kg high, what is the change in the potential energy of the brick-Earth system?

$$GPE = mgh$$

$$GPE = (1.8)(9.8)(-6.7)$$

$$GPE = -118.188 \text{ J}$$

$$GPE = -1.2 \times 10^2 \text{ J}$$

**Q 34.** 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.)

Lifting the box	Across the table.	Lowering the box.
$GPE = mgh$	$GPE = mgh$	$GPE = mgh$
$GPE = (10.1)(9.8)(1.1)$	$GPE = (10.1)(9.8)(0.0)$	$GPE = (10.1)(9.8)(-1.1)$
$GPE = 108.878 \text{ J}$	$GPE = 0.0 \text{ J}$	$GPE = -108.878 \text{ J}$
$GPE = 1.1 \times 10^2 \text{ J}$		$GPE = -1.1 \times 10^2 \text{ J}$



To lift the box to the table:  $W = 1.1 \times 10^2 \text{ J}$

To slide the box across the table:  $W = 0.0 \text{ J}$  because the height did not change, and we ignored friction.

To lower the box to the floor:  $W = -1.1 \times 10^2 \text{ J}$

The sum of the three energy changes = 0.0 J.

LO – 11:

1. Define kinetic energy and apply the relationship between a particle's kinetic energy, mass, and speed

$$(KE = \frac{1}{2}mv^2).$$

2. Solve problems related to work and kinetic energy.

**Q 49.** 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 to be conserved? If not, what happens to the energy?

Even though the rubber ball rebounds with little waste of energy, kinetic energy would not be conserved in this case because the glob of chewing gum probably was deformed in the collision.

### Get It?

Explain whether the light from a battery-powered lamp can have more energy than the battery's energy.

No, the light from a battery-powered lamp cannot have more energy than the battery's energy. Energy can be transported from one place to another, transferred between systems, and converted to different forms, such as thermal energy released to the surrounding environment from a running car. However, the system's total energy in all of its forms remains constant.

LO – 12:

1. Relate the rotational kinetic energy to the object's moment of inertia and its angular velocity:

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

2. Calculate the translational and rotational kinetic energies for objects.

**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?

The angular momentum is doubled because it is proportional to the angular velocity. The rotational kinetic energy is quadrupled because it is proportional to the square of the angular velocity. The children did work in rotating the merry-go-round.

LO – 13:

Apply the equation ( $P = \rho gh$ ) to calculate the pressure exerted by a column of fluid on a body where ( $\rho$ ) is the density of the fluid, ( $g$ ) is the gravitational acceleration, and ( $h$ ) is the height of the column of fluid.

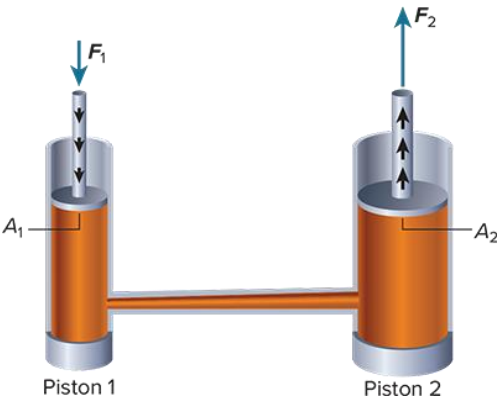
Figure 11

Submersibles are built to withstand the crushing pressure exerted by the water column.



LO – 14:  
 Apply Pascal's principle to hydraulic systems to solve problems.

Figure 10  
 As  $F_1$  exerts pressure on the smaller piston (piston 1), the pressure is transmitted throughout the fluid. As a result, a multiplied force ( $F_2$ ) is exerted on the larger piston (piston 2).



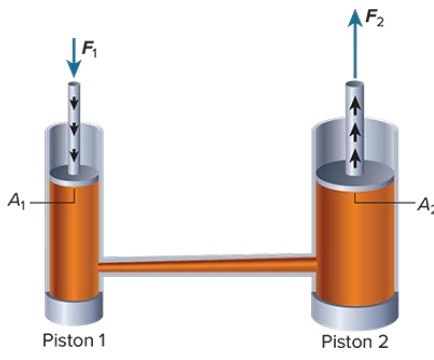
How would  $F_2$  change if  $F_1$  increased? Explain why.  
 $F_2$  would increase because the increased force is transmitted throughout the fluid.

**EXAMPLE Problem – 3**

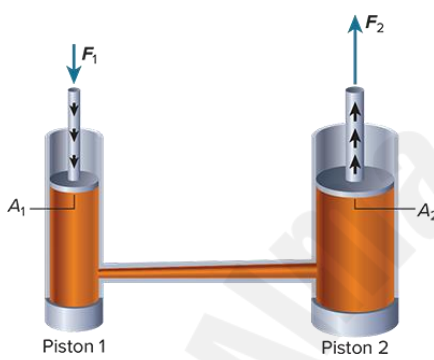
A cubic decimeter ( $1.00 \times 10^{-3} \text{ m}^3$ ) of a granite building block is submerged in water. The density of granite is  $2.70 \times 10^3 \text{ kg/m}^3$ .

[1] What is the magnitude of the buoyant force acting on the block? [2] What is the net force on the block?		
[1] $F_{\text{buoyant}} = \rho_{\text{water}} V g$ $F_{\text{buoyant}} = (1.00 \times 10^3)(1.00 \times 10^{-3})(9.8)$ $F_{\text{buoyant}} = 9.80 \text{ N}$	[2] $F_g = m g$ $F_g = (\rho_{\text{granite}} \times V_{\text{granite}}) g$ $F_g = (2.70 \times 10^3 \times 1.00 \times 10^{-3})(9.8)$ $F_g = 26.46 \text{ N}$	$F_{\text{net}} = F_g - F_{\text{buoyant}}$ $F_{\text{net}} = 26.46 - 9.8$ $F_{\text{net}} = 16.66 \text{ N}$

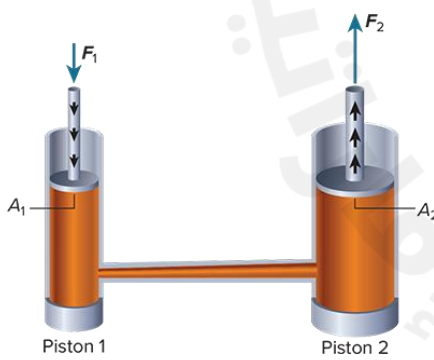
**Q 24.** Dentists' chairs are examples of hydraulic-lift systems. If a chair weighs 1600 N and rests on a piston with a cross-sectional area of 1440 cm<sup>2</sup>, what force must be applied to the smaller piston, with a cross-sectional area of 72 cm<sup>2</sup>, to lift the chair?

	$\frac{F_1}{A_1} = \frac{F_2}{A_2}$ $\frac{1600}{1440 \times 10^{-4}} = \frac{F_2}{72 \times 10^{-4}}$ $F_2 = 80 \text{ N}$
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**Q 25.** A mechanic exerts a force of 55 N on a 0.015 m<sup>2</sup> hydraulic piston to lift a small automobile. The piston the automobile sits on has an area of 2.4 m<sup>2</sup>. What is the weight of the automobile?

	$\frac{F_1}{A_1} = \frac{F_2}{A_2}$ $\frac{55}{0.015} = \frac{F_2}{2.4}$ $F_2 = 8800 \text{ N}$
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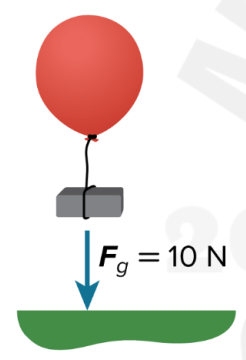
**Q 26.** By multiplying a force, a hydraulic system serves the same purpose as a lever or a seesaw. If a 400-N child standing on one piston is balanced by a 1100-N adult standing on another piston, what is the ratio of the areas of their pistons?

	$\frac{F_1}{A_1} = \frac{F_2}{A_2}$ $\frac{400}{A_1} = \frac{1100}{A_2}$ $\frac{A_1}{A_2} = \frac{400}{1100}$	$\frac{A_1}{A_2} = \frac{4}{11}$ $A_1 : A_2 = 0.4 : 1$
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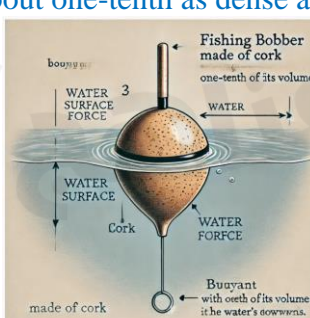
**Q 33.** A toy rocket launcher is designed so that a child stomps on a rubber cylinder, which increases the air pressure in a launching tube and pushes a foam rocket into the sky. If the child stomps with a force of 150 N on a  $2.5 \times 10^{-3} \text{ m}^2$  area piston, what is the additional force transmitted to the  $4.0 \times 10^{-4} \text{ m}^2$  launch tube?

	$\frac{F_1}{A_1} = \frac{F_2}{A_2}$ $\frac{150}{2.5 \times 10^{-3}} = \frac{F_2}{4.0 \times 10^{-4}}$ $F_2 = 24 \text{ N}$
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**Q 34.** A helium balloon rises because of the buoyant force of the air lifting it. The density of helium is  $0.18 \text{ kg/m}^3$ , and the density of air is  $1.3 \text{ kg/m}^3$ . How large a volume would a helium balloon need to lift the lead brick shown in Figure 18?

<p>Figure – 18</p> 	$F_{\text{buoyant}} = \rho_{\text{air}} V g$ $F_{\text{buoyant}} = (1.3)(V)(9.8)$ $F_{\text{buoyant}} = (12.74)(V)$	$(F_g)_{\text{total}} = \rho_{\text{helium}} V g + (F_g)_{\text{brick}}$ $(F_g)_{\text{total}} = (0.18)(V)(9.8) + 10$ $(F_g)_{\text{total}} = (1.764)(V) + 10$
	$F_{\text{buoyant}} = (F_g)_{\text{total}}$ $(12.74)(V) = (1.764)(V) + 10$ $V = 0.9 \text{ m}^3$	

**Q 35.** A fishing bobber made of cork floats with one-tenth of its volume below the water's surface. What is the density of cork?

$F_{\text{buoyant}} = F_g$ $\rho_{\text{water}}(0.1V)g = mg$ $\rho_{\text{water}}(0.1V)g = \rho_{\text{cork}}Vg$ $\rho_{\text{cork}} = 0.1\rho_{\text{water}}$	<p>The cork is about one-tenth as dense as water.</p> 
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**Q 36.** An automobile weighing  $2.3 \times 10^4 \text{ N}$  is lifted by a hydraulic cylinder with an area of  $0.15 \text{ m}^2$ .

a. What is the pressure in the hydraulic cylinder?

b. The pressure in the lifting cylinder is produced by pushing on a  $0.0082 \text{ m}^2$  cylinder. What force must be exerted on this small cylinder to lift the automobile?

[a]	[b]
$P = \frac{F}{A}$	$\frac{F_1}{A_1} = \frac{F_2}{A_2}$
$P = \frac{2.3 \times 10^4}{0.15}$	$\frac{2.3 \times 10^4}{0.15} = \frac{F_2}{0.0082}$
$P = 1.5 \times 10^5 \text{ Pa}$	$F_2 = 1.3 \times 10^3 \text{ N}$

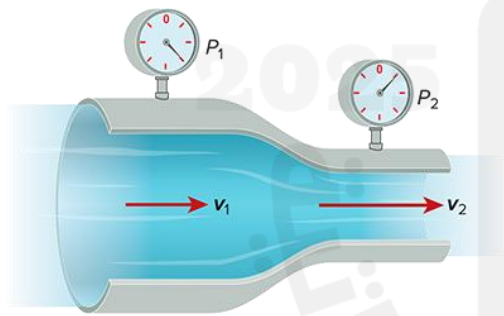
**LO – 15:**

1. Verify, through experimental demonstration, Bernoulli equation [dependence of pressure at some point inside a dynamic fluid on the speed of the fluid at that point and the height of the point] and develop mathematical models for special cases of fluid flow.

2. Explain the change of speed of flow of a fluid passing through a pipe with a variable cross - section.

Figure 15

The fluid flowing through this pipe also demonstrates Bernoulli's principle. As the velocity of the fluid increases ( $v_2$  is greater than  $v_1$ ), the pressure it exerts decreases ( $P_2$  is less than  $P_1$ ).



**Q 12.** A weather balloon used by meteorologists is made of a flexible bag that allows the gas inside to freely expand. If a weather balloon containing  $25.0 \text{ m}^3$  of helium gas is released from sea level, what is the volume of gas when the balloon reaches a height of 2100 m, where the pressure is  $0.82 \times 10^5 \text{ Pa}$ ? Assume the temperature is unchanged.

$$P_1 V_1 = P_2 V_2$$

$$101.3 \times 10^3 \times 25.0 = 0.82 \times 10^5 \times V_2$$

$$V_2 = 31 \text{ m}^3$$



**Q 13.** Starting at 0 °C, how will the density of water change as it is heated to 4 °C? To 8 °C?  
 As the water is heated from 0 °C, the density will increase until it reaches a maximum at 4 °C. On further heating to 8 °C, the density of the water will decrease.

**Q 14.** In a certain internal-combustion engine, 0.0021 m<sup>3</sup> of air at atmospheric pressure and 303 K is rapidly compressed to a pressure of 20.1 × 10<sup>5</sup> Pa and a volume of 0.0003 m<sup>3</sup>. What is the final temperature of the compressed gas?

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $\frac{101.3 \times 10^3 \times 0.0021}{303} = \frac{20.1 \times 10^5 \times 0.0003}{T_2}$ $T_2 = 859 \text{ K}$ $T_2 = 586 \text{ }^\circ\text{C}$	$T_{\text{Kelvin}} = T_{\text{Celsius}} + 273$ $T_{\text{Celsius}} = T_{\text{Kelvin}} - 273$
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**Q 15.** What is the volume of 1.00 mol of a gas at atmospheric pressure and a temperature of 273 K?

$PV = nRT$ $101.3 \times 10^3 \times V = 1.00 \times 8.31 \times 273$ $V = 0.02239516288 \text{ m}^3$ $V = 0.0224 \text{ m}^3$
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**Q 16.** How many moles of air are in a refrigerator with a volume of 0.635 m<sup>3</sup> at a temperature of 2.00 °C? If the average molar mass of air is 29 g/mol, what is the mass of the air in the refrigerator?

$PV = nRT$ $101.3 \times 10^3 \times 0.635 = n \times 8.31 \times 275$ $n = 28.14812384 \text{ mole}$ $n = 28.1 \text{ mole}$	$m = nM$ $m = (28.14812384)(29)$ $m = 816.3 \text{ g}$
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**Q 38.** A tornado passing over a house sometimes makes the house explode from the inside out. How might Bernoulli's principle explain this phenomenon? What could be done to reduce the danger of a door or window exploding outward?

The fast-moving air of the tornado has a lower pressure than the still air inside the house. Therefore, the air inside the house is at a higher pressure and produces an enormous force on the windows, doors, and walls of the house. This pressure difference is reduced by opening doors and windows to let the air flow freely to the outside.

## PART TWO – FREE RESPONSE QUESTIONS (FRQ)

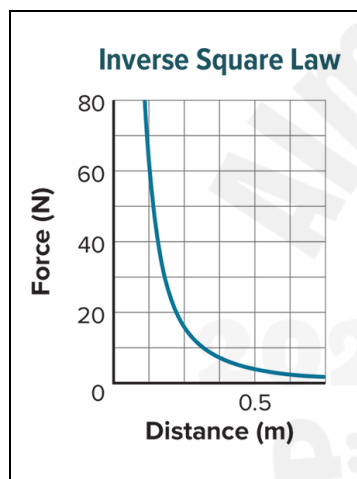
### QUESTION – 1:

**Part A:** Determine the free-fall acceleration of objects on the surface of the Earth and at higher altitudes.

**Part B:** Calculate the orbital speed of a satellite.

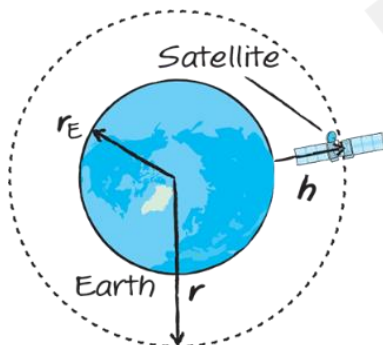
Figure 6

This is a graphical representation of the inverse square relationship.



### Example Problem – 2.

Assume that a satellite orbits Earth 225 km above its surface. Given that the mass of Earth is  $5.97 \times 10^{24}$  kg and the radius of Earth is  $6.38 \times 10^6$  m, what are the satellite's orbital speed and period?



Orbital speed	Orbital period
$v = \sqrt{\frac{G m_s}{r}}$	$T = 2 \pi \sqrt{\frac{r^3}{G m_s}}$
$v = \sqrt{\frac{(6.67 \times 10^{-11})(5.97 \times 10^{24})}{225000 + (6.38 \times 10^6)}}$	$T = 2 \pi \sqrt{\frac{[225000 + (6.38 \times 10^6)]^3}{(6.67 \times 10^{-11})(5.97 \times 10^{24})}}$
$v = 7764.503169 \text{ m/s}$	$T = 5344.893041 \text{ s}$
$v = 7.76 \times 10^3 \text{ m/s}$	$T = 89.08 \text{ minutes} \approx 1.5 \text{ hours}$

Assume a circular orbit for all calculations.

**Q 14.** Suppose that the satellite in Example Problem 2 is moved to an orbit that is 24 km larger in radius than its previous orbit. What is its speed? Is this faster or slower than its previous speed? Explain.

$$r = 225 \text{ km} + 24 \text{ km} = 249 \text{ km}$$

Orbital speed	
$v = \sqrt{\frac{G m_s}{r}}$	$v_{(r=249 \text{ km})} < v_{(r=225 \text{ km})}$
$v = \sqrt{\frac{(6.67 \times 10^{-11})(5.97 \times 10^{24})}{249000 + (6.38 \times 10^6)}}$	$7750.434905 \text{ m/s} < 7764.503169 \text{ m/s}$
$v = 7750.434905 \text{ m/s}$	The speed is slower because ( $r$ ) is larger. The satellite is farther from Earth's center.
$v = 7.75 \times 10^3 \text{ m/s}$	

**Q 15.** Uranus has 27 known moons. One of these moons is Miranda, which orbits at a radius of  $1.29 \times 10^8 \text{ m}$ . Uranus has a mass of  $8.68 \times 10^{25} \text{ kg}$ . Find the orbital speed of Miranda. How many Earth days does it take Miranda to complete one orbit?

Orbital speed	Periodic time.	
$v = \sqrt{\frac{G m_U}{r}}$	$T = 2 \pi \sqrt{\frac{r^3}{G m_U}}$	$m_{\text{Uranus}} = 8.68 \times 10^{25} \text{ kg}$
$v = \sqrt{\frac{(6.67 \times 10^{-11})(8.68 \times 10^{25})}{1.29 \times 10^8}}$	$T = 2 \pi \sqrt{\frac{(1.29 \times 10^8)^3}{(6.67 \times 10^{-11})(8.68 \times 10^{25})}}$	$1 \text{ day} = 86400 \text{ s}$

$v = 6699.276832 \text{ m/s}$	$T = 120987.8208 \text{ s}$	
$v = 6.70 \times 10^3 \text{ m/s}$	$T = 1.400322 \text{ days}$	

**Q 16.** Use Newton's thought experiment on the motion of satellites to calculate the speed that a satellite shot from a cannon must have to orbit Earth 150 km above its surface. How long, in seconds and minutes, would it take for the satellite to complete one orbit and return to the cannon?

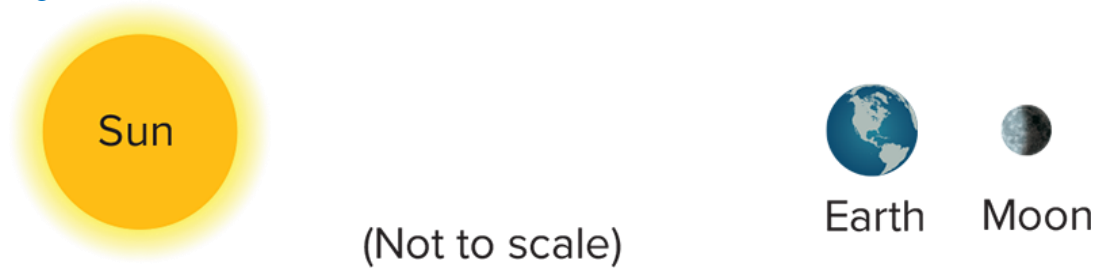
Orbital speed	Periodic time.	
$v = \sqrt{\frac{G m_E}{r}}$ $v = \sqrt{\frac{(6.67 \times 10^{-11})(5.97 \times 10^{24})}{150000 + (6.38 \times 10^6)}}$ $v = 7808.96528 \text{ m/s}$ $v = 7.8 \times 10^3 \text{ m/s}$ $v = 7.8 \text{ km/s}$	$T = 2\pi \sqrt{\frac{r^3}{G m_E}}$ $T = 2\pi \sqrt{\frac{(150000 + (6.38 \times 10^6))^3}{(6.67 \times 10^{-11})(5.97 \times 10^{24})}}$ $T = 5254.114801 \text{ s}$ $T = 88 \text{ minutes}$	$m_{\text{Earth}} = 5.97 \times 10^{24} \text{ kg}$ 1 minute = 60 s 1 km = 1000 m

**Q 17.** Use the data for Mercury in Table 1 to find the speed of a satellite that is in orbit 260 km above Mercury's surface and the period of the satellite.

Orbital speed	Periodic time.	
$v = \sqrt{\frac{G m_M}{r}}$ $v = \sqrt{\frac{(6.67 \times 10^{-11})(3.30 \times 10^{23})}{260000 + (2.44 \times 10^6)}}$ $v = 2855.209663 \text{ m/s}$ $v = 2.86 \times 10^3 \text{ m/s}$ $v = 2.86 \text{ km/s}$	$T = 2\pi \sqrt{\frac{r^3}{G m_M}}$ $T = 2\pi \sqrt{\frac{(260000 + (2.44 \times 10^6))^3}{(6.67 \times 10^{-11})(3.30 \times 10^{23})}}$ $T = 5941.630328 \text{ s}$ $T = 1.65 \text{ hours}$	$m_{\text{Mercury}} = 3.30 \times 10^{23} \text{ kg}$ $r_{\text{Mercury}} = 2.44 \times 10^6 \text{ m}$ 1 hour = 3600 s 1 km = 1000 m

**Q 18.** The Moon is  $3.9 \times 10^5$  km from Earth's center and Earth is  $14.96 \times 10^7$  km from the Sun's center. The masses of Earth and the Sun are  $5.97 \times 10^{24}$  kg and  $1.99 \times 10^{30}$  kg, respectively. During a full moon, the Sun, Earth, and the Moon are in line with each other, as shown in Figure 17.

Figure – 17.



- Find the ratio of the gravitational fields due to Earth and the Sun at the center of the Moon.
- What is the net gravitational field due to the Sun and Earth at the center of the Moon?

<p>[a] Gravitational Field due to the Sun</p> $g_s = \frac{G m_s}{(r_s)^2}$ $g_s = \frac{6.67 \times 10^{-11} \times 1.99 \times 10^{30}}{(14.96 \times 10^{10})^2}$ $g_s = 5.93 \times 10^{-3} \text{ N/kg}$	<p>[a] ... Gravitational Field due to the Earth</p> $g_E = \frac{G m_E}{(r_E)^2}$ $g_E = \frac{6.67 \times 10^{-11} \times 5.97 \times 10^{24}}{(3.9 \times 10^8)^2}$ $g_E = 2.62 \times 10^{-3} \text{ N/kg}$	<p>[a] ...</p> $\frac{g_s}{g_E} = \frac{5.93 \times 10^{-3}}{2.62 \times 10^{-3}}$ $\frac{g_s}{g_E} = 2.3$
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⬇

<p>[b] Both gravitational fields are pointing toward the surface of the Moon.</p> $g_{\text{net}} = g_s + g_E$ $g_{\text{net}} = (5.93 \times 10^{-3}) + (2.62 \times 10^{-3})$ $g_{\text{net}} = 8.55 \times 10^{-3} \text{ N/kg}$
---

**Q 19.** Chairs in an orbiting spacecraft are weightless. If you were on board such a spacecraft and you were barefoot, would you stub your toe if you kicked a chair? Explain.

Yes. The chairs are weightless but not massless. They still have inertia and can exert contact forces on your toe.

**Q 20.** 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?

$$g_s = \frac{G m_M}{(r_M)^2}$$

$$g_s = \frac{6.67 \times 10^{-11} \times 7.3 \times 10^{22}}{(1738000)^2}$$

$$g_s = 1.6 \text{ N/kg}$$

**Q 21.** 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?

$$M_{\text{Earth}} = 5.97 \times 10^{24} \text{ kg} \quad R_{\text{Earth}} = 6.371 \times 10^6 \text{ m} \quad \text{Note that: } (r = h + R_{\text{Earth}})$$

<p>1<sup>st</sup> satellite (<math>h = 150000 \text{ m}</math>)</p> $r_1 = (150 \times 10^3) + (6.371 \times 10^6)$ $r_1 = 6.521 \times 10^6 \text{ m}$ $T_1 = 2\pi \sqrt{\frac{r_1^3}{G m_E}}$ $T_1 = 2\pi \sqrt{\frac{(6.521 \times 10^6)^3}{(6.67 \times 10^{-11})(5.97 \times 10^{24})}}$ $T_1 = 5243 \text{ s} = 87.4 \text{ minutes}$	<p>2nd satellite (<math>h = 160000 \text{ m}</math>)</p> $r_2 = (160 \times 10^3) + (6.371 \times 10^6)$ $r_2 = 6.531 \times 10^6 \text{ m}$ $T_2 = 2\pi \sqrt{\frac{r_2^3}{G m_E}}$ $T_2 = 2\pi \sqrt{\frac{(6.531 \times 10^6)^3}{(6.67 \times 10^{-11})(5.97 \times 10^{24})}}$ $T_2 = 5255 \text{ s} = 87.6 \text{ minutes}$
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a. When the orbital radius is large, the period also will be large. Thus, the one at 160 km will have the larger period.

[b] The speed.

$v_1 = \sqrt{\frac{G m_E}{r_1}}$ $v_1 = \sqrt{\frac{(6.67 \times 10^{-11})(5.97 \times 10^{24})}{(6.521 \times 10^6)}}$ $v_1 = 7814.4 \text{ m/s} = 7.8144 \text{ km/s}$	$v_2 = \sqrt{\frac{G m_E}{r_2}}$ $v_2 = \sqrt{\frac{(6.67 \times 10^{-11})(5.97 \times 10^{24})}{(6.531 \times 10^6)}}$ $v_2 = 7808.4 \text{ m/s} = 7.8084 \text{ km/s}$
--	--

b. The one at 150 km has the greater speed because the smaller the orbital radius, the greater the speed.

### Get It?

Calculate how much force is acting on a 75.0-kg astronaut that is 405 km above Earth's surface, assuming  $g = 8.7 \text{ N/kg}$ .

$g_{\text{Space}} = \frac{G M_{\text{Earth}}}{(r)^2}$ $g_s = \frac{6.67 \times 10^{-11} \times 5.97 \times 10^{24}}{(405000 + (6.371 \times 10^6))^2}$ $g_s = 8.7 \text{ N/kg}$	$\mathcal{W}_{\text{Space}} = mg_{\text{Space}}$ $\mathcal{W}_{\text{Space}} = 75.0 \times 8.7$ $\mathcal{W}_{\text{Space}} = 650 \text{ N}$	$M_{\text{Earth}} = 5.97 \times 10^{24} \text{ kg}$ $R_{\text{Earth}} = 6.371 \times 10^6 \text{ m}$
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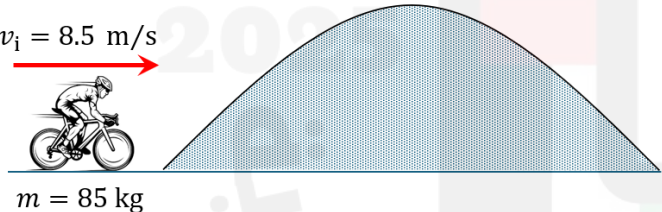
### Question – 2:

1. State and explain the law of conservation of energy

2. Define mechanical energy as the sum of all kinetic and potential energies of the system;  $ME = KE + PE$ .

3. Apply the law of conservation of mechanical energy ( $KE_i + PE_i = KE_f + PE_f$ ) to solve problems on different physical situations like roller coaster rides, skiing on ski slopes, motion on inclined planes/ hills, motion of pendulums, or others.

**Q 39.** 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?

 <p><math>v_i = 8.5 \text{ m/s}</math></p> <p><math>m = 85 \text{ kg}</math></p>	$KE_i = \frac{1}{2}mv_i^2$ $KE_i = \frac{1}{2} \times 85 \times 8.5^2$ $KE_i = 3070.625 \text{ J}$ $KE_i = 3.1 \times 10^3 \text{ J}$	$KE_{\text{bottom}} = mgh_{\text{top}}$ $\frac{1}{2}mv_i^2 = mgh_{\text{top}}$ $\frac{1}{2}v_i^2 = gh_{\text{top}}$ $\frac{1}{2} \times 8.5^2 = 9.8 \times h_{\text{top}}$ $h_{\text{top}} = 3.7 \text{ m}$
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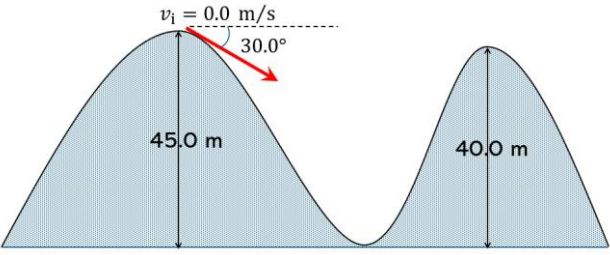
**Q 40.** Suppose that the bike rider in the previous problem pedaled up the hill and never came to a stop. In what system is energy conserved? From what form of energy did the bike gain mechanical energy?

The system of Earth, bike, and rider remains the same, but now the energy involved is not mechanical energy alone. The rider must be considered as having chemical potential energy, some of which is converted to mechanical energy.



**Q 41.** A skier starts from rest at the top of a hill that is 45.0 m high, skis down a 30° 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?

 <p> <math>(ME)_{\text{top}} = (ME)_{\text{bottom}}</math>  <math>(GPE)_{\text{top}} + (KE)_{\text{top}} = (GPE)_{\text{bottom}} + (KE)_{\text{bottom}}</math> </p>	<p>[a]</p> $(GPE)_{\text{top}} = (KE)_{\text{bottom}}$ $mgh_{\text{top}} = \frac{1}{2}mv_{\text{bot}}^2$ $gh_{\text{top}} = \frac{1}{2}v_{\text{bot}}^2$ $9.8 \times 45 = \frac{1}{2}v_{\text{bot}}^2$ $v_{\text{bot}} = 29.7 \text{ m/s}$
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<p>[b]</p> $(GPE)_{\text{bottom}} + (KE)_{\text{bottom}} = (GPE)_{\text{top}} + (KE)_{\text{top}}$ $0 + \frac{1}{2}mv_{\text{bot}}^2 = mgh_{\text{top}} + \frac{1}{2}mv_{\text{top}}^2$ $\frac{1}{2}v_{\text{bot}}^2 = gh_{\text{top}} + \frac{1}{2}v_{\text{top}}^2$ $\frac{1}{2}(29.7)^2 = (9.8 \times 40) + \frac{1}{2}v_{\text{top}}^2$ $v_{\text{top}} = 9.9 \text{ m/s}$	<p>[c]</p> <p>No; the angles do not have any impact.</p>
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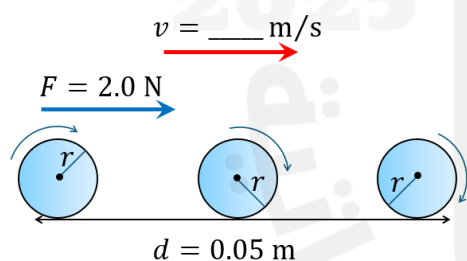
**Q 42.** In a belly-flop diving contest, the winner is the diver who makes the biggest splash upon hitting the water. The size of the splash depends not only on the diver's style, but also on the amount of kinetic energy the diver has.

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?



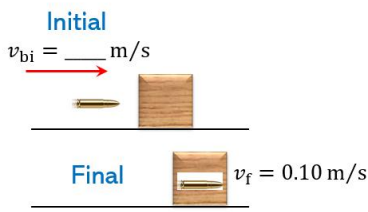
First Diver.	Second Diver.
$(GPE)_{\text{top}} + (KE)_{\text{top}} = (GPE)_{\text{bottom}} + (KE)_{\text{bottom}}$ $mgh_{\text{top}} + 0 = 0 + (KE)_{\text{bottom}}$ $136 \times 9.8 \times 3.00 = (KE)_{\text{bottom}}$ $(KE)_{\text{bottom}} = 3998.4 \text{ J}$	$(GPE)_{\text{top}} + (KE)_{\text{top}} = (GPE)_{\text{bottom}} + (KE)_{\text{bottom}}$ $mgh_{\text{top}} + 0 = 0 + (KE)_{\text{bottom}}$ $100 \times 9.8 \times (h + 3.00) = (KE)_{\text{bottom}}$ $100 \times 9.8 \times (h + 3.00) = 3998.4$ $h = 1.08 \text{ m above the platform}$

**Q 43.** The spring in a pinball machine exerts an average force of 2 N on a 0.08-kg pinball over 5 cm. As a result, the ball has both translational and rotational kinetic energy. If the ball is a uniform sphere ( $I = \frac{5}{2}mr^2$ ), what is its linear speed after leaving the spring? (Ignore the table's tilt.)




$W = E_{\text{mechanical}}$ $Fd = KE_{\text{tran.}} + KE_{\text{rot.}}$ $Fd = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$ $Fd = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{5mr^2}{2}\right)\left(\frac{v}{r}\right)^2$	$Fd = \frac{1}{2}mv^2 + \frac{5mv^2}{4}$ $2 \times 0.05 = \left(\frac{1}{2} \times 0.08 \times v^2\right) + \left(\frac{5 \times 0.08 \times v^2}{4}\right)$ $v = 0.8451542547 \text{ m/s}$ $v = 0.8 \text{ m/s}$
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**Q 44.** 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.

 <p>Initial <math>v_{bi} = \text{---} \text{ m/s}</math></p> <p>Final <math>v_f = 0.10 \text{ m/s}</math></p>	$m_b v_{bi} + m_w v_{wi} = (m_b + m_w) v_f$ $(0.008 \times v_{bi}) + (9.00 \times 0.0) = (0.008 + 9.00)(0.10)$ $v_{bi} = 112.6 \text{ m/s}$
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**Q 45.** 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?

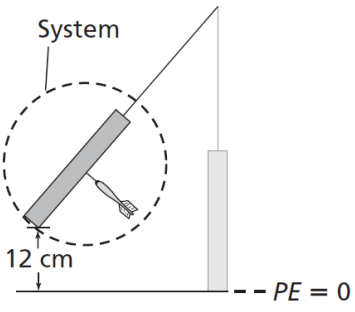
 <p>First <math>v_{1i} = 5.5 \text{ m/s}</math> 91 kg</p> <p>Second <math>v_{2i} = 8.1 \text{ m/s}</math> 91 kg</p> $(p_i)_{\text{total}} = m_1 v_{1i} + m_2 v_{2i}$ $(p_i)_{\text{total}} = (91 \times 5.5) + (91 \times 8.1)$ $(p_i)_{\text{total}} = 1237.6 \text{ kg} \cdot \text{m/s}$	<p>[a]</p> $(KE_i)_{\text{total}} = \frac{1}{2} m_1 v_{1i}^2 + \frac{1}{2} m_2 v_{2i}^2$ $(KE_i)_{\text{total}} = \left( \frac{1}{2} \times 91 \times 5.5^2 \right) + \left( \frac{1}{2} \times 91 \times 8.1^2 \right)$ $(KE_i)_{\text{total}} = 4361.63 \text{ J}$
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<p>[b]</p> $m_1 v_{1i} + m_2 v_{2i} = (m_1 + m_2) v_f$ $(91 \times 5.5) + (91 \times 8.1) = (91 + 91) v_f$ $v_f = 6.8 \text{ m/s}$	<p>[c]</p> $(KE_f)_{\text{total}} = \frac{1}{2} (m_1 + m_2) v_f^2$ $(KE_f)_{\text{total}} = \frac{1}{2} (91 + 91) (6.8^2)$ $(KE_f)_{\text{total}} = 4207.84 \text{ J}$	<p>[c]</p> $\Delta KE = KE_f - KE_i$ $\Delta KE = 4207.84 - 4361.63$ $\Delta KE = -153.79 \text{ J}$
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**Q 46.** A 0.73-kg magnetic target is suspended on a string. A 0.025-kg magnetic dart, shot horizontally, strikes the target head-on. The dart and the target together act like a pendulum and swing 12.0 cm above the initial level before instantaneously coming to rest.

- Sketch the situation and choose a system.
- Decide what is conserved in each step of the process and explain why.
- What was the initial velocity of the dart?

	<p>Only momentum is conserved in the inelastic dart-target collision. As the dart-target combination swings upward, energy is conserved.</p>	$m_d v_{di} + m_m v_{mi} = (m_d + m_m) v_f$ $m_d v_{di} + m_m v_{mi} = (m_d + m_m) v_f$ $0.025 \times v_{di} + 0 = (0.025 + 0.73) v_f$ $0.025 v_{di} = 0.755 v_f$
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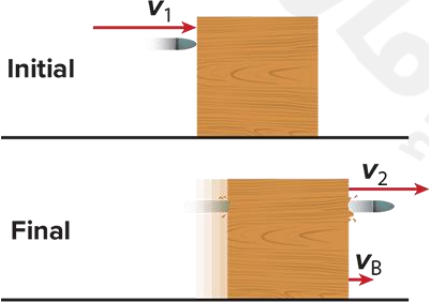


$(ME)_{\text{bottom}} = (ME)_{\text{top}}$ $(GPE)_{\text{bottom}} + (KE)_{\text{bottom}} = (GPE)_{\text{top}} + (KE)_{\text{top}}$ $0 + (KE)_{\text{bottom}} = (GPE)_{\text{top}} + 0$ $\frac{1}{2} (m_d + m_m) v_f^2 = (m_d + m_m) g h_{\text{top}}$ $\frac{1}{2} v_f^2 = g h_{\text{top}}$ $\frac{1}{2} v_f^2 = 9.8 \times 0.12$ $v_f = 1.533623161 \text{ m/s}$	$0.025 v_{di} = 0.755 v_f$ $0.025 v_{di} = (0.755)(1.533623161)$ $v_{di} = 46.31541946 \text{ m/s}$ $v_{di} = 46 \text{ m/s}$
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### PHYSICS Challenge

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.

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


	<p>[a]</p> $m_b v_{bi} + m_B v_{Bi} = m_b v_{bf} + m_B v_{Bf}$ $m v_1 + 0 = m v_2 + m_B v_B$ $v_B = \frac{m v_1 - m v_2}{m_B}$ $v_B = \frac{m(v_1 - v_2)}{m_B}$	<p>[b]</p> $(KE_i)_{\text{bullet}} = \frac{1}{2} m_b v_{bi}^2$ $(KE_i)_{\text{bullet}} = \frac{1}{2} m v_1^2$ $(KE_f)_{\text{bullet}} = \frac{1}{2} m_b v_{bf}^2$ $(KE_f)_{\text{bullet}} = \frac{1}{2} m v_2^2$
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<p>[b] . . . .</p> $(\Delta KE)_{\text{bullet}} = (KE_f)_{\text{bullet}} - (KE_i)_{\text{bullet}}$ $(\Delta KE)_{\text{bullet}} = \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$ $(\Delta KE)_{\text{bullet}} = \frac{1}{2}m(v_2^2 - v_1^2)$	<p>[c]</p> $(KE_i)_{\text{total}} = (KE_f)_{\text{total}} + E_{\text{lost}}$ $\frac{1}{2}m_b v_{bi}^2 = \frac{1}{2}m_b v_{bf}^2 + \frac{1}{2}m_B v_{Bf}^2 + E_{\text{lost}}$ $\frac{1}{2}mv_1^2 = \frac{1}{2}mv_2^2 + \frac{1}{2}m_B v_B^2 + E_{\text{lost}}$ $E_{\text{lost}} = \frac{1}{2}mv_1^2 - \frac{1}{2}mv_2^2 - \frac{1}{2}m_B v_B^2$
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**Q 47.** A child jumps on a trampoline. Draw energy bar diagrams to show the forms of energy in the following situations.

- The child is at the highest point.
- The child is at the lowest point

<p>[a]</p> <p>Energy Bar Diagram</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <p>Elastic Potential Energy = 0 J</p> <p>(EPE)</p> </div> <div style="text-align: center;"> <p>Gravitational Potential Energy</p> <p>(GPE)</p> </div> <div style="text-align: center;"> <p>Kinetic Energy = 0 J</p> <p>(KE)</p> </div> </div>	<p>[b]</p> <p>Energy Bar Diagram</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <p>Elastic Potential Energy</p> <p>(EPE)</p> </div> <div style="text-align: center;"> <p>Gravitational Potential Energy = 0 J</p> <p>(GPE)</p> </div> <div style="text-align: center;"> <p>Kinetic Energy = 0 J</p> <p>(KE)</p> </div> </div>	
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**Q 48.** Explain why energy is considered a single quantity.

Energy is considered a single quantity because, even though energy transformations take place all the time, the transformations just involve different manifestations of the same energy.

**Q 49.** 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 to be conserved? If not, what happens to the energy?

Even though the rubber ball rebounds with little waste of energy, kinetic energy would not be conserved in this case because the glob of chewing gum probably was deformed in the collision.

**Q 50.** 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 m?

$$E_{\text{total}} = mgh$$


Since the rebound height is proportional to energy, each bounce will rebound to  $\frac{4}{5}$  the height of the previous bounce.

After one bounce:  $h = \left(\frac{4}{5}\right)(8 \text{ m}) = 6.4 \text{ m}$

After two bounces:  $h = \left(\frac{4}{5}\right)(6.4 \text{ m}) = 5.12 \text{ m}$

After three bounces:  $h = \left(\frac{4}{5}\right)(5.12 \text{ m}) = 4.096 \text{ m}$

**Q 51.** In Figure 27, 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?

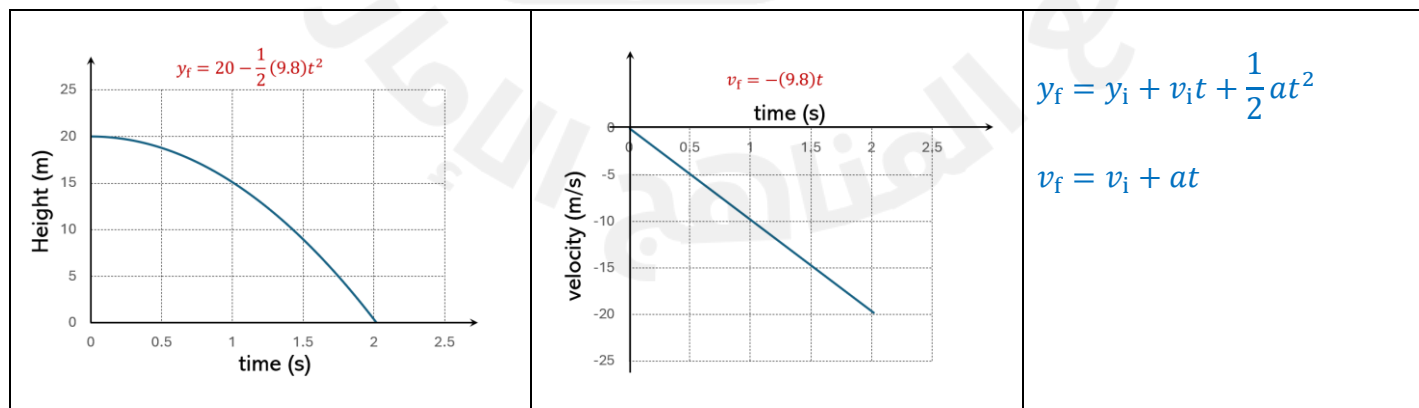
$(ME_i)_{\text{total}} = (ME_f)_{\text{total}} + E_{\text{friction}}$ $KE_i + GPE_i = KE_f + GPE_f + E_{\text{friction}}$ $0.0 + mgh_i = \frac{1}{2}mv_f^2 + 0.0 + E_{\text{friction}}$ $36 \times 9.8 \times 2.5 = \left(\frac{1}{2} \times 36 \times 3^2\right) + E_{\text{friction}}$ $E_{\text{friction}} = 720 \text{ J}$	<p>Figure – 27</p> 
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**Q 52.** 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.

The availability of energy limits what can occur in a system, so if my friend's device only receives a certain amount of energy, then it cannot deliver/transfer/transform more than it receives.

**Q 53.** A ball drops 20 m. When it has fallen 10 m, half of the energy is potential energy and half is kinetic energy. When the ball has fallen for half the amount of time it takes to fall, will more, less, or exactly half of the energy be potential energy?

The ball falls more slowly during the beginning part of its drop. Therefore, in the first half of the time that it falls, it will not have traveled half of the distance that it will fall. Therefore, the ball will have more potential energy than kinetic energy.



Question – 3:

1. 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 ( $\theta$ ) is the angle between the direction of the force and the direction of displacement.
2. Determine graphically the work done by a force from the area of force versus displacement graph.
3. Apply the work-energy theorem to relate the net work done on a system and the resulting change in kinetic energy.

**EXAMPLE Problem 1**

A hockey player uses a stick to apply a constant 4.50 N force forward to a 105 g puck sliding on ice over a displacement of 0.150 m forward. How much work does the stick do on the puck? Assume friction is negligible.

$W = F d$ $W = 4.50 \times 0.150$ $W = 0.675 \text{ J}$	
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**Q 1.** Refer to Example Problem 1 to solve the following problem.

- a. If the hockey player exerted twice as much force (9.00 N) on the puck over the same distance, how would the amount of work the stick did on the puck be affected?

$$W = F d$$

$$W = 9.00 \times 0.150$$

$$W = 1.35 \text{ J}$$

- b. If the player exerted a 9.00-N force, but the stick was in contact with the puck for only half the distance (0.075 m,) how much work does the stick do on the puck?

$$W = F d$$

$$W = 9.00 \times 0.075$$

$$W = 0.675 \text{ J}$$

**Q 2.** Together, two students exert a force of 825 N in pushing a car a distance of 35 m.

- a. How much work do the students do on the car?
- b. If their force is doubled, how much work must they do on the car to push it the same distance?

[a]	[b]
$W = F d$	$W = F d$
$W = 835 \times 35$	$W = (2 \times 835) \times 35$
$W = 29225 \text{ J}$	$W = 58450 \text{ J}$



**Q 3.** A rock climber wears a 7.5-kg backpack while scaling a cliff. After 30.0 min, the climber is 8.2 m above the starting point.

a. How much work does the climber do on the backpack?

b. If the climber weighs 645 N, how much work does she do lifting herself and the backpack?

[a]	[b]
$W = F_g d$	$W = F_g d$
$W = m_{\text{backpack}} \times g \times h$	$W = (645 + (7.5 \times 9.8)) \times 8.2$
$W = 7.5 \times 9.8 \times 8.2$	$W = 5891.7 \text{ J}$
$W = 602.7 \text{ J}$	

**Q 4.** Marisol pushes a 3.0-kg box 7.0 m across the floor with a force of 12 N. She then lifts the box to a shelf 1 m above the ground. How much work does Marisol do on the box?

$$W = W_{\text{horizontal}} + W_{\text{vertical}}$$

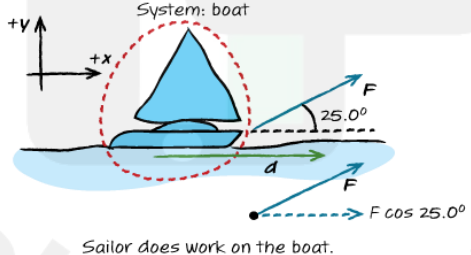
$$W = (F d) + (F_g h)$$

$$W = (12 \times 7) + (3.0 \times 9.8 \times 1.0)$$

$$W = 113.4 \text{ J}$$

**EXAMPLE Problem 2.**

A sailor pulls a boat a distance of 30.0 m along a dock using a rope that makes a  $25.0^\circ$  angle with the horizontal. How much work does the rope do on the boat if its tension is 255 N?

$W = F d \cos \theta$	
$W = 255 \times 30 \times \cos 25^\circ$	
$W = 6933.254571 \text{ J}$	
$W = 6.93 \times 10^3 \text{ J}$	

**Q 5.** If the sailor in Example Problem 2 pulls with the same force through the same displacement but at an angle of  $50.0^\circ$ , how much work is done on the boat by the rope?

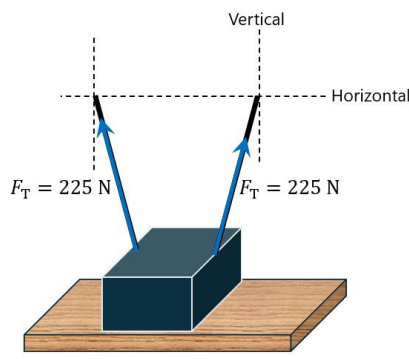
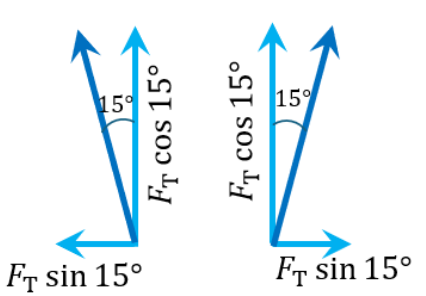
$$W = F d \cos \theta$$

$$W = 255 \times 30 \times \cos 50^\circ$$

$$W = 4917.325214 \text{ J}$$

$$W = 4.92 \times 10^3 \text{ J}$$

**Q 6.** Two people **lift** a heavy box a distance of 15 m. They use ropes, each of which makes an angle of  $15^\circ$  with the vertical. Each person exerts a force of 225 N. Calculate the work done by the ropes.


		$W_{\text{total}} = F_{\text{net}} d$ $W_t = (2 \times F_T \times \cos 15^\circ) \times 15$ $W_t = (2 \times 225 \times \cos 15^\circ) \times 15$ $W_t = 6519.999327 \text{ J}$ $W_t = 6.5 \times 10^3 \text{ J}$
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**Q 7.** An airplane passenger carries a 215-N suitcase up the stairs, a displacement of 4.20 m horizontally.

- How much work does the passenger do on the suitcase?
- The same passenger carries the same suitcase back down the same set of stairs. How much work does the passenger do on the suitcase to carry it down the stairs?

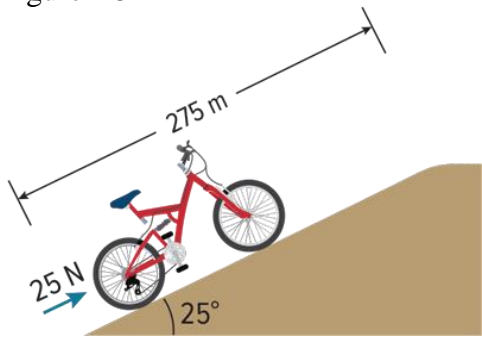
<p>[a]</p> $W = F d \cos \theta$ $W = 215 \times 4.20 \times \cos 0.0^\circ$ $W = 903 \text{ J}$	<p>[b]</p> $W = F d \cos \theta$ $W = 215 \times 4.20 \times \cos 180^\circ$ $W = -903 \text{ J}$
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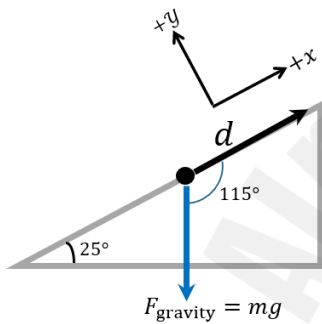
**Q 8.** A rope is used to pull a metal box a distance of 15.0 m across the floor. The rope is held at an angle of  $46.0^\circ$  with the floor, and a force of 628 N is applied to the rope. How much work does the rope do on the box?

	$W = F d \cos \theta$ $W = 628 \times 15.0 \times \cos 46.0^\circ$ $W = 6543.68185 \text{ J}$ $W = 6.54 \times 10^3 \text{ J}$
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**Q 9.** A bicycle rider pushes a 13-kg bicycle up a steep hill. The incline is  $25^\circ$  and the hill is 275 m long, as shown in Figure 5. The rider pushes the bike parallel to the road with a force of 25 N

- How much work does the rider do on the bike?
- How much work is done by the force of gravity on the bike?

<p>Figure – 5</p> 	<p>[a]</p> $W = F d$ $W = 25 \times 275$ $W = 6875 \text{ J}$ $W = 6.9 \times 10^3 \text{ J}$	<p>[b]</p> $W = F d \cos \theta$ $W = (13 \times 9.8) \times 275 \times \cos 115^\circ$ $W = -14806.4308 \text{ J}$ $W = -1.5 \times 10^4 \text{ J}$
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**Q 10.** A catamaran with a mass of  $5.44 \times 10^3 \text{ kg}$  is moving at 12 knots. How much work is required to increase the speed to 16 knots? (One knot = 0.51 m/s.)

$$W = \Delta K$$

$$W = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$$

$$W = \frac{1}{2} (5.44 \times 10^3) (16 \times 0.51)^2 - \frac{1}{2} (5.44 \times 10^3) (12 \times 0.51)^2$$

$$W = 79236.864 \text{ J}$$

$$W = 7.9 \times 10^4 \text{ J}$$

**Q 11.** A 52.0-kg skater moves at 2.5 m/s. and stops over a distance of 24.0 m. Find the skater's initial kinetic energy. How much of her kinetic energy is transformed into other forms of energy by friction as she stops? How much work must she do to speed up to 2.5 m/s again?

$K_i = \frac{1}{2}mv_i^2$ $K_i = \frac{1}{2}(52.0)(2.5)^2$ $K_i = 162.5 \text{ J}$	$W = \Delta K$ $W = K_f - K_i$ $W = 0.0 - 162.5$ $W = -162.5 \text{ J}$	<p>162.5 Joules of the skater kinetic energy have transferred into other forms of energy.</p> $W = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$ $W = \frac{1}{2}(52.0)(2.5)^2 - 0$ $W = 162.5 \text{ J}$
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**Q 12.** An 875.0-kg car speeds up from 22.0 m/s to 44.0 m/s. What are the initial and final kinetic energies of the car? How much work is done on the car to increase its speed?

$K_i = \frac{1}{2}mv_i^2$ $K_i = \frac{1}{2}(875.0)(22.0)^2$ $K_i = 211750 \text{ J}$	$K_f = \frac{1}{2}mv_f^2$ $K_f = \frac{1}{2}(875.0)(44.0)^2$ $K_f = 847000 \text{ J}$	$W = \Delta K$ $W = K_f - K_i$ $W = 847000 - 211750$ $W = 635250 \text{ J}$
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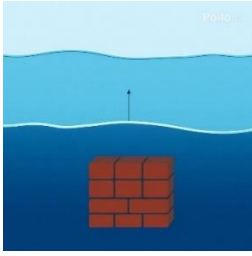
**Q 13.** A comet with a mass of  $7.85 \times 10^{11} \text{ kg}$  strikes Earth at a speed of 25.0 km/s. Find the kinetic energy of the comet in joules, and compare the work that is done by Earth in stopping the comet to the  $4.2 \times 10^{15} \text{ J}$  of energy that was released by the largest nuclear weapon ever exploded.

$K = \frac{1}{2}mv^2$ $K = \frac{1}{2}(7.85 \times 10^{11})(25.0 \times 10^3)^2$ $K = 2.453125 \times 10^{20} \text{ J}$	$\frac{K}{E_{\text{nuclear}}} = \frac{2.453125 \times 10^{20}}{4.2 \times 10^{15}}$ $\frac{K}{E_{\text{nuclear}}} = 58407.7381$	<p>The kinetic energy of the comet is equivalent to 58408 nuclear bombs.</p>
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**Question – 4:**


1. Analyze the forces acting on an object immersed in a fluid and calculate the net force ( $F_{\text{net}} = F_g - F_{\text{buoyant}}$ ) to predict whether it will float, sink, or remain in its place (neutral buoyancy).
2. Explain why some objects float while others sink by comparing the density of an object and the density of the fluid in which it is placed.

**Q 27.** Common brick is about 1.8 times denser than water. What is the net force on a  $0.20 \text{ m}^3$  block of bricks under water?


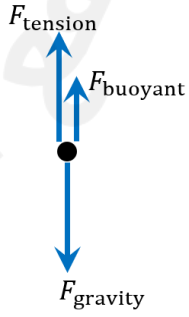


$F_{\text{buoyant}} = \rho_{\text{water}} V g$	$F_g = m g$	$F_{\text{net}} = F_g - F_{\text{buoyant}}$
$F_{\text{buoyant}} = (1.00 \times 10^3)(0.2)(9.8)$	$F_g = \rho_{\text{brick}} V g$	$F_{\text{net}} = 3528 - 1960$
$F_{\text{buoyant}} = 1960 \text{ N}$	$F_g = (1.8)(1.00 \times 10^3)(0.2)(9.8)$	$F_{\text{net}} = 1568 \text{ N}$
	$F_g = 3528 \text{ N}$	

**Q 28.** A girl is floating in a freshwater lake with her head just above the water. If she weighs 610 N, what is the volume of the submerged part of her body?

	$F_{\text{net}} = F_g - F_{\text{buoyant}}$	$F_g = \rho_{\text{water}} V g$
	$0.0 = F_g - F_{\text{buoyant}}$	$610 = (1.00 \times 10^3)(V)(9.8)$
	$F_g = F_{\text{buoyant}}$	$V = 0.0622 \text{ m}^3$


**Q 29.** What is the tension in a wire supporting a 1250-N camera submerged in water? The volume of the camera is  $16.5 \times 10^{-3} \text{ m}^3$ .

	$F_{\text{buoyant}} = \rho_{\text{water}} V g$ $F_{\text{buoyant}} = (1.00 \times 10^3)(16.5 \times 10^{-3})(9.8)$ $F_{\text{buoyant}} = 161.7 \text{ N}$ $F_{\text{tension}} + F_{\text{buoyant}} = F_{\text{gravity}}$ $F_{\text{tension}} + 161.7 = 1250$ $F_{\text{tension}} = 1088.3 \text{ N}$	
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**Q 30.** Plastic foam is about 0.10 times as dense as water. What weight of bricks could you stack on a  $1.0 \text{ m} \times 1.0 \text{ m} \times 0.1 \text{ m}$  slab of foam so that the slab of foam floats in water and is barely submerged, leaving the bricks dry?

$(F_g)_{\text{total}} = (F_g)_{\text{foam}} + (F_g)_{\text{brick}}$ $(F_g)_{\text{total}} = \rho_{\text{foam}} V g + (F_g)_{\text{brick}}$ $(F_g)_{\text{total}} = (0.1)(1000)(1.0 \times 1.0 \times 0.1)(9.8) + (F_g)_{\text{brick}}$ $(F_g)_{\text{total}} = 98 + (F_g)_{\text{brick}}$	$F_{\text{buoyant}} = \rho_{\text{water}} V g$ $F_{\text{buoyant}} = (1000)(1.0 \times 1.0 \times 0.1)(9.8)$ $F_{\text{buoyant}} = 980 \text{ N}$
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$F_{\text{buoyant}} = (F_g)_{\text{total}}$ $980 = 98 + (F_g)_{\text{brick}}$ $(F_g)_{\text{brick}} = 882 \text{ N}$	
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**Q 31.** Canoes often have plastic foam blocks mounted under the seats for flotation in case the canoe fills with water. What is the approximate minimum volume of foam needed for flotation for a 480-N canoe?

$(F_g)_{\text{canoe}} = F_{\text{buoyant}}$ $480 = \rho_{\text{water}} V g$ $480 = (1000)(V)(9.8)$ $V = 0.049 \text{ m}^3$
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**Question – 5:**

**Part A:**

Clarify the meaning of the important terms and concepts contained in the GRAVITATION Module.

**Part B:**

Define kinetic energy and apply the relationship between a particle's kinetic energy, mass, and speed

$$\left( KE = \frac{1}{2} m v^2 \right)$$

**Q 10.** If Earth began to shrink, but its mass remained the same, what would happen to the value of ( $g$ ) on Earth's surface?

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

The value of ( $g$ ) would increase.

**Q 11.** Cavendish did his investigation using lead spheres. Would his value of  $G$  be the same or different if he used copper spheres of equal mass? Explain.

It would be the same, because the same value of  $G$  is used to describe the attraction of bodies having diverse chemical compositions: the Sun (a star), the planets, and satellites.

**Q 12.** Kepler's three statements and Newton's equation for gravitational attraction are called laws. Were they ever theories? Will they ever become theories?

No. A scientific law is a statement of what has been observed to happen many times. A theory explains scientific results. None of these statements offers explanations for why the motion of planets is as it is or for why gravitational attraction acts as it does.

**Q 13.** Picking up a rock requires less effort on the Moon than on Earth. How will the Moon's gravitational force affect the path of the rock if it is thrown horizontally?

Horizontal throwing requires the same effort because the inertial character,  $F = ma$ , of the rock is involved. The mass of the rock depends only on the amount of matter in the rock, not on its location in the universe. The path would still be a parabola, but it could be much wider because the rock would go farther before it hits the ground, given the smaller acceleration rate and longer time of flight.

### Get It?

Describe the common feature that Kepler's first law found concerning the paths of orbiting objects around the Sun.

The paths of the planets are ellipses with the Sun at one focus.

### Get It?

Summarize how the gravitational force can be used to explain the phenomena of a planet orbiting the Sun.

Newton found that the magnitude of the force on a planet varies inversely with the square of the distance from the planet to the Sun. Newton also found that the law of universal gravitation applied to planets.

*the end*