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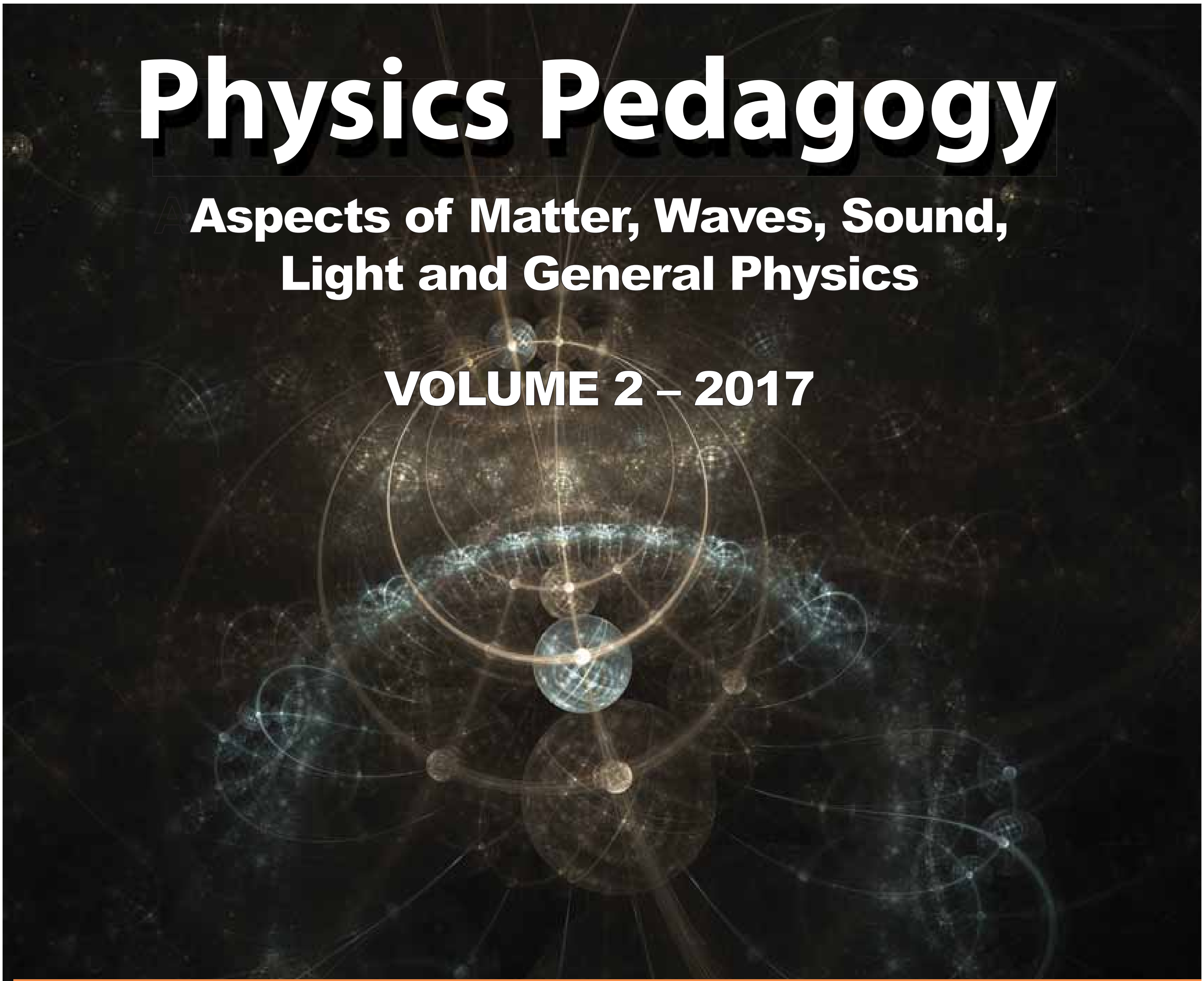
Physics Pedagogy

Aspects of Matter, Waves, Sound, Light and General Physics



VOLUME 2 – 2017

Compiled by Case Rijsdijk

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BACKGROUND

The SA Institute of Physics (SAIP) is a non-profit, voluntary and professional physics society that was established in 1955.

The SAIP has a membership of over 600 made up of professionals, academics and students.

Over 10% of the membership are in other African countries and further abroad.

SAIP is dedicated to increasing the understanding and application of physics in South Africa.

OUR OBJECTIVES

To promote study and research in physics and the encourage applications thereof

To further the exchange of knowledge among physicists by means of publications and conferences. To uphold the status and ensure a high standard of professionals conduct among physicists

To do all such other lawful things as many be necessary to attain the above objectives including the co-operation with other institutes, companies, organisations or societies, to the benefit of both

To offer a wide range of services addressing many levels of involvement with the Physics community and related stakeholders

CONTACT DETAILS

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With thanks to unknown artist

Best to Work as a Team!

Physics Pedagogy

1 Background

The primary aim with this booklet is to introduce an approach to teaching students to learn the concepts needed to understand Physics and solve Physics problems. It follows from the success of the first volume on Mechanics and Electricity produced in 2016. This volume follows a similar pattern, focussing on Matter, Waves, Sound and Light in line with the CAPS document, but some General Physics and Heat has been added to broaden and extend the teachers and learners knowledge. This will help them prepare for University Physics and participation in Olympiads and Competitions.

The conceptual knowledge required includes Physics concepts they have difficulty with in constructing solutions to problems, i.e. a constructivist approach is adopted. The approach is not a set of rules for manipulation, but a set of concepts that are implemented by the teachers at an appropriate time or place.

Another hurdle faced by students is that of misconceptions, of which there are many, but can be classified as follows:

- Preconceived notions
- Non-scientific beliefs
- Conceptual misunderstandings
- Vernacular misconceptions
- Factual misconceptions

These need to be broken down, which means that the following steps have to be taken:

- Identifying students' misconceptions
- Providing a forum for students to confront their misconceptions
- Helping students reconstruct and internalize their knowledge, based on scientific models

There is one class of alternative theories (or misconceptions) that is very deeply entrenched. These are Ontological misconception and relate to ontological beliefs, i.e., beliefs about the fundamental categories and properties of the world. Some common mistaken ontological beliefs that have been found to resist change include:

- that objects like electrons and photons move along a single discrete path
- belief that time flows at a constant rate regardless of relative motion
- belief that concepts like heat, light, force, and current are a material substance
- belief that the seasons are caused by the Earth's closer approach to the Sun during summer due to the exaggerated ellipse drawn for the Earth's orbit
- belief that force is something internal to a moving object

There are of course many others, and it would be worthwhile to have students identify these and discuss how best to correct these. A possible route to helping students resolve/reconstruct these misconceptions is related to problem solving.

2 Developing a Problem Solving Strategy

Students need to develop a strategy to tackle problems and solve them, and it is difficult to do so without knowing more than one way to solve the problem. Most students have developed a habit of looking at a problem, decide what formula to apply, use the data given and produce an answer. What a Physics teacher called "Cookery Book Physics": find the recipe, mix the ingredients, put it in the oven and out comes the cake!

Students generally don't use concepts to tackle a problem, primarily because they are unable to identify which ones to use or are relevant. They have a minimal grasp of concepts and are thus unable to use them to resolve the problem: they don't really understand the concepts or **how** to use them.

Below are some of the various types of knowledge that students need to know:

Conceptual knowledge, like the concept of energy transmission by a wave, or that light waves can interfere or be diffracted: in general the concept of a wave.

Factual Knowledge, like the value of the velocity of sound, the radius of the Moon, or the density of a substance.

Representational knowledge, like how to draw and use graphs.

Operational knowledge, like how to manipulate equations, draw diagrams and so on.

Procedural knowledge, mapping out what the question is asking by drawing or sketching diagrams to help identify the concepts needed to solve the problem: turning words into understandable pictures.

Below are many MCQs, and a few more general longer questions that would be suitable for discussion. There will also be the occasional "worked example" to show you how new or different concepts can be incorporated into the problem solving exercise. As was stated at the beginning, the approach is not a set of rules for manipulation, but a set of concepts that can be implemented when the occasion arises. **Read the question carefully, transform the words into a diagram and then construct a strategy to solve the problem**. It is always a good idea to discuss an issue with a colleague or tutor – often the problem can be resolved by getting rid of a misconception or a misinterpretation.

The questions are not graded for degree of difficulty or type – just a random selection of questions from a range of sources and individuals. So read through the questions and tackle the ones that interest you – but eventually you will have done the bulk of them. Or they can be answered in numerical order!

Notes

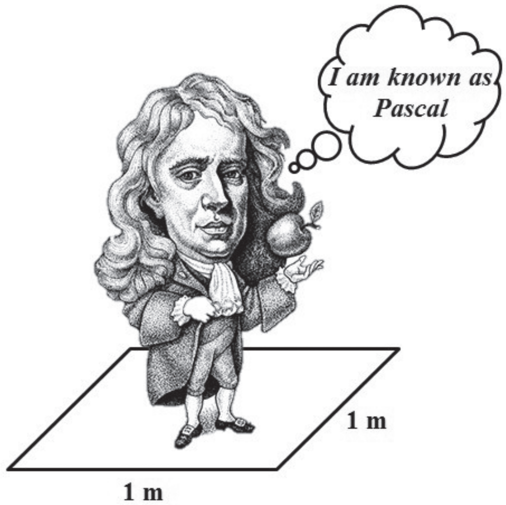
1 Students using this booklet are encouraged to work in groups and discuss problems and their answers. Often there is more than one way to get to the answer, using a totally different conceptual approach. In going through the many examples below the ones that might generate a stimulating discussion have the following phrase inserted below the problem:

Discuss the answer of the above question within your group

2 Sometimes questions do not pose "real" problems – but rather assess the ability of students to recognize what the question is asking, often making something simple look really tough!

3 The MCQs and general questions are not ordered in anyway so they can be answered in any order. The additional problems in # 8 are a little more challenging and students are advised to start with those they are comfortable with in # 3 to # 7. Questions in # 3 are of a general Physics nature, sometimes beyond the CAPS document, but which contribute to a solid foundation for Physics. The additional questions in # 8 are more difficult and should help both teachers and learners get used to Olympiad and Competition questions.

3 General Properties of Matter



Units and dimensions are important, and quite often problems are "solved", and an answer is produced with the incorrect units or dimensions.

A knowledge of establishing the correct units by using something known as Dimensional Analysis is a powerful and useful tool.

Below are some examples of using this tool followed by some MCQ.

Example 1

Pressure is defined as the force per unit area, or N.m^{-2} where 1 N.m^{-2} = 1 Pascal (Pa).

Now the units of force are mass x acceleration which has dimensions [M][L][T]$^{-2}$ and area has dimensions of [L]^2, so a Pascal (or pressure) has dimensions of [M][L]$^{-1}$[T]$^{-2}$.

Example 2

The equation of state for a real gas is given by $\left(P+\frac{a}{V^2}\right)(V-b)=RT$ where P, V and T are pressure, volume and temperature respectively and R is the universal gas constant. The dimensions of the constant *a* in the above equation are:

A [$M^{-1}L^{-5}T^{-2}$] B [ML^2T^{-2}] C ML^5T^{-2}] D [ML^3T^{-2}]

Answer C

The term (a/V^2) has been added to the pressure, hence it should have the dimensions of pressure.

$$\left[\frac{a}{V^2}\right]=\left[P\right]\Rightarrow\left[a\right]=\left[V^2\right]\left[P\right]=\left[L^6\right]\left[\frac{MLT^2}{L^2}\right]=\left[ML^5T^{-2}\right]$$

Obviously the dimensions of *b* are [L]^3

MCQ on General Properties of Matter

3.1 For many purposes it is convenient to compare substances with one another. Pure water at 4^{o}C is often used as a standard substance and we define the relative density as:

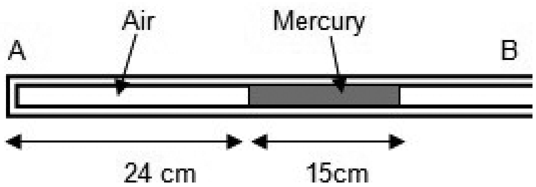
$\text{relative density} = \frac{\text{density of substance}}{\text{density of water}}$. The dimensions of relative density are:

A [ML^{-3}] B [M^2L^{-3}]
C Dimensionless D [ML^{-2}]

3.2 Five water ice cubes, each of volume 10 cm^3, are placed in a measuring cylinder. Water is added until the water level reads exactly 100 cm^3. What is the reading on the measuring cylinder when all the ice has melted?

A 100 cm^3
B 105 cm^3
C 110 cm^3
D 150

3.3 The diagram below shows a 15 cm thread of Mercury in a capillary tube used to trap a fixed mass of air. The air column is 24 cm long when the tube is horizontal and the air pressure is 75 cm of Mercury. The tube is now mounted vertically with the closed end A at the top. If the temperature stays constant, what is the length of the trapped air column now?



A 18 cm B 24 cm C 30 cm
D 36 cm E None of the above: the Mercury will fall out of the tube.

3.4 A box contains a large number of balls of **N** different colours and an equal number of each colour. How many balls must be drawn from the box to be sure that you have two balls of the same colour?

A N^2 B N(N + 1) C N + 1
D 2N E 2(N + 1)

3.5 An ant is in the corner of a cubic box of side 1 m. It crawls to the diagonally opposite corner by the shortest route. Which of the following gives the correct **distance** crawled by the ant and the magnitude if its **displacement**, in m

	Distance	**Displacement**
A	$\sqrt{2}$	$\sqrt{2}$
B	$\sqrt{5}$	$\sqrt{3}$
C	3	$\sqrt{3}$
D	2	3
E	$\sqrt{2}+1$	$\sqrt{5}$

3.6 A drop of water falls from a tap and takes a spherical shape as it starts to fall because:

A the volume is greater than for other shapes
B the surface area is a minimum for a given volume
C a sphere offers less resistance to its surroundings than other shapes
D the pressure outside the drop is less than the pressure inside the drop

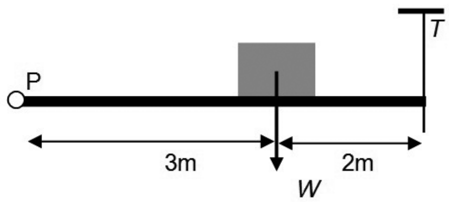
3.7 A catapult (or slingshot) uses two rubber cords which obey Hooke's Law. When each cord is extended by a distance X, a small stone leaves the catapult at speed V when released. If all the energy in the rubber cords is turned into the kinetic energy of the stone, what is the speed of the stone when the cords are each is extended by 2X?

A $(2V)^{1/2}$ B $\sqrt{2}$ V C 2V D 4V

3.8 If the Sun is half a degree (½°) in diameter as seen from Earth, how long would it take to set as seen from a west facing beach? You can assume that the Sun sets vertically and that any optical effects can be neglected.

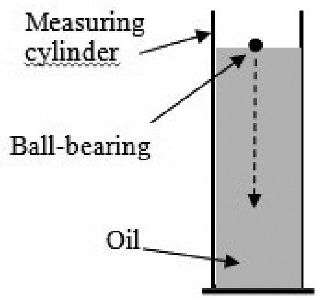
A	20 seconds	B	33.33 seconds
C	2 minutes	D	4 minutes

3.9 The diagram right shows a uniform beam of weight W, pivoted at point P and supporting a block of weight W as shown. The tension T in the string is:

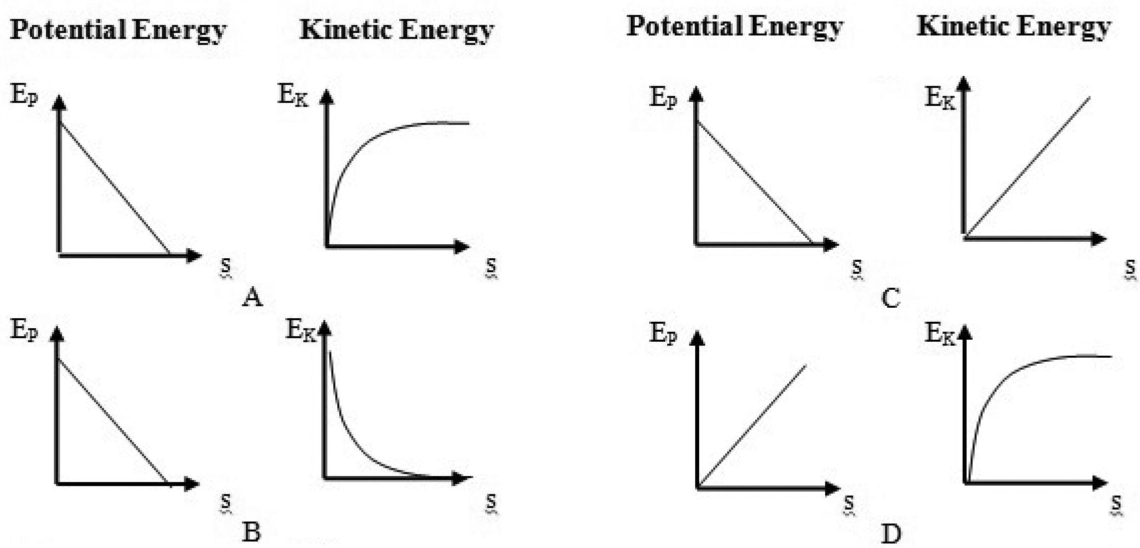


A	$3W/5$	B	$5W/2$	C	$11W/6$
D	$10W/11$	E	$11W/10$		

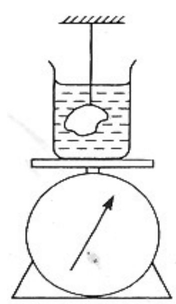
3.10 The diagram right shows a tall measuring cylinder filled with cooking oil. A small, steel ball-bearing is held on the surface of the oil and then released.



Which one of the following pairs of energy (E) versus distance (s) graphs correctly shows the change of potential energy, E_p, and kinetic energy, E_K of the ball-bearing?



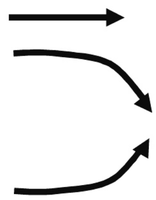
3.11 When a beaker of water rests on a balance, the weight indicated is X. A solid object of weight W in air displaces weight Z of water when completely immersed What will be the balance reading when the object is suspended in the beaker of water so that it is totally immersed (but does not touch the beaker) as shown

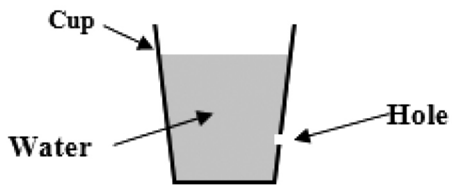


A X
B X + Z
C X + Y – Z
D X + Y

Discuss the answer of the above question within your group

3.12 A plastic cup is filled with water as shown below with one finger covering the hole. The cup is now allowed to fall freely. In which direction will the water come out of the hole as it falls?

A
B

C



D No water will come out of the hole.

Discuss the answer of the above question within your group

3.13 When a long spring is stretched by 2 cm its potential energy is U. If the spring is now stretched by 10 cm its potential energy is:

A $\frac{U}{25}$ B $\frac{U}{5}$
C 5U D 25U

3.14 An object has a mass of 2.64×10^{24} kg. The number of significant figures this is expressed in is:

A 10^{24} B 7
C 5 D 3

3.15 If $\vec{A} \cdot \vec{B} = 0$ then $|A \times B|$ will be:

A zero B AB C $\sqrt{AB}$ D $\frac{A}{B}$

3.16 Which one of the following is equivalent to mass?

A $\frac{Ns^2}{m}$ B $\frac{Nm}{s}$ C $\frac{Jm}{s^2}$

D Js^{-2} E $\frac{J}{N}$

3.17 Which one of the following shows the least change in value when measured all over the world?

A Acceleration due to gravity, g.
B Speed of sound
C Density of the air
D The speed of light

3.18 Which of the following pairs have the same unit?

A Weight, Work.
B Capacitance, Charge
C Impulse, Momentum
D Potential Difference, Energy.

3.19 The absorption of ink by blotting paper involves

A viscosity of ink
B capillary action phenomenon
C diffusion of ink through the blotting
D siphon action

3.20 A light year is a unit of

A Time
B Distance
C The amount of light collected in a year
D The velocity of light

3.21 Planets do not twinkle because:

A they emit light of a constant intensity
B their distance from the Earth does not change with time
C they are very far away from the Earth resulting in decrease in intensity of light
D they are not seen as point sources of light

3.22 Which one of the following has the dimensions of time?
(R = resistance, C = capacitance and L = inductance)

A LC B $\frac{R}{L}$

C $\frac{L}{R}$ D $\frac{C}{L}$

3.23 Which one of the following has the same SI unit as acceleration?

A $\frac{\text{energy}}{\text{mass}}$ B $\frac{\text{velocity}}{\text{area}}$ C $\frac{\text{weight}}{\text{mass}}$ D $\frac{\text{force}}{\text{length}}$

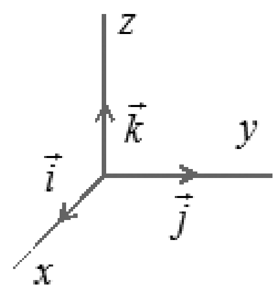
3.24 The unit for momentum is $kg{\cdot}m{\cdot}s^{-1}$. Which one of the following is also a unit of momentum?

A W•s (W = Watt) B J•m
C N•s D $J{\cdot}s^{-1}$

3.25 A right handed coordinate system is shown on the right:
The cross product of $\vec{i}$ and $\vec{k}$ is:

A $-\vec{j}$ B $+\vec{j}$

C $-\vec{k}$ D $+\vec{k}$



Discuss the answer of the above question within your group

3.26 If |**c**| = |**a**| + |**b**| then the angle between the vectors **a** and **b** will be:

A 0^o B 45^o C 60^o D 90^o

3.27 In SI system of units which of the following are chosen as the fundamental quantities?

A Mass, length and time
B Mass, force and length
C Force, time and length
D Speed, force and velocity

3.28 If all of a components of a vector are reversed in direction, the vector itself

A Will stay the same in direction and magnitude
B Will be reversed in direction
C Will be the square root of the original magnitude
D Will be the square of the original vector

3.29 When a motor turns through an integral number of revolutions, the angle in radians is an integer multiple of

A $\frac{\pi}{2}$ B π C 2π D $n\pi$

Discuss the answer of the above question within your group

3.30 If two vectors *a* and *b* are placed tail to tail and are making an angle of θ with each other, the magnitude of their resultant is

A $\sqrt{a^2 + b^2}$

B $\sqrt{a^2 + b^2} + 2ab\cos\theta$

C $\sqrt{a^2 + b^2 + 2ab\cos\theta}$

D $\sqrt{a^2 + b^2 + 2ab\sin\theta}$

3.31 Which of the following cannot be correct because of the dimensional inconsistency?

A $s = v_0 t + 3at^2$
B $v^2 = v_0^2 - 1/2as$
C $s + i/2at^2 = vt$
D $P = \sqrt{\rho gh}$

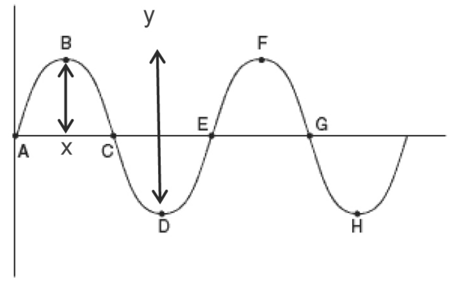
Discuss the answer of the above question within your group

3.32 The potential energy of a stretched spring is proportional to

A the square of the force constant
B the square of the amount of stretch
C the square root of the amount of stretch
D the force constant times the amount of stretch

4 Waves

Use the diagram on the right to answer questions 4.1 – 4.4:



4.1 The wavelength of the wave is given by:

A CE   B DH
C AC   D EG

4.2 The amplitude of the wave is:

A BX   B EF
C YD   D FH

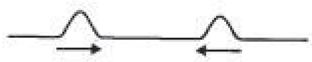
4.3 If the distance AX = 0.5 m, and the speed of the wave 8 $m.s^{-1}$ then the frequency of the wave is:

A 16 Hz   B 8 Hz
C 4 Hz   D 2 Hz

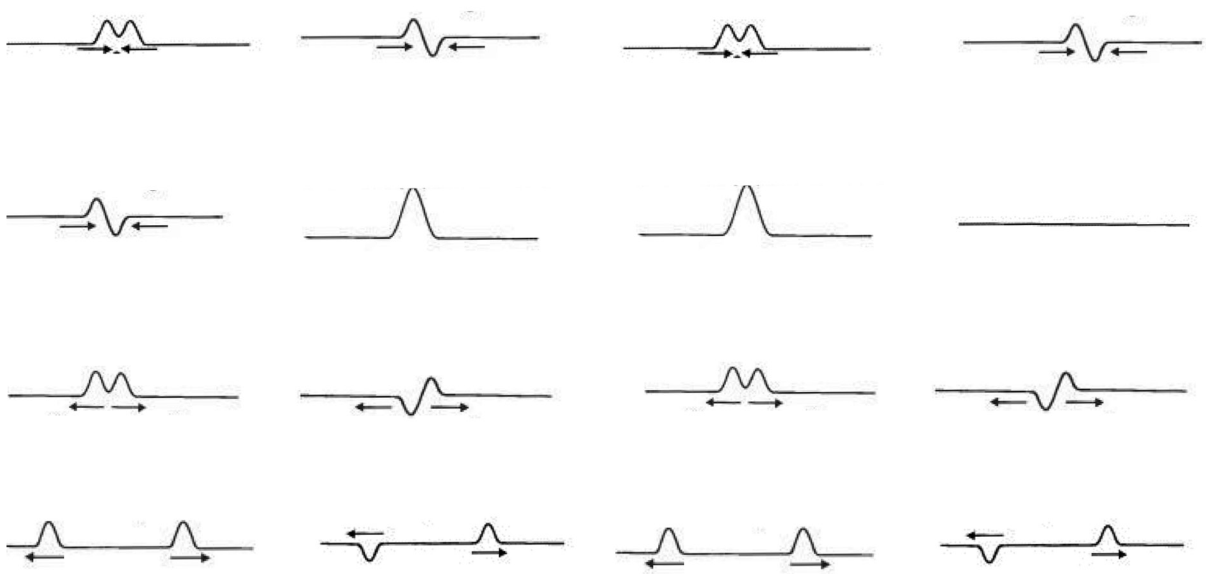
4.4 The period of the wave is:

A 0.625 s   B 0.125 s
C 0.25 s   D 0.5 s

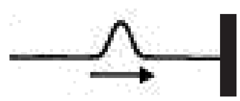
4.5 Two pulses approach each other as shown right, which one of the following shows the correct sequence as the pulses interact as time progresses: (answers vertically downwards)

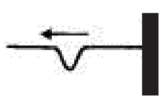
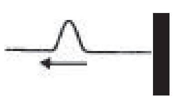
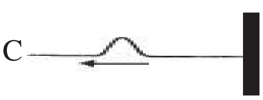
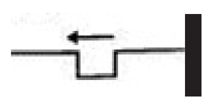


A   B   C   D



4.6 A pulse as shown, strikes a wall and is reflected back
Which one of the following shows the correct reflected wave

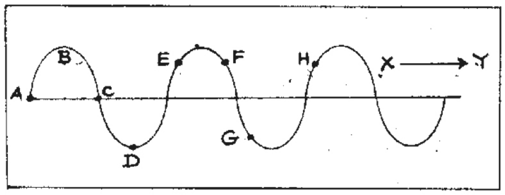


A  B  C  D 

4.7 A ripple tank is used to show the interference of waves. The two dippers are set in a vibratory motion to produce waves of wavelength λ. The path difference of the waves to produce a maximum in the interference pattern is best described by:

A (n - ½)λ
B (n + ½)
C nλ/2
D 3nλ/2
E nλ

Questions **4.8 and 4.9** refer to the diagram below which shows the profile of a transverse wave.



4.8 The distance which represents on wavelength is

A AC B BD C EH D EF

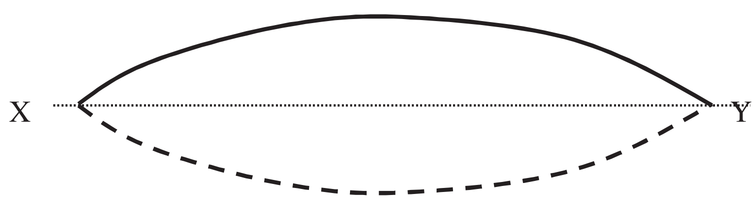
4.9 If the arrow XY represents the direction in which the energy is being propagated, the direction of the motion of point E at the instant shown is

A ↓ B ↑ C → D ↗

Discuss the answer of the above question within your group

4.10 The diagram illustrates a standing wave on a string stretched between supports X and Y. The distance XY is 40 cm. The wavelength of this wave, in cm, is

A 80
B 40
C 20
D 10



4.11 Which of the following waves do not exhibit polarization?

A X-rays B Radio waves C Sound waves D Gamma radiation

4.12 A source emits electromagnetic waves of wavelength 3 m with intensity *I*. One beam reaches the observer directly and the other after reflection from a water surface, and so traveling an extra distance of 1.5 m whilst its intensity is reduced to ¼ of the original intensity. The resultant intensity as seen by the observer is:

A ¼*I* B ¾*I*
C $\frac{5}{4}I$ D $\frac{9}{4}I$

4.13 An oscillator generates waves along an elastic cord 20 cm long. Four complete waves fit along its length when the oscillator vibrates 30 times per second. The frequency and speed of the waves is:

	frequency	speed
A	30/4 Hz	$1.5\ m.s^{-1}$
B	20 Hz	$5.0\ m.s^{-1}$
C	30 Hz	$1.5\ m.s^{-1}$
D	30 Hz	$150\ m.s^{-1}$
E	30/20 Hz	$150\ m.s^{-1}$

4.14 A wave has the equation $y = 4 \sin (3\pi t - 6\pi x)$. This wave is travelling in the:

A $-x$ direction
B $+x$ direction
C Need to know the amplitude of the wave
D Need to know the speed of the wave.

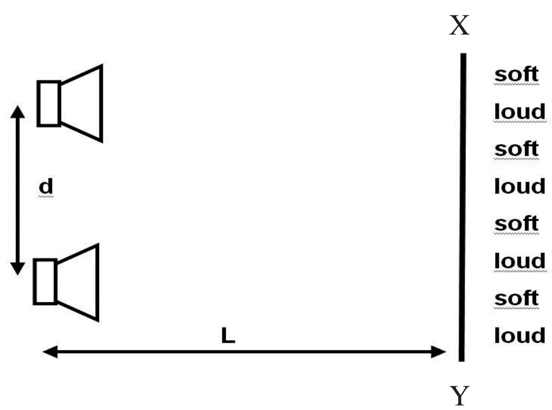
4.15 Longitudinal waves cannot

A have frequency
B transmit energy
C be polarized
D be reflected

4.16 Which **one** of the following statements is **not** true about sound and light waves?

A Both can experience the Doppler effect.
B Both can create an interference pattern
C Both can be plane polarized.
D The speed of both depends on the medium in which they are travelling.

4.17 Two loudspeakers are arranged as shown in the diagram below, are emitting sound waves of frequency 1 000 Hz, in phase and of the same amplitude. The sound heard along XY alternates between loud and soft.



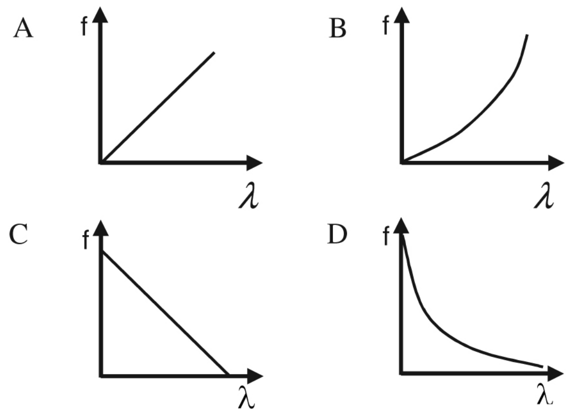
The distance between loud and soft regions may be decreased by

A using only one loud speaker
B decreasing the distance d
C increasing distance L
D using sound of higher frequency

4.18 A single slit diffraction pattern is obtained on a screen using blue light. If the blue light is replaced by yellow light without making any other changes in the experimental setup, what will happen to the diffraction bands?

A Bands will become broader and farther apart
B Bands will become broader and crowded together
C Bands will become narrower and farther apart
D Bands will become narrower and crowded together

4.19 Which one of the following graphs correctly represents the relationship between frequency *f* and wavelength λ of photons of electromagnetic radiation?



4.20 Which one of the following statements about a wave, that is propagated through a medium, from point X to point Y, is **true**?

A Only energy is transferred from X to Y.
B Only some of the material of the medium goes from X to Y.
C Some energy and some of the material goes from X to Y.
D Energy is only transferred from X to Y if it is a standing wave.

Worked Example

A wave is represented by the equation

$$y = 7\sin\left(7\pi f - 0.04x + \pi / 3\right)$$

The speed of the wave is

A 175 ms^{-1} B 550 ms^{-1} C 49π ms^{-1} D 49/π ms^{-1}

Solution Answer B

Standard equation of a wave is $y = a\sin\left(\omega t - kx\right)$ and where $\left(k = \frac{2\pi}{\lambda}\right)$

Now the velocity, *v*, of a wave is $v = \frac{\omega}{k}$. So substituting in the values given we get

$$v = \frac{7\pi}{0.04} = \frac{7\times 3.14}{0.04} = 550\ \text{m.s}^{-1}$$

4.21 A travelling wave in a stretched string is described by the equation:

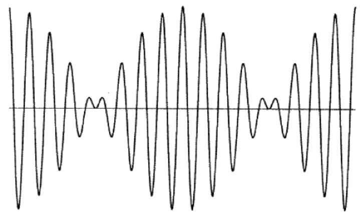
$$Y = A\sin\left(\omega t - kx\right)$$

The maximum particle velocity is

A Aω B $\frac{\omega}{k}$ C $\frac{d\omega}{dk}$ D $\frac{x}{\omega}$

4.22 The diagram below shows a type of waveform which is typical of:

A an echo
B an electromagnetic wave
C a beat frequency
D a diffraction pattern.



4.23 A sinusoidal wave is propagated on a string with amplitude 0.050 m, wavelength 0.20 m and frequency 40 Hz. An expression for the displacement of the string as a function of the time and position on the string is

A $y = (0.050)Sin2\pi\left(\frac{t}{0.025s} - \frac{x}{0.20m}\right)$

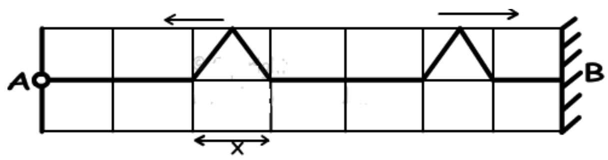
B $y = (0.050)Sin2\pi\left(\frac{t}{0.25s} - \frac{x}{0.20m}\right)$

C $y = (0.050)Sin2\pi\left(0.025t - \frac{x}{0.20m}\right)$

D $y = (0.050)Sin2\pi\left(0.025t - 0.20x\right)$

4.24 In the figure below, pulses move distance X in one second. Find when they interfere?

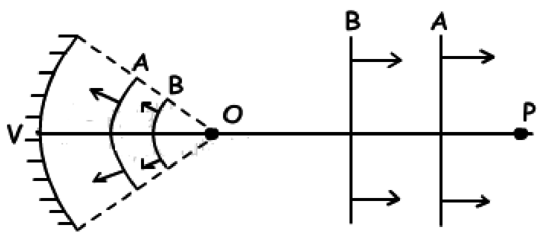
A 4 s
B 5 s
C 5.5 s
D 8 s



4.25 If distance between 5 crests is 60 cm and frequency of the wave source is 3 Hz, find velocity of wave.

A 0.40 m.s^{-1}
B 0.45 m.s^{-1}
C 0.30 m.s^{-1}
D 0.20 m.s^{-1}

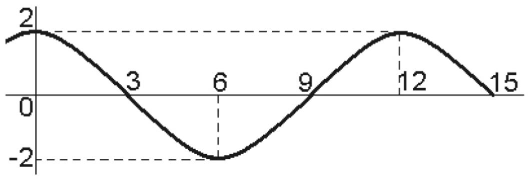
4.26 If the waves A and B coming from point O, to the curved surface, they reflect as shown in the picture given below. Find whether the following statements are true or false



I O is centre of the curved surface
II O is focal point of the curved surface
III P is the centre of the curved surface

A Only I is correct
B Only II is correct
C Both II and III are correct
D Only I and III are correct

4.27 The wavelength of the wave illustrated in the diagram is



A 2 units
B 3 units
C 4 units
D 6 units
E 12 units
F 15 units

Note

As you work through these MCQs, there will be several instances when you are unfamiliar with the work the question covers. Make a note of the question and at some later time find a good Physics text and read up about that work. This can be a most satisfying experience, and inspire you to look deeper in to Physics and so form part of your life-long learning process!

5 Sound

5.1 It takes sound approximately 3 s to travel through a distance of 1 km. If you hear the thunder 9 seconds after having seen the lightning flash, the distance between you and the lightning flash, is, in km

A 27 B 9 C 3 D 1/3

5.2 Suppose you are standing on the platform of a railway station. As the train approaches the station, it gradually slows down. During this process of slowing down, the driver sounds the horn which emits sound waves at a constant frequency of 300 Hz. Which statement correctly describes the pitch, or changes in pitch, that you will you hear as the train approaches you?
It will:

A remain at 300 Hz
B remain constant above 300 Hz
C gradually increase from 300 Hz to above 300 Hz
D gradually decrease from above 300 Hz to 300 Hz

5.3 If a 1.00 kHz sound source moves at a speed of 50.0 $m.s^{-1}$ toward a listener who moves at a speed of 30.0 $m.s^{-1}$ in a direction away from the source, what is the apparent frequency heard by the listener?

A 796 Hz B 949 Hz C 1 000 Hz
D 1 068 Hz E 1 273 Hz

5.4 The speed of sound in air is 333 $m.s^{-1}$. A man, standing 50 m from a cliff, claps his hands regularly so that each clap coincides with the echo of the previous clap. With what frequency does he clap his hands, in Hz?

A 0.33
B 1.67
C 3.33
D 6.66

5.5 Two tuning forks are marked “C 256 Hz”. One is very old and has lost some of its “springiness”. When struck and sounded together there is a beat frequency of 4 Hz. The actual frequency of the older tuning fork is most likely to be:

A 260 Hz B 258 Hz C 254 Hz
D 252 Hz E 252 Hz or 260 Hz

5.6 Sound waves travel faster in water than in air because water

A has a greater density
B has a greater bulk modulus
C is very elastic. ie stretches easily
D is easily compressible.

5.7 A sound wave of frequency 500 Hz covers a distance of 1000 m in 5 seconds between two points X and Y. The number of waves between X and Y is:

A 5000 B 1000
C 2500 D 5000

5.8 When a source of sound approaches you, the sound waves that reach you have a:

A shorter wavelength and higher frequency
B longer wavelength and lower frequency
C shorter wavelength and lower frequency
D longer wavelength and higher frequency

5.9 Ultrasonic waves are sound waves with frequency:

A greater than 2 000 Hz but less than 20 000 Hz
B less than 2 000 Hz
C greater than 20 000 Hz
D less than 20 000 Hz but more 2 000Hz

5.10 The intensity of sound wave gets reduced by 20% on passing through a slab. The reduction in intensity on passage through two such consecutive slabs is:

A 40% B 36%
C 30% D 50%

5.11 A tuning fork of frequency 380 Hz is moving towards a wall with a velocity of 4 $m.s^{-1}$. If the velocity of sound in air is 340 $m.s^{-1}$, then the number of beats heard per second between the direct and the reflected sound will be

A 9 B 6 C 71.8 D 33

5.12 In the case of the open organ pipe the frequency of the fundamental note is 500 Hz. Then the frequency of the second harmonic will be

A 750 Hz B 400 Hz, C 1 000 Hz, D 2 000 Hz

5.13 Anne is waiting to cross the road, when an ambulance, with its siren wailing, approaches her at a speed of 120 $km.h^{-1}$. If Anne hears a frequency of 13 kHz, what is the frequency of the ambulance's siren? (Assume the speed of sound in air is 333 $m.s^{-1}$)

A 7.67 kHz B 13.0 kHz
C 11.7 kHz D 18.8 kHz

5.14 A piano tuner hears four beats per second when she sounds a 256 Hz tuning fork. She tightens the string and hears 6 beats per second. The frequency of the string at first must have been:

A 262 Hz B 252 Hz C 250 Hz
D 260 Hz E 266 Hz

5.15 John is standing next to the freeway and hears a car sounding its hooter as the car passes by. He notices that the pitch of the hooter changes in the ratio 5:4 as the car passes by. What is the speed of the car in $km.h^{-1}$.

A 153 B 136 C 98 D 72 E 37.8

6 Light

6.1 The basic colours used by a colour television to create the picture are:

A the seven colours of the rainbow,
B red, green and blue,
C red, blue, green and yellow,
D red, yellow and blue.

6.2 The sky is blue and many sunsets are red. This is because of the:

A refraction of light
B reflection of light from the sea
C scattering of light
D Sun's light is blue and changes colour when it is reflected off objects

6.3 When monochromatic light is totally reflected by a mirror, which of the properties of the light stay(s) the same after reflection?

A Speed only
B Frequency only
C Photon energy only
D Speed, frequency and photon energy

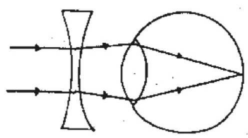
6.4 Diamond is optically more dense (has a greater refractive index) than water because

A it has a greater density than water
B water is more transparent
C water retards the speed of light less than a diamond
D a diamond glitters more than water

6.5 Two photons travelling in a vacuum have different energies. This implies that they necessarily differ in their

A velocity B intensity C amplitude D frequency

6.6 The one following statements is true when referring to the accompanying sketch:



A The concave lens diminishes the focal length of the eye's lens
B The concave lens replaces the lens of the eye
C The concave lens represents the adjustment of a short-sighted eye
D The concave lens converges the rays that fall in on the eye

6.7 When some oil is spilt on water, many colours are visible. This is due to:

A refraction of light
B diffraction of light
C scattering of light
D thin film interference of light

6.8 Planets do not twinkle because they:

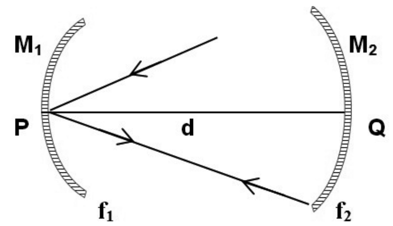
A emit light of a constant intensity
B distance from the Earth does not change with time
C are very far away from the Earth resulting in decrease in intensity of light
D are not seen as point sources of light

6.9 What is the f-number of a lens of focal length 50 cm and diameter 4 cm

A 12.5
B 1.25
C 0.40
D 0.08

6.10 Two mirrors, M_1 and M_2 are placed on the same principal axis, PQ, a distance d apart. A ray of light strikes M_1, is reflected to M_2. Here it is reflected back along the same path as shown above. The focal length, f_2, of M_2 is, in terms of d:

A d
B 2d
C d/2
D 4d



Discuss the answer of the above question within your group

6.11 What is the complementary colour of red?

A Green B Yellow C Magenta D Cyan

6.12 Which one of the following statements is not true about sound and light waves?

A Both can experience the Doppler effect.
B Both can create an interference pattern
C Both can be plane polarized.
D The speed of both depends on the medium in which they are travelling.

6.13 In water the speed of light is 0.75 that of the speed in air. So if the wavelength in air is λ, the wavelength in water is:

A 0.33λ B λ C 0.75λ
D 0.33λ E 0.25λ

6.14 What happens to wavelength, velocity and frequency of light waves, when moving from air into glass?

	Velocity	Wavelength	Frequency
A	increase	increase	increase
B	decrease	decrease	no change
C	increase	decrease	decrease
D	decrease	increase	no change

6.15 The colour of light with the highest photon energy is

A red
B orange
C yellow
D violet

6.16 Gamma rays are examples of

A Electrical waves
B Electromagnetic waves
C Longitudinal waves
D Surface waves

6.17 A card has a green letter X painted on a white background. When the card is viewed through red glass, the following will be observed:

A a red X on a black background
B a blue X on a green background
C a black X on a red background
D a white X on a red background

6.18 Red light passes through a yellow filter, what colour is seen coming out of the filter?

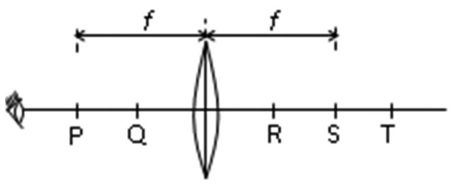
A Orange B Green C Red D Blue

6.19 A patient's eye is astigmatic. The shape of lens used to correct astigmatism is

A Convex lens
B Concave lens
C Cylindrical lens
D A polarized lens

6.20 An artist uses a magnifying glass to draw a picture on a grain of rice. The focal length of the magnifying glass is f. At which one of the points, in the diagram shown below, must he place the rice so that she gets an upright, magnified image?

A Q B R C S D T



6.21 Optical fibres are used to transmit pulses of light and in telecommunications to transmit telephone conversations and data. This is possible due to:

A Total internal reflection
B Diffraction of light
C Total internal refraction
D Interference of light

6.22 A light passes through a flat slab of glass mounted in in a frame standing in a laboratory. The angle of incidence of the ray of light on the glass is 30^0. What is the angle (with the normal) with which the light emerges on the other side of the slab?

A 60^o B 30^o C 45^o
D could be any angle, depending on the thickness of the glass

Discuss the answer of the above question within your group

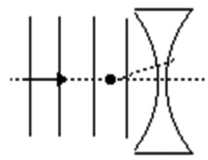
6.23 In order for a convex (converging) lens, of focal length f, to form a real image of the same size as the object is, the object must be placed at

A $2f$ B $\frac{f}{2}$ C $\frac{3f}{2}$ D f

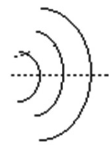
6.24 Joyce stands in front of a mirror and wishes to see herself from head to foot. What is the shortest mirror that she can use if she is 1.6 m tall, stands 1.5 m from the mirror, and the bottom of the mirror is 0.5 m off the floor ?

A 0.8 m B 1.6 m C 2.1 m D 3.1 m

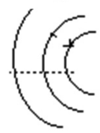
6.25 The diagram on the right shows plane waves approaching a concave lens. Which one of the following diagrams correctly shows what happens when the plane waves reach the lens? The plane waves will:



A Pass through the lens and emerge as shown



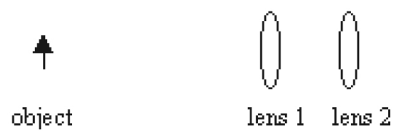
B Pass through the lens and emerge as shown



C Be reflected off the lens as shown

D Pass through the lens and changed as shown

6.26 An object is placed 75.0 cm in front of a converging lens of focal length $f_1 = 15.0$ cm. A second lens of focal length $f_2 = 10.0$ cm is placed 12 cm from the first lens on the opposite side from the object as shown in the diagram below.



The location of the image produced by these **two** lenses is:

A 32.50 cm beyond lens 1
B 22.50 cm behind lens 2
C 18.75 cm beyond lens 1
D 4.03 cm beyond lens 2

6.27 What is the name given to light that has a slightly longer wavelength than red light?

A hyper-red
B hypo-red
C infra-red
D inter-red
E ultra-red

6.28 If the speed of light in vacuum is c, its speed in a medium of refractive index n is

A nc B c C $\frac{c}{n}$ D n^2c

6.29 A light of wavelength 600 nm in air enters a medium with refractive index 1.5. Inside the medium its wavelength will be:

A 900 nm B 450 nm C 400 nm D 300 nm

Discuss the answer of the above question within your group

6.30 In order to produce an interference pattern, light from the two sources producing it must:

A be of equal intensity (brightness)
B have the same colour
C travel the same distance
D be source and image of source or both be an image of the same source
E be polarized in the same way

6.31 Mary sees a coin, directly beneath her, at the bottom of a 2.4 m deep swimming pool. If the refractive index of water is 1.33, how far from the surface of the pool does the coin appear to be?

A 3.2 m B 2.8 m C 1.8 m D 1.6 m

6.32 The splitting up of a beam of white light by refraction into its components is called

A Reflection
B Refraction
C Dispersion
D Secular reflection

6.33 The sine of 30^o is 0.5000. What is the refractive index of a material with critical angle of 30^o?

A 0.50 B 1.00 C 1.50 D 2.00

6.34 Visible light has wavelength between 400 nm and 700 nm. What is the maximum frequency of visible light?

A 1.2×10^{11} Hz
B 4.3×10^{11} Hz
C 4.3×10^{14} Hz
D 7.5×10^{14} Hz

6.35 A light of wavelength 600 nm in air enters a medium with refractive index 1.5. Inside the medium its wavelength will be:

A 900 nm B 600 nm C 400 nm D 300 nm

6.36 Solid P has a higher refractive index than solid Q. What happens to the speed, wavelength and frequency of light passing from solid P to solid Q?

	speed	wavelength	Frequency
A	decreases	decreases	stays constant
B	increases	increases	Decreases
C	increases	stays constant	Increases
D	increases	increases	stays constant

6.37 The magnifying power of a toy telescope is found to be 9 and the separation between the lenses is 20 cm for relaxed eye. The focal lengths of the component lenses are

A 20 cm and 9 cm
B 20 cm and 10 cm
C 20 cm and 11 cm
D 2 cm and 18 cm

6.38 The angle of minimum deviation and the angle of the prism are equal for a prism of glass of refractive index of 1.5. The angle of the prism will be

A 41^{o} 24' B 82^{o} 48' C 60^{o} 24' D 30^{o} 24'

6.39 If an astronomical telescope has objective and eye-piece of focal length 2 m and 4 cm respectively, then the magnifying power of the telescope for the normal vision is

A 24 B 50 C 58 D 204

6.40 Which one of the following is **not** true for the image formed by a convex mirror? It is:

A erect or upright
B diminished or smaller
C virtual
D beyond the focal length

6.41 What is the f-number of a lens of focal length 50 cm and diameter 4 cm

A 12.5 B 1.25 C 0.40 D 0.08

6.42 What is the complementary colour of red?

A Green
B Yellow
C Magenta
D Cyan

6.43 A microscope has an objective of focal length 1.5 cm and an eye-piece of focal length 2.5 cm. if the distance between objective and eye-piece is 20.5 cm, the magnification produced when the final image is at infinite distance is :

A 110 B 1 100 C 11 D 100

6.44 Assuming the mean wavelength of white light as 555 nm. Estimate the smallest angular separation of the two stars which can be just resolved by an astronomical telescope. The diameter of the objective of the telescope is 25 cm:

A 0.56 arcsec B 1.49 arcsec C 5.57 arcsec D 14.8 arcsec

6.45 A slit with a width of 2 511 nm has a red light of wavelength 650 nm impinge on it. The diffracted light interferes on a surface. At what angle will the first minimum be?

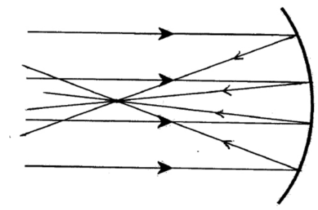
A 1.5^{o} B 15^{o} C 150^{o} D 2.5^{o}

6.46 A person who can see things most clearly at a distance of 10 cm requires spectacles to enable her to see clearly things at a distance of 30 cm. Calculate the focal length of the spectacles lens.

A 15 cm (concave lens)
B 15 cm (convex lens)
C 30 cm (concave lens)
D 20 cm (convex lens)

6.47 4 rays of light are incident upon a mirrored surface and rays come to a focus as shown in the figure. The applications of this parabolic reflector or concave surface is in

A Car headlights
B Radio telescopes
C Satellite dishes
D All of the above



6.48 Different colours can be produced by different combinations of the primary colours. Which combination of primary colours produces cyan?

A Green + blue
B Red + blue
C Red + Green
D White + Green

6.49 Light of wavelength 497.0 nm appears to have a wavelength of 500.2 nm when it reaches Earth from a distance star. Find the velocity of the star. The speed of light is $3x10^8$ $m.s^{-1}$

A $5x10^6$ $m.s^{-1}$
B $4x10^6$ $m.s^{-1}$
C $3x10^6$ $m.s^{-1}$
D $2x10^6$ $m.s^{-1}$

6.50 A child is blowing bubbles in the sunlight, and as the bubbles drift around in the air they show a wide range of different colours. What effect of light causes these differing colours?

A Reflection
B Diffraction
C Refraction
D Interference

6.51 Red light passes through a yellow filter, what colour is seen coming out of the filter?

A Orange B Green C Red D Blue

6.52 A patient's eye is astigmatic. The shape of lens used to correct astigmatism is

A Convex lens
B Concave lens
C Cylindrical lens
D A polarized lens

7 Heat

7.1 If body X has a higher temperature than body Y, then:

A body X must contain more energy than body Y,
B the average EK per molecule of X is greater than the average EK per molecule of Y
C the total molecular energy of X is greater than the total molecular energy of Y
D body A has a greater heat capacity than B

7.2 The temperature of a black body is increased from 300 K to 600 K. Then the rate of emission of energy will increase by a factor of:

A 2 B 4 C 8 D 16

7.3 When picking up a knife that is lying on a table, the steel blade feels colder that the wooden handle. This is because:

A steel is a better conductor of heat than wood,
B wood has a higher specific heat capacity than steel,
C steel has a higher specific heat capacity than wood ,
D the steel blade is actually colder than the wooden handle.

7.4 A cup of hot tea placed on a metallic table loses heat by

A Conduction only
B Radiation and evaporation only
C Convection only
D All of the above

7.5 Which of the following are true for **closed systems**?

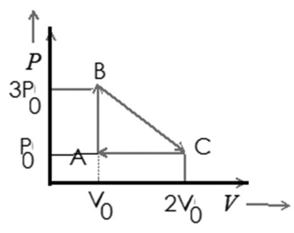
A they are able to exchange energy (heat and work) with their environment
B there is no transfer of mass with its surroundings
C Both (A) and (B) are correct
D Only (A) is correct

7.6 Which one of the following is true for a **free expansion** (i.e. expansion into a vacuum)

A Work done is zero
B Work done is positive
C Work done is negative
D None of the above

7.7 According to the figure if one mole of an ideal gas is taken in a cyclic process, the work done by the gas in the process will be:

A P_0V_0 B $2P_0V_0$
C $3P_0V_0$ D $4P_0V_0$



Discuss the answer of the above question within your group

7.8 A heater is put into a block of metal X of mass 1 kg and the temperature rises by 2 K. When the same heater is used to heat 0.5 kg of another metal Y for the same time its temperature rises by 1 K. The specific heat capacity of Y is

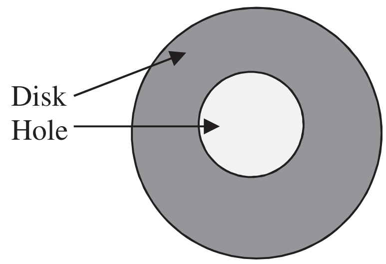
A four times that of X
B twice that of X
C the same as that of X
D half that of X
E one quarter that of X

7.9 A material used to measure temperature has a value of 2.5 in melting ice and 7.5 in boiling water. When the value is 3.5, what ids the temperature, to the nearest ^{o}C?

A 14 B 20 C 47
D 70 E 87

7.10 An iron disk has a large hole drilled through the centre as shown on the right. What happens to the area of the hole as the disk is heated?

A It will decrease
B It will stay the same
C It will increase
D Cannot tell. The circumference of the disk is larger than the circumference of the hole. The greater length will expand at a greater rate and so the disk will buckle.



Discuss the answer of the above question within your group

7.11 Heat and work are the only two mechanisms by which energy can be transferred to or from a system. Latent energy is:

A the internal energy associated with the phase of a system
B the internal energy associated with the temperature of the system
C the internal energy associated with both the phase and the temperature of a system
D the heat capacity of the object.

7.12 The temperature of an ideal gas is increased from 120 K to 480 K. If the rms velocity of the gas molecules at 120 K is v, then at 480 K it becomes:

A $4v$
B $2v$
C $\frac{v}{2}$
D $\frac{v}{4}$

7.13 Absolute zero (0 K) is the temperature at which

A Matter ceases to exist.
B Ice melts and water freezes
C Volume and pressure of a gas becomes zero.
D Molecular motion stops in an ideal gas.

7.14 The temperature of a black body is increased from 100 K to 200 K. By what factor the rate of emission of energy shall change

A 8 times
B 12 times
C 16 times
D 32 times

7.15 Some hot water was added to twice its mass of cold water at 10^{o} C. The resulting temperature of the mixture was 20^{o} C. What was the temperature of the hot water?

A 20^{o} C   B 30^{o} C
C 40^{o} C   D 50^{o} C

7.16 The heat capacity of a substance is:

A The temperature per kg of substance
B The amount of energy per kg needed to raise it temperature by 1 K
C The amount of energy needed to raise it temperature by 1 K
D Its capacity to absorb energy.

7.17 200 g of water at 10^{o} C are mixed with 400 g of water at 30^{o} C. What is the final temperature of the mixture?

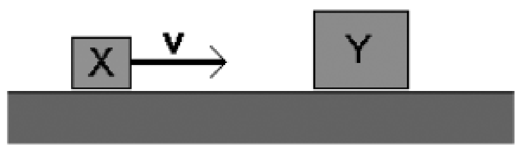
A 50^{o} C   B 23.5^{o} C
C 33.7^{o} C   D 40^{o} C

7.18 A burn by steam is very much more painful (and dangerous!) than one by boiling water because:

A steam has a higher temperature than boiling water
B steam is a dry gas, but boiling water wets the burn area
C the Latent Heat of Vapourization of steam is very large
D water is a poor conductor of heat.

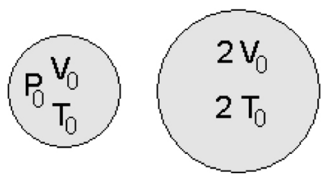
7.19 The small box X moves with speed V and kinetic energy E_0 on a smooth horizontal surface towards the heavier stationary box Y. After the boxes rebound, X moves to the left with a kinetic energy E_X and Y moves to the right with a kinetic energy E_Y. Some heat is generated during the collision. What is always true about the relationship between E_0, E_X and E_Y?

A $E_0 > E_X + E_Y$
B $E_0 = E_X + E_Y$
C $E_0 = E_Y - E_X$
D $E_0 = E_X - E_Y$
E $E_0 < E_Y - E_X$
F $E_0 < E_X - E_Y$



7.20 A balloon contains an ideal gas at pressure P_0, temperature T_0 and volume V_0. Both the temperature and volume of the gas in the balloon are then doubled (see right diagram). The pressure of the gas in the balloon is now

A $\frac{P_0}{4}$ B $\frac{P_0}{2}$ C P_0
D $2P_0$ E $4P_0$



Worked Example

How many joules of energy are required to heat a 200 g piece of copper from 20^o C to 50^o C?

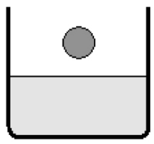
Solution

From the data sheet we see that Q = cmΔT, where

c = the Specific Heap Capacity, SHC, (for Copper this is 400 $J.kg^{-1}$ K^{-1}: this would normally be given
m = the mass = 200 g = 0.2 kg (be careful with units – make sure you use the correct ones)
ΔT = change in temperature = 30^o C

So Q = 400 x 0.2 x 30 = 2 400 J

7.21 A 1 kg ball with volume of 100 cm^3 and a temperature of 30^oC is dropped in a 2 kg liquid with a volume of 1100 cm^3 and a temperature of 18^oC. What is the final temperature of the mixture?



A 19^oC
B 22^oC
C 24^oC
D 26^oC
E 29^oC
F We cannot solve this problem without additional information

Discuss the answer of the above question within your group

By looking at problems 7.15 and 7.17 above, it is possible to answer these without needing the SHC of the substances involved because there is only one substance. So in working out the problem, the value of *c* cancels out! In the avbove question, try and identify what you would need to be able to solve it.

8 Modern Physics

8.1 A Uranium 238 nucleus ($^{238}U_{92}$) decays by emitting the following particles: α β β α β in turn. The isotope that remains has the following mass and atomic number:

	Mass	Number
A	230	91
B	237	84
C	234	90
D	230	88

8.2 A helium nucleus, or α-particle, and an electron have the same kinetic energy T. If the speed of the α-particle is 100 $m.s^{-1}$, the approximate speed of the electron is nearly, in $m.s^{-1}$?

A 200 B 400 C 900 D 9 000

8.3 If the two particles in Question 8.2 above were accelerated through the same potential difference V, the kinetic energy of the α-particle would be

A 4 times larger B 2 times larger
C $\sqrt{2}$ times larger D the same, as that of the electron.

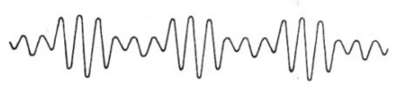
8.4 A source of light is placed 1 m from a photo cell and the cut off potential is found to be V_0. If the distance is doubled, the cut off potential will be:

A $2V_0$ B $\frac{V_0}{2}$ C V_0 D $\frac{V_0}{4}$

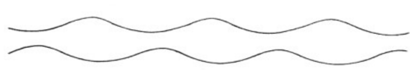
8.5 A radioactive isotope with a half-life of 4.5 hours gives a Geiger counter a count rate of 7 213 counts per minute. 18 hrs later, the count rate is most likely to be about:

A 450 B 900 C 1 800 D 3 600

8.6 A signal is applied to a cathode ray oscilloscope and gives pattern shown in the figure.



When a p-n junction diode is connected in series with the signal, which one of the following patterns will be observed?

A 

B 

C 

D 

Discuss the answer of the above question within your group

.8.7 Which of the following expressions correctly gives the energy, E, of a photon?

A $E = h\,c\,\lambda$ B $E = \dfrac{f\,\lambda}{h}$

C $E = \dfrac{h\,\lambda}{c}$ D $E = \dfrac{h\,c}{\lambda}$

8.8 A proton, a deuteron and an alpha particle with the same kinetic energy enter a region of uniform magnetic field moving at right angles to the field. What is the ratio of the radii of their circular paths?

A $\sqrt{3}:2:1$ B $1:2:3$ C $1:\sqrt{2}:1$ D $\sqrt{2}:1:1$

8.9 What is the maximum kinetic energy (in eV) of a photoelectron emitted from a surface whose work function is 5 eV when illuminated by a light whose wavelength is 200 nm?

A 1.90 B 1.21 C 3.10 D 3.43 E zero

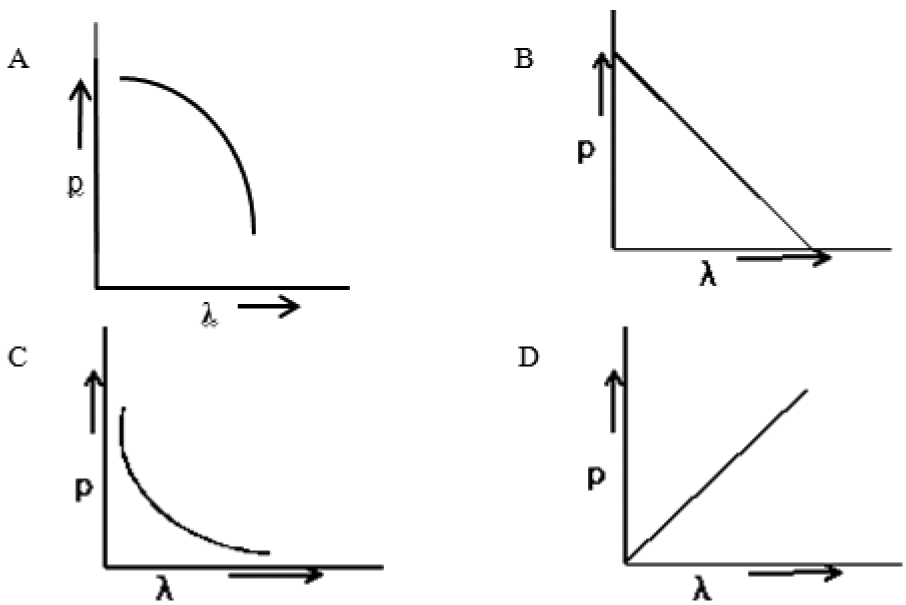
8.10 Radiation of frequency 10^{15} Hz shines on the surface of a metal whose work function is 1 eV (1.6×10^{-19} J). The retarding potential which just prevents the ejection of photo-electrons is:

A 1 V B 3 V C 3.84 V D 5 V

8.11 Beta decay can occur when a neutron in a radioactive nucleus splits into a proton and an electron. What else is emitted in this process?

A Only a photon
B Only a neutrino
C A neutrino and a photon
D An anti-neutrino and a photon

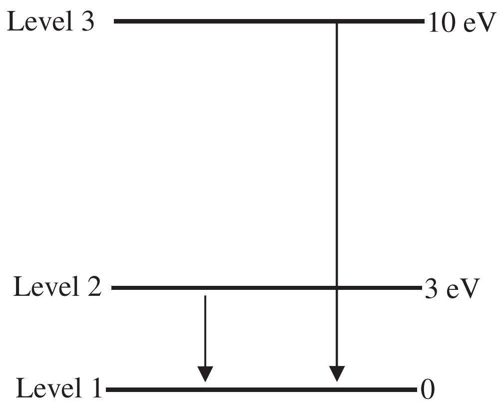
8.12 Which of the following graphs correctly represents the variation of momentum, p, of a particle and its de Broglie wavelength, λ?



8.13 The age of wood can be found by comparing the amount of carbon-14 a sample contains to the amount of carbon-14 in a fresh piece of wood. Such a piece of wood contains 8 times the amount of carbon-14 as a sample from an ancient campfire. How many years ago was the campfire burning if the half -life of carbon-14 is 5 600 years?

A 44 800 B 22 400 C 16 800 D 11 200

8.14 The diagram below shows three of the energy levels of an atom. A transition from level 2 to level 1 results in the emission of a photon of blue light. A transition from level 3 to level 1 could result in the emission of a photon of:



A γ-radiation
B X-rays
C ultra-violet light
D red light

Discuss the answer of the above question within your group

8.15 For a “p” electron (quantum number $l = 1$) the possible values of the magnetic quantum numbers m are:

A –1, 0 B 0, +1 C –1, +1 D –1, 0, +1

8.16 When light shines on a metal surface, electrons will be emitted if the wavelength is less than or equal to λ. When light of wavelength $\lambda/2$ shines on the same metal, the maximum kinetic energy of ejected electrons is T J. When light of wavelength $\lambda/3$ shines on the metal, the maximum kinetic energy of emitted electrons is:

A $\dfrac{2T}{3}$
B $\sqrt{\dfrac{2}{3}T}$
C $\dfrac{3T}{2}$
D $2T$

E $3T$

8.17 In a photo-electric experiment the energy of a photo-electron can be measured by applying a sufficient potential difference to prevent the emission of the electron from the metal surface. Light of different wavelength (frequency f) is shone onto the metal and each time the potential difference required to stop emission is measured in volts. A straight line graph is produced by plotting:

A V^2 against λ B V against λ C λ against 1/V
D V^2 against f *E* V against f

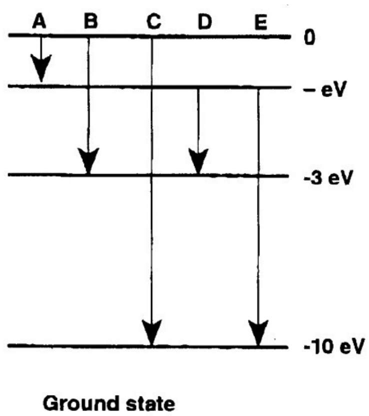
8.18 The ratio of momenta of an electron and an α-particle which are accelerated from rest by a potential difference of 100 V is:

A $\sqrt{\left(\frac{m_e}{2m_\alpha}\right)}$ B $\sqrt{\left(\frac{m_e}{m_\alpha}\right)}$ C $\sqrt{\left(\frac{2m_e}{m_\alpha}\right)}$

D 1 E ~85

Discuss the answer of the above question within your group

8.19 The energy levels of the electrons in an atom are given in the diagram right. Which electronic transition will produce photons with a wavelength of 414 nm?



8.20 Radon is a radioactive gas, Rn^{222}_{86}, and decays by emitting α (He^4_2) and β (e^0_{-1}) particles to produce polonium,

$$Rn^{222}_{86} \rightarrow Po^{214}_{84}$$

Which one of the following decay processes correctly describes this decay?

A α α β β B α β β β β
C α β α α β β D β β α

8.21 The difference in kinetic energies of photo electrons emitted from a surface by light of wavelength 250 nm and 500 nm respectively, will be:

A 1.6×10^{-19} J B 3.96×10^{-20} J
C 3.96×10^{-19} J D 1.6×10^{-30} J

8.22 Electrons are accelerated from rest through a small potential difference V and reach a speed u.

The ratio of the charge of the electron to its mass ($\frac{e}{m}$) is:

A $\frac{u}{V}$ B $\frac{V}{u}$
C $\frac{u^2}{2V}$ D $\frac{2u^2}{V}$

8.23 Sodium atoms emit a spectral line of wavelength 589.6 nm. What is the difference in energy between the two energy levels that produce this spectral line?

A 2.1 eV B 0.0021 eV
C 3.37 eV D 5.34 eV

8.24 An electron falls through a potential difference of 100V. What is its de Broglie wavelength?

A 234 nm B 0.123 nm
C 2.15 µm D 12.3 pm

8.25 For the following nuclear fusion reaction to occur:

$$ {}^{1}_{1}H + {}^{1}_{1}H + {}^{2}_{1}H \rightarrow {}^{4}_{2}He + {}^{0}_{1}e + \text{energy} $$

A Only a very high temperature is required
B A normal temperature and very high pressure are required
C A very high temperature and a very high pressure are required
D A very high temperature and a very low pressure are required

8.26 Visible light has wavelength between 400 nm and 700 nm and its speed is 3.0 x 10^8 ms^{-1}. What is the maximum frequency of visible light?

A 1.2 X 10^{11} Hz B 4.3 X 10^{11} Hz
C 4.3 X 10^{14} Hz D 7.5 X 10^{14} Hz

8.27 Light of two different frequencies whose photons have energies 1.0 eV and 2.5 eV respectively, successively illuminate a metal whose work function is 0.5 eV. The ratio of maximum speeds of the emitted electrons will be:

A 2:4 B 1:2 C 1:4 D 1:5

8.28 What voltage is required to balance an oil drop carrying 10 electronic charges when located between the plates of a capacitor which are 6 mm apart? (Mass of the oil drop = 3x10^{-15} kg)

A 11.25 V, B 110.25 V,
C 25.11 V, D 21.15 V

8.29 The emission spectrum of Hydrogen shows a spectral line in the Balmer series with a wavelength of 656 nm. The frequency of this line, in Hz, is:

A 2.2 x 10^{-15} B 4.57 x 10^{14}
C 19.8 D 8.23 x 10^{14}

8.30 The half-life of Iodine-131 is 8 days. How much of a 10 g sample remains after 32 days?

A 2.5 g B 1.25 g C 0.625 g
D 0.313 g E 0.156 g

8.31 When light is shone onto a metal surface, electrons will be emitted if the wavelength is less than, or equal to, λ. If light of wavelength 0.5λ shines on the metal, an electron with E_K of T is emitted. When light of wavelength 0.33λ shines in the metal the E_K of electrons is:

A 0.67T B 0.82T C 1.5T
D 2T E 3T

8.32 Ultraviolet radiation is incident on the surface of a certain metal. Photoelectrons are ejected with a maximum velocity v and kinetic energy E_K. Light of the same frequency, but twice the intensity, is now shone onto the same metallic surface. Which of the following statement(s) is (are) true?

I The maximum speed of ejected photo-electrons will increase from v to $2v$.
II Twice the amount of electrons will now be emitted per second.
III The maximum kinetic energy of ejected photoelectrons will increase from E_K to $2E_K$.

A Only I and III
B Only I and II
C I, II and III
D Only II
E Only III

8.33 The temperature of a black body is increased from 300 K to 600 K. By what factor will the rate of emission of energy increase?

A 2 times
B 4 times
C 8 times
D 16 times
E 18 times

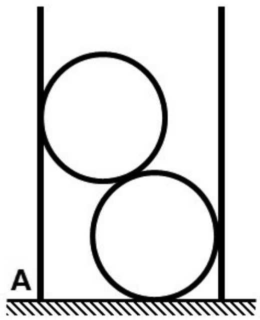
9 Additional Problems

All these are worth discussing within your group

9.1 A raindrop of mass *m* falls to the ground at its terminal speed *v*. The specific heat capacity of water is *c* and the acceleration due to gravity is *g*. Given that 25% of the energy is retained by the raindrop when it strikes the ground, what is the rise in temperature of the raindrop?

A $\frac{mv^2}{8c}$ B $\frac{v^2}{4mc}$ C $\frac{mg}{4c}$ D $\frac{v^2}{8c}$ E $\frac{v^2 g}{8m}$

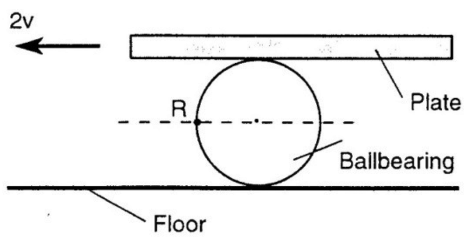
9.2 A hollow right cylinder, radius 3 cm and mass M, is open at both ends. It is resting vertically on a horizontal surface. Two spheres of radius 2 cm and mass 200 g are placed inside the cylinder as shown right. All surfaces are smooth and the cylinder is on the point of toppling at A. For what mass M will toppling start to occur?



A 184 g
B 173 g
C 133 g
D 100 g
E 67.7 g

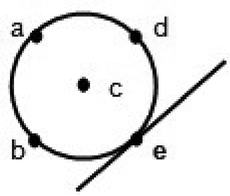
9.3 A ball bearing is being rolled along the floor by means of a horizontal metal plate resting on it and moving at 2v as shown below. The speed of the forward point R, on the surface of the ball bearing is:

A √5 v
B 2v
C √3 v
D √2 v
E v



9.4 A bicycle wheel is rolling down a slope as shown below. The points a, b and d are marks on the hoop, c is the axle and e is where the hoop touches the ground. Which one of the points does not change speed as the rim rolls down the slope?

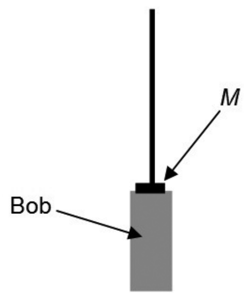
A a
B b
C c
D d
E e



9.5 Determine the dimensions of "k" in $e^{\frac{hf}{k\theta}} - 1$, where *h* is Planck's constant, *f* is frequency and θ is absolute temperature:

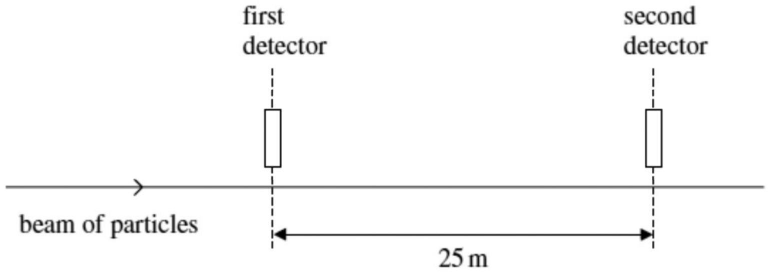
A $ML^2\theta$ B $ML^2T^2\theta^{-2}$
C ML^2T^{-2} D $ML^2T^{-2}\theta^{-1}$

9.6 The diagram right shows a pendulum which is used to regulate a clock. The clock is running slow, so a learner works out that if she were to place a ring with a pre-calculated mass M on the bob as shown, the clock would keep good time again. Which one of the following statements is true?



A By placing the ring on the bob, the effective length of the pendulum is shortened, which decreases the period allowing the clock to keep proper time.
B It wouldn't work as the bob would then be heavier and the clock would slow even more.
C Adding the mass would make no difference since the period of a pendulum is independent of the mass of the bob.
D It wouldn't work as the only way to change the period of the pendulum is to shorten or lengthen the pendulum shaft.
E Adding the ring would create more air resistance would slow the pendulum even more

9.7 A beam of identical particles moving at speed of 0.98c is directed along a straight line between two detectors 25 m apart.



The particles are unstable and the intensity of the beam at the second detector is a quarter of the intensity at the first detector. The half-life of the particles is:

A 17×10^{-8} s B 1.7×10^{-8} s C 8.5×10^{-9} s D 4.25×10^{-9} s

This one will need some additional reading and an in depth discussion

9.8 The length of a sample pendulum is increased by 4%, the percentage increase in its time period is will be

A 5% B 4% C 2% D 1%

9.9 The speed of sound in a diatonic gas is given by:

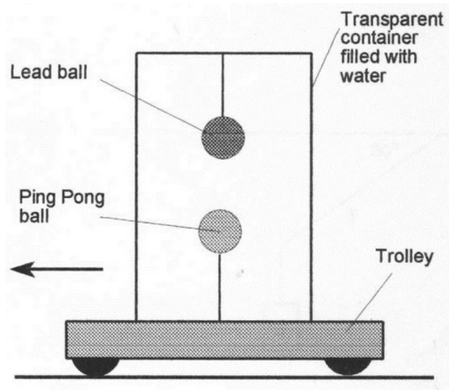
$v = \sqrt{1.4 \times \frac{\text{Pressure}}{\text{density}}}$. The gas law is PV= RT. If the pressure is doubled and the temperature remains constant, the speed of sound in the gas will be:

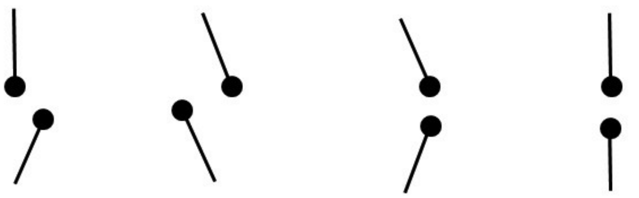
A Unchanged
B Doubled
C multiplied by $\sqrt{2}$
D Multiplied by 4
E multiplied by ¼

9.10 June is piloting a space ship that is travelling at 0.75c (c = speed of light). She points a laser directly towards Peter who is watching from a stationary spaceship, observes the speed of the laser light to be:

A 1.75c B 1.25c C c D 0.75c E 0.25c

9.11 A rectangular transparent container is filled with water and placed on a trolley. It has a lead ball suspended from the lid and a Ping-Pong tethered tom the base as shown. The trolley is now accelerated in the direction shown (to the left). Which one of the following diagrams correctly shows the position of the balls during acceleration?





A B C D

9.12 The two villages, Greyton and McGregor, are connected by a narrow mountain path. A hiker leaves Greyton at 06h00, walks at an irregular pace along the path and arrives in McGregor at 18h00. The following day the hiker returns to Greyton, leaving McGregor at 06h00 and arriving in Greyton at 18h00 again, having walked at an irregular pace along the same narrow path. At how many points on the path is the hiker at the same point at the same time of day? Prove your answer!

A 0 B 1 C 2 D 3 E ∞

This is a true Olympiad type of problem – it's easy when you know how!

9.13 A source, emitting a steady note, is moving at half the speed of sound passes close by a stationary observer, the air be still. The frequency of the note the observer hears changes from f_1 to f_2, where the ratio $f_1 : f_2$ is:

A 4 B 3 C 2
D 1.2 E $\sqrt{2}$

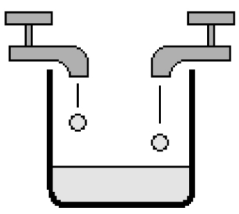
9.14 Calculate the change in entropy for 200 kg of water slowly heated from 20°C to 80°C.

A 1.16×10^6 J.K^{-1}
B 8.4×10^5 J. K^{-1}
C 3.36×10^6 J. K^{-1}
D 2.32×10^6 J. K^{-1}

9.15 Two moles of an ideal gas maintained at 20°C expand until the pressure is one-half the original. How much work is done by the gas?

A 2 432 J B 4 864 J
C 3 370 J D 5 86 J

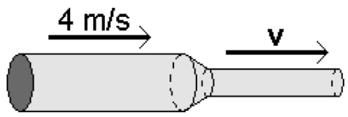
9.16 Drops from two taps are dripping into a bucket. The left tap releases a drop at regular 3 s intervals, while the right tap regularly releases 30 drops per minute. At what average frequency are drops hitting the water in the bucket?



A 33 drops per minute
B 50 drops per minute
C 60 drops per minute
D 90 drops per minute
E 120 drops per minute
F 180 drops per minute

9.17 Water flows from left to right through the pipe illustrated below. The cross-section of the pipe is circular. The diameter of the left half of the pipe is double the diameter in the right half of the pipe. If the speed of the water in the left half of the pipe is 4 $m.s^{-1}$, what is the speed of the water in the right half? (Assume the liquid is incompressible, and that there are no viscous or frictional forces)

A 1 $m.s^{-1}$
B 2 $m.s^{-1}$
C 4 $m.s^{-1}$
D 8 $m.s^{-1}$
E 16 $m.s^{-1}$



10 Data Sheet

1 Physical Constants

Quantity	Symbol	Value
Acceleration due to gravity*	g	10 m.s^{-2}
Universal Constant of Gravitation	G	6.67 x 10^{-11} N.m^2.kg^{-2}
Speed of light in a vacuum	c	3.0 x 10^{8} m.s^{-1}
Planck's Constant	h	6.63 x 10^{-34} J.s
Coulomb's Constant	k	9.0 x 10^{9} N.m^2 C^{-2}
Charge on Electron	e	– 1.6 x 10^{-19} C
Electron mass	m_e	9.11 x 10^{-31} kg

* For simplicity use this unless otherwise stated

2 Other

Earth – diameter = 12 800 km
Sun – diameter = 1.4 x 10^{9} m
1AU = 1.5 x 10^{11} m

3 Sound, Waves and Light

$v = f\lambda$ $\qquad T = 1/f$ $\qquad E = hf$ $\qquad \frac{1}{f} = \frac{1}{v} + \frac{1}{u}$ $\qquad f_L = \frac{v \pm v_L}{v \mp v_S} f_S$

Speed of sound in air = 344 m.s^{-1} or as given in the question.

Frequency (in Hz):		
	IR from	~5 x 10^{11} – 4 x 10^{14}
	Visible from	~4 x 10^{14} – 8 x 10^{14}
	UV from	~8 x 10^{14} – 5 x10^{15}
	X-rays	~5 x 10^{15} – 3 x 10^{21}

4 Heat

$\Delta Q = mc\Delta\theta$ $\qquad$ Specific Heat Capacity $c = \frac{\Delta Q}{m\Delta\theta}$ J.kg^{-1}.K^{-1}

5 Modern Physics

$E_K = hf - w$ $\qquad c = f\lambda$

11 Contributors

11.1 National Science and Technology Forum
11.2 Department of Science and Technology, Rep. of South Africa
11.3 Institute of Physics, IOP for Africa Project, United Kingdom
11.4 British High Commission to South Africa
11.5 The South African Institute of Physics, SAIP.

12 Acknowledgements

12.1 Where the letters DLG appear it is stating that this piece has been adapted from ***An Approach to Promoting Conceptual Understanding of Physics Through Problem-Solving Activities*** by Robert Dufresne, William Leonard and William Gerace, Universality of Massachusetts, Amherst, USA.
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12.5 Prof Andre Venter, NMMU for providing some problems
12.4 Mr Brian Masara, Executive Officer, South African Institute of Physics for making it possible.

BIOPHYSICS INITIATIVE

Biophysicists study the physics of biological systems. Merging the disciplines of physics and biology provides unparalleled insight into biological phenomena and it is used to explain how biological molecules and systems work.

Many interesting biological phenomena occur on the scales ranging from micrometers to nanometers. These can be probed and visualised using electromagnetic radiation which can be used to obtain information about the structure, function and dynamics of the systems. The interesting properties that determine behaviour include conductivity and binding energy which can only be measured and described using physical methods. The forces that determine the properties of biological systems are often weak and this makes the systems fragile.

Much of the discipline of experimental biophysics is devoted to overcoming the problems of obtaining reliable measurements of exquisite and delicate, nanoscale, naturally occurring machines without destroying them. Two large branches of Biophysics are spectroscopy and microscopy. Both these techniques are used to study the structures and dynamics of biological samples under as near physiological conditions as possible and without damaging the sample. More recently a third approach has been introduced which is rapidly gaining importance - this is the ability to manipulate biological materials and is called optical tweezing.

Biophysics has undergone rapid advances over the past 10 years due mainly to the development of new technologies – synchrotrons, electron microscopes, lasers and computers. These technologies enable multiscale imaging ranging from cellular to atomic resolution and allow events to be recorded on ultra-fast (pico- and femto-second) time scales.

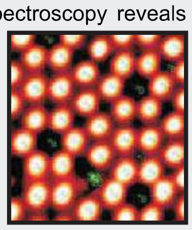
MICROSCOPY

There has been a recent increase in the use of light microscopy in the study of biological systems. Optical microscopy is one of the very few techniques by which physiologically active sample can be studied giving high spatial resolution. Microscopy also enables the study of sub-surface and intra-cellular processes. Confocal microscopy is a powerful tool in biology. By changing the focus of the laser within a sample images through the tissue can be obtained and in this way it may be optically sectioned to a depth of 600μm. From these sections three dimensional images can be constructed. A limitation of confocal microscopy is that the laser energy required for optimal resolutions can damage cells. In recent years new microscopy techniques have been developed called non-linear microscopy. This includes multiphoton-excitation fluorescence (MPF), second harmonic generation (SHG) and third harmonic generation (THG).

SPECTROSCOPY

This basket of techniques is usually concerned with studying in more detail a specific sub-cellular fraction. This may be to determine more precisely the molecular structure of the sample or to follow the reaction mechanisms of the sample.

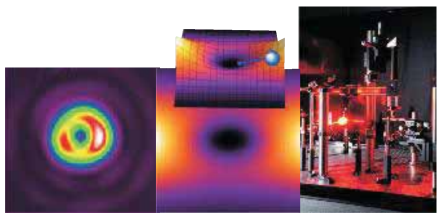
These techniques fall mainly into one of three categories of measuring light and its interaction with the sample. One is the scattering of the light from the sample for example Raman spectroscopy. This is very powerful for detecting the chemical composition of the sample. Then there is the absorption of the light by the sample and then light that is produced as a result of first being absorbed and then re-emitted at a longer wavelength which is termed fluorescence. All the above techniques can be measured in both the steady state and in a time resolved means. Steady state spectroscopy reveals information mostly about the structure and composition of the sample where as time-resolved spectroscopy provides information on the dynamics of a reaction.



OPTICAL TWEEZING

Laser light possesses momentum as outlined in the de Broglie relationship. It is possible to transfer the momentum of light onto another body and exert a force on it. This force may only be a few piconewtons but is able to trap or move a cell or nanosized particle. An optical tweezer makes use of a tightly focused light beam and differences in the refractive index of a particle and surrounding medium.

A particle with a refractive index higher than the surrounding environment is drawn into the laser focus. This technique has been used to measure biomechanical forces acting on macromolecules or cells in the order of femtonewtons. By using optical forces it is possible to manipulate cellular and sub-cellular samples without physical contact.



SOUTH AFRICAN INSTITUTE OF PHYSICS
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For more information about this initiative please visit http://biophysics.saip.org.za/
or email biophysics@saip.org.za

PHYSICS

science & technology
Department: Science and Technology
REPUBLIC OF SOUTH AFRICA

Improves Quality of Life
Makes the World Beautiful!

PHYSICS is the branch of science concerned with the study of matter, energy, the universe and the fundamental laws that govern them

PHYSICS is about solving daily problems and understanding how the world works, and so physicists are brilliantly equipped to deal with all sorts of issues, from technological challenges, chaotic financial problems, to complex strategic planning

SPOT THE PHYSICS - ANYWHERE ANY TIME

1. LCD screens on the wall, phones and laptop
2. Solar powered LED backup lights
3. Microprocessors and transistors in electronic gadgets
4. Accurate time via satellite
5. Battery technologies for phones, laptop and watch
6. Accurate measurement of weights of trade items such as chips, drinks and bread
7. Digital Camera Chips
8. Spectacles Optics
9. Eye sight corrected by Laser Surgery
10. Facial Cosmetics and Sunscreen from Nanomaterials
11. WiFi Radio Network to access internet
12. Novel paint design using Nano powders
13. Stain free clothes with nanoparticles
14. Material Physics for electronic devices casings

PHYSICS is the basis for science, engineering and technology thus in order to increase human capital in science engineering and technology more learners must study physical science at high school

PHYSICS plays the role of the canary in the mine in the sense that if Physics gets seriously ill, it is a warning that science and technology as a whole, and hence the growth of a knowledge-based economy, are in grave danger

SOUTH AFRICAN INSTITUTE OF PHYSICS

National Science Week

NRF National Research Foundation

SAASTA South African Agency for Science and Technology Advancement

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