B

Free Exam
for 2013-16 VCE study design

Engage Education Foundation

Units 3 and 4 Physics

Practice Exam Question and Answer Booklet

Duration: 15 minutes reading time, 2 hours 30 minutes writing time

Structure of book:

Section	Number of questions	Number of questions to be answered	Number of marks
A Part 1	16	16	37
A Part 2	8	8	26
A Part 3	18	18	38
A Part 4	13	13	25
B	72	12	24
		Total	150

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, up to two pages (one A4 sheet) of pre-written notes (typed or handwritten) and one scientific calculator.
- Students are not permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied:

- This question and answer booklet of 58 pages, including a formula sheet on the last three pages.

Instructions:

- You must complete all sections of the examination.
- Write all your answers in the spaces provided in this booklet.

Section A – Core

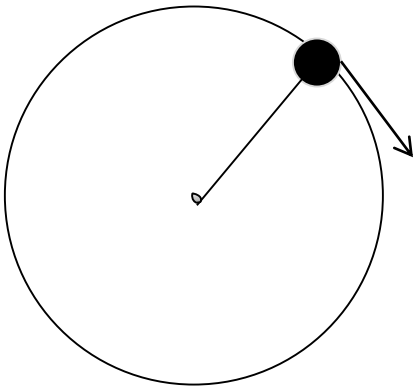
Instructions

Answer all questions for all areas of study in this section in the spaces provided.
Where an answer box has a unit printed in it, give your answer in that unit.
You should take the value of g to be 10 m s^{-2}.
In questions where more than one mark is available, appropriate working must be shown.

Part 1: Motion in one and two dimensions

The following information relates to questions 1 to 3:

A 70 g ball attached to a string of length 40 cm is swung so that it moves in a horizontal circle. The period of the ball's motion is 1.2 seconds.



Question 1
On the diagram above, draw an arrow to indicate the direction of the net force on the ball.

1 mark

Question 2
Calculate the magnitude of this net force.

N

2 marks

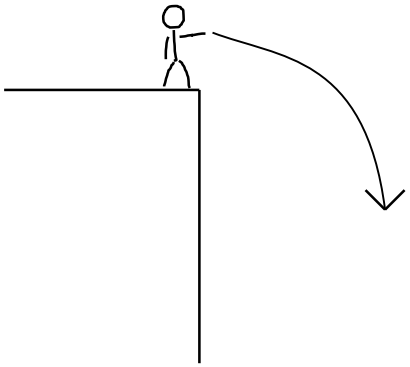
Question 3

As it is spun, the ball moved at constant speed. Explain how this can be true, while the net force on the ball does not equal zero.

3 marks

The following information relates to questions 4 to 8:

Alice stands at the top of a cliff and throws an object off. This projectile has an initial horizontal velocity of 3 ms^{-1}, and is thrown from a height of 24m. Air resistance can be ignored.



Question 4

State whether the following quantities are increasing, remain constant, or are constant and zero for the duration of the ball's motion.

a. The horizontal component of the object's velocity

b. The horizontal component of the object's acceleration

c. The vertical component of the object's velocity

d. The vertical component of the object's acceleration

4 marks

Question 5
What is the object's velocity the moment before it hits the ground?

m s^{-1}

2 marks

Question 6
What is the horizontal distance travelled by the projectile?

m

2 marks

Question 7
What effect, if any, does doubling the object's mass have on this horizontal distance travelled by the projectile? Air resistance can still be ignored.

1 mark

Question 8
On the diagram on the previous page, draw a dotted line to indicate how the trajectory of the projectile would be different if air resistance was not ignored.

2 marks

The following information relates to questions 9 to 12:

A spring (that can be modelled as an ideal spring) is 10 cm long when no mass is attached. When a small 50 g block is attached to one end, the spring's length is 16 cm. When the object bounces up and down, its oscillations have an amplitude of 4 cm.

Question 9
What is the value of the spring constant, k?

N m^{-1}

2 marks

Question 10
What is the total energy in this system of the oscillating spring and block?

J

2 marks

Question 11
With reference to the conservation of energy, describe the energy transformations involved for one oscillation of the block.

3 marks

Question 12

Over time, it is observed that the amplitude of the oscillations gradually decreases. Explain how this can happen, while still obeying conservation of energy.

2 marks

Question 13

A satellite is in orbit around a planet (not Earth). Each orbit takes 32 hours to complete, and the radius of the satellite's orbit is 8.6×10^{7} m.

Calculate the mass of the planet.

5 marks

The following information relates to questions 14 to16:

In a game of billiards, a ball (ball 1) travelling at 3.2 m s^{-1} collides head on with a stationary ball (ball 2). Immediately after this collision, ball 1 is stationary and ball 2 is in motion. Both balls are identical, each with a mass of 140 g.

Question 14

In this collision, what quantity is conserved?

1 mark

Question 15

What is the kinetic energy of ball 2 immediately after the collision?

J

1 mark

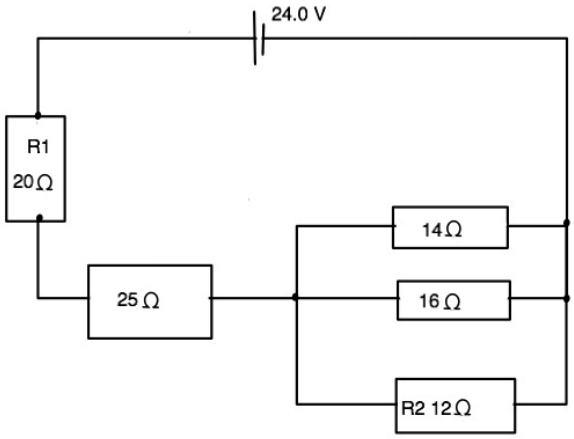
Question 16

Ball 2 travels 2.8 m along the table before coming to a rest. Draw a free body diagram of all the forces acting on ball 2 immediately after the collision, indicating direction and labelling the magnitude of each vector.

4 marks

Part 2: Electronics and photonics

The following information relates to questions 1 and 2:



Question 1

For the circuit above, calculate the following:

a. Total resistance of the circuit

Ω

2 marks

b. Power dissipated in R1

W

2 marks

c. Potential difference across R2

V

1 mark

Question 2

Caitlin wants to measure the current and potential difference of resistor R2. On the diagram on the previous page, draw how an ammeter and voltmeter could be connected to do this.

2 marks

The following information relates to questions 3 and 4:

Question 3

Three components of a circuit are connected in parallel to a 12.0 volt battery. One is a fixed resistor with resistance 6.0 Ω, one is a variable resistor that has been set at 6.0 Ω, and the third is a light bulb with resistance 8.0 Ω.

What is the power dissipated in the light bulb?

W

3 marks

Question 4

What effect, if any, would changing the value of the variable resistor have on the power dissipated in the light bulb?

3 marks

Question 5

A different component connected in a circuit has an efficiency of 35%. If the power output of this device is 80 mW, what is the current through it in the circuit if 15 volts is supplied to the component?

mA

2 marks

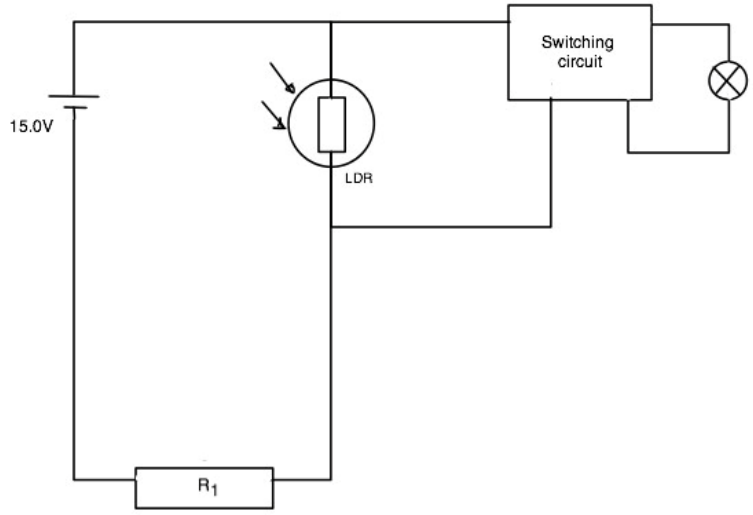
Question 6

An amplifier has an input voltage of 40 mV and an output voltage of 5 V. What is its gain?

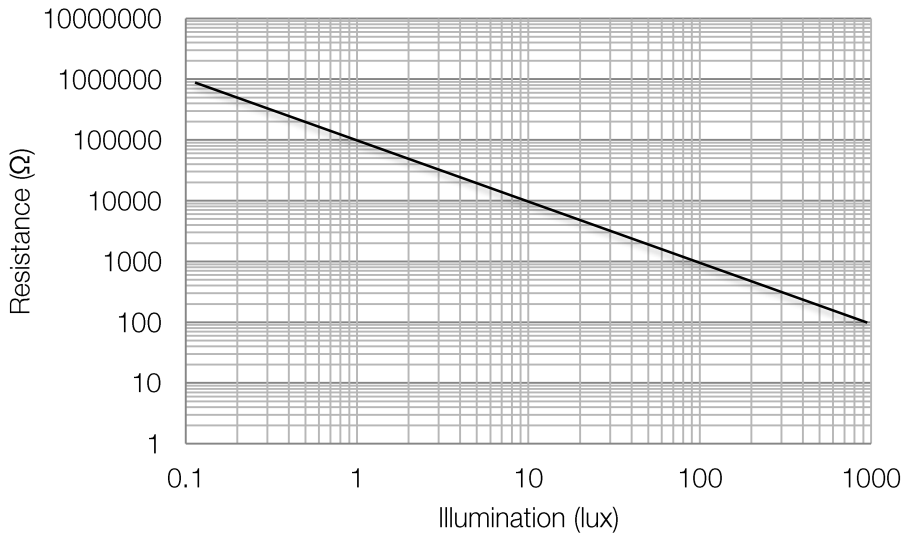
1 mark

Question 7

Tom connects a circuit (shown below) that incorporates a light dependent resistor, to make a night light.



The characteristics of this LDR used in this circuit are shown below:



The switching circuit will turn the light on when it is connected to a voltage equal to or greater than 8.8 V. Tom notices that when the illumination equals 10 lux, the light turns on.

a. What is the resistance of R1?

kΩ

4 marks

Tom now wants the light to turn on only once the room is darker than 10 lux.

b. What should he make the resistance of R_1, if he wants to keep the potential difference required by the switching circuit the same? Explain your answer.

2 marks

c. What should he make the potential difference required for the switching circuit to turn the light on, if he wants to keep the resistance of R_1 the same? Explain your answer.

2 marks

Total: 8 marks

Question 8

Steve has a 12 V battery and 5 resistors of 1 Ω, 2 Ω, 3 Ω, and 4 Ω.

Draw a possible circuit arrangement that will result in:

a. The lowest possible total resistance of the circuit

1 mark

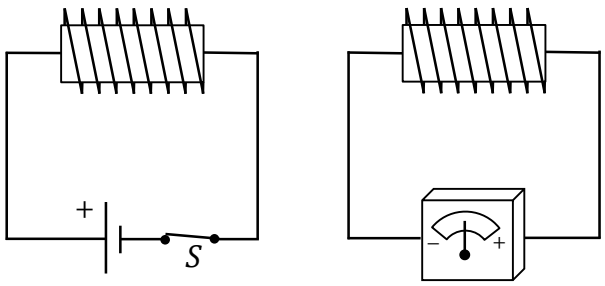
b. The maximum potential difference across the 2 Ω resistor

1 mark

Part 3: Electric power

Use the information below to answer questions 1 to 4:

An electromagnet (on the left) and a solenoid (on the right) are held next to one another, as shown below.



Initially, switch S is closed and the current through the electromagnet is $0.5\ \text{A}$.

Question 1

Draw field lines to indicate the magnetic field of the electromagnet. Include at least 4 field lines.

2 marks

Question 2

The current through the electromagnet is increased by a factor of 2. Is a current induced in the solenoid? If so, in what direction?

1 mark

Question 3

Switch S is turned off. In what direction does the current flow in the solenoid (if there is a current at all)?

1 mark

Question 4

Explain your answers to questions 2 and 3 with particular reference to Lenz's law.

3 marks

Use the information below to answer questions 5 to 10:

A factory is powered by a distant generating station. Power is generated at a voltage of $250\ V_{RMS}$ and at a current of $1600\ A_{RMS}$.

The current is passed through ideal step-up transformer before transmission through power lines. The transformer has 5 turns on the primary coil and 800 turns on the secondary coil. An ideal step-down transformer (with 800 turns on the primary coil and 5 turns on the secondary coil) is located at a substation nearby to the factory.

Question 5
What is the input voltage to the transmission line?

V

2 marks

Question 6
During transmission, 7500 W is lost. Calculate the voltage drop in the wire over the course of transmission.

V

2 marks

Question 7
What is the voltage available at the factory?

V

2 marks

Question 8

The cables used for transmission have a resistance per meter of $0.001\ \Omega\ \mathrm{m}^{-1}$. Find how far the generating station is from the substation, given that a complete circuit must be formed between the generating station and the substation using transmission lines.

m

2 marks

Question 9

The power lines run north to south, parallel to the ground. If the strength of earth's magnetic field is $5.8 \times 10^{-5}\ \mathrm{T}$, find the magnitude and direction of the force on $1\ \mathrm{km}$ of a single transmission wire.

N

2 marks

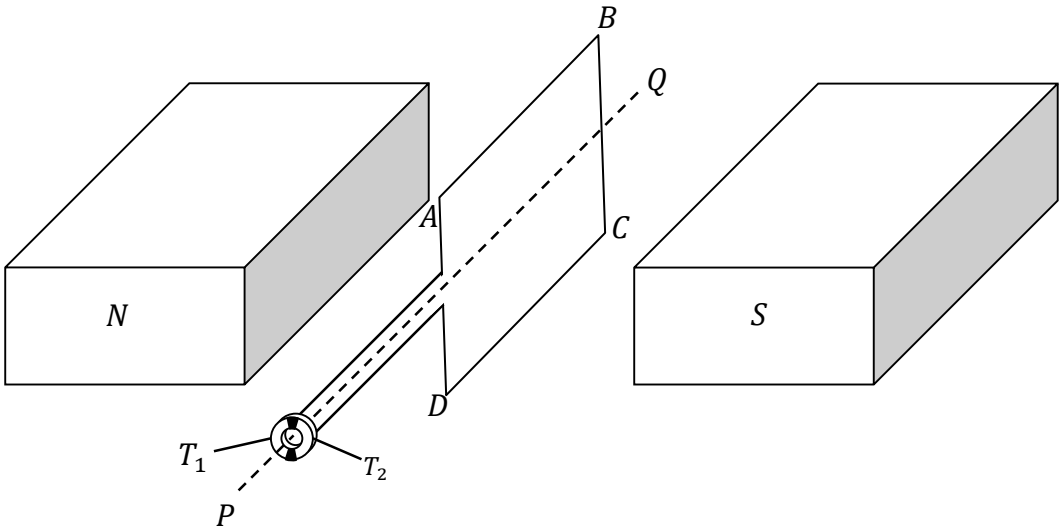
Question 10

Outline the benefits of using AC for transmission of electricity.

3 marks

Use the following information to answer questions 11 to 14:

The figure below shows a schematic for DC power generation. A square coil $ABCD$ is rotated in a magnetic field by mechanical input, and a voltage is generated across terminals T_1 and T_2. The coil is rotating at 20 revolutions per second counter-clockwise along the axis $\overline{PQ}$.



Question 11

Identify the mechanism that joins the terminals to the armature and briefly explain its function.

3 marks

Question 12

If the strength of the magnetic field is $0.7\ \mathrm{T}$, and the coil has side length $15\ \mathrm{cm}$, find the maximum voltage across T_1 and T_2, correct to two decimal places.

V

2 marks

Question 13

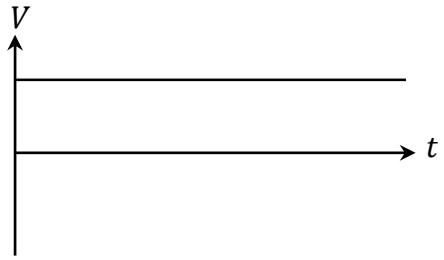
At what orientation of the loop is the greatest EMF generated? Make reference to a specific physical law.

2 marks

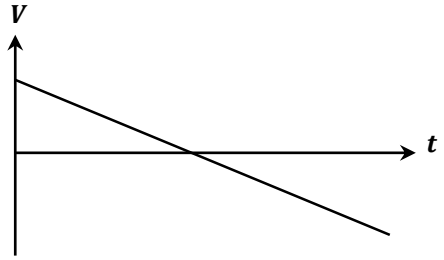
Question 14

Which of the following correctly shows the EMF generated by the coil as a function of time?

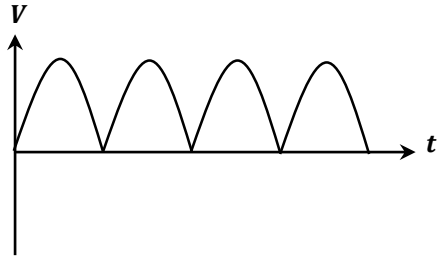
A.



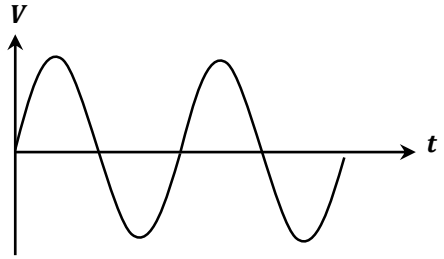
B.



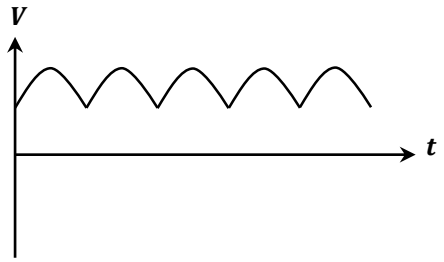
C.



D.



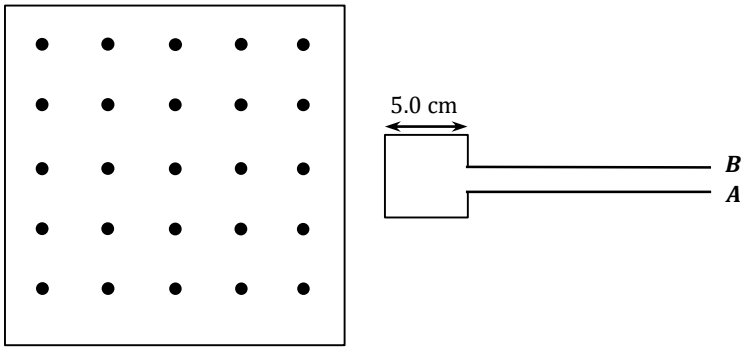
E.



2 marks

Use the following information to answer questions 15 to 18:

A square coil of wire of side length $5.0\ \mathrm{cm}$, with terminals A and B, is held perpendicular to a uniform magnetic field of strength $4.6 \times 10^{-2}\ \mathrm{T}$, as shown below. Assume the field is zero outside the large square.



The coil is moved from right to left at $5\ \mathrm{m/s}$.

Question 15

Draw a graph of the induced emf in the loop as a function of time, where current from A to B is positive. (You do not need to label values on your graph)

2 marks

Question 16
Explain your answer to question 15 with particular reference to a physical law.

3 marks

Question 17
Find the average induced emf in the coil when it moves from just outside the field to just inside to the field if it has 25 turns.

V

2 marks

Question 18
The same experiment as above is repeated with a different coil. The original coil is replaced with a circular coil of 10 turns and area $7.5 \times 10^{-3} m^2$. Find the ratio between the maximum induced emf of the original coil and the maximum induced emf of the new coil.

2 marks

Part 4: Interactions of light and matter

Question 1

Provide an example of an historical experiment that supports the particle model. Explain how it does this.

2 marks

Question 2

Provide an example of an historical experiment that supports the wave model. Explain how.

2 marks

Question 3

An experiment is conducted in which a light source is shone on a plate of zinc, and the energy of the emitted electrons is observed. Explain the effect (if any) that increasing the intensity of this light would have on the energy of the emitted electrons.

2 marks

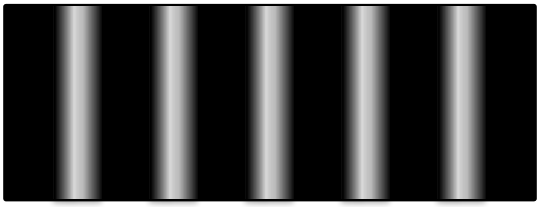
Question 4

State and explain two key differences between light received from the sun and light emitted from a laser.

3 marks

Question 5

To observe two source interference with light, a student sets up Young's double slit experiment: a monochromatic light source is shone through two slits, and the effects are observed on a screen placed 1 m away. The image below is of what is observed on a section of this screen.



In the box below, draw the diffraction you would expect to see if the wavelength of the monochromatic light source is increased.

2 marks

Question 6

Explain any changes you did or did not make to the image of the two-slit diffraction pattern in question 5.

2 marks

Question 8
A source is used to produce x-rays for crystallography. The energy of one x-ray photon is measured to be 9.0 keV. What is the wavelength of these x-rays?

m

2 marks

Question 9
Explain why the electron beam produces a similar diffraction pattern to the x-ray beam.

2 marks

Question 10
Calculate the maximum velocity of electrons that are emitted from a selenium surface (ϕ = 5.11 eV) when electromagnetic radiation of wavelength 240 nm illuminates it.

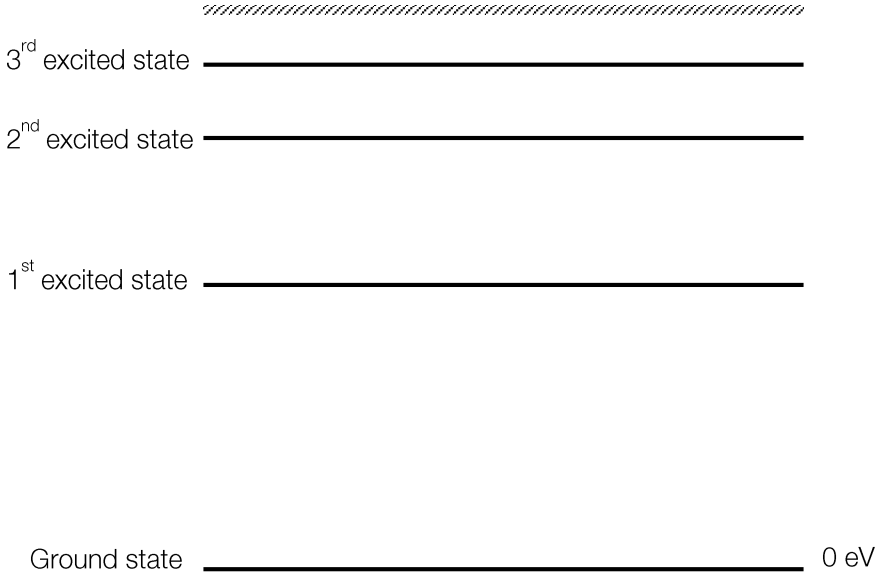
m s^{-1}

3 marks

Question 11
An atom is in a given excited state, and is capable of emitting a photon with one possible value of energy. Which excited state is this atom in? Explain.

1 mark

Question 12
On the diagram below, indicate with arrows the possible transitions for an electron in its second excited state that correspond to the different energies of photons that can be emitted.



2 marks

Question 13
With reference to standing waves, outline how the De Broglie hypothesis helps explain the quantized energy states of atoms.

2 marks

Section B – Detailed Studies

Instructions

Select **one** detailed study.
Answer all questions by circling your choice.
Choose the response that is correct or that best answers the question.
A correct answer scores 2, an incorrect answer scores 0.
Marks will not be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.
You should take the value of g to be 10 m s^{-2}.

Einstein's special relativity

Question 1

Consider a train moving at constant velocity with a light bulb in the centre of the carriage. The light is initially off. Alice is a passenger seated at the very centre of the carriage, while Bob is standing stationary outside the train. The light bulb flashes once. Suppose both Alice and Bob are able to see both ends of the carriage, and are able to identify when the light hits each side of the carriage. Which of the following best describes what Alice and Bob see?

A. They both see the light hit both ends of the carriage at once
B. They both see the light hit the back of the carriage before the light hits the front
C. Alice sees the light hit the front end first; Bob sees the light hit both ends of the carriage at once
D. Alice light hit both ends of the carriage at once; Bob sees the light hit the back end first

Question 2

Which of the following best describes the purpose of the Michelson-Morley experiment?

A. To demonstrate that the speed of light is independent of the speed of the observer
B. To demonstrate that that length contracts parallel to the direction of travel
C. To prove Einstein's two postulates
D. To find the speed of the earth relative to the luminiferous ether

Question 3

Which of the following best describes the findings of the Michelson-Morley experiment?

A. Relativistic observers experience time dilation
B. Relativistic observers perceive length contraction
C. The speed of light is the same in all inertial reference frames
D. The luminiferous ether does not exist

Question 4

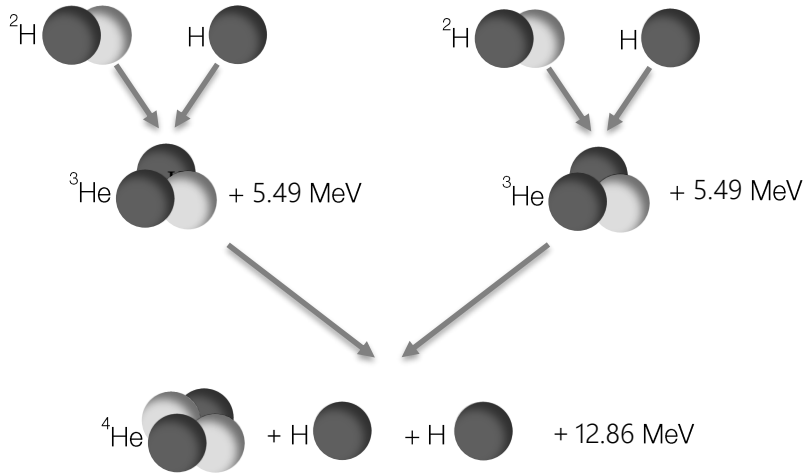
A stationary observer standing in a field perceives a rocket, moving at 0.8c, to have a length of 30 m. What is the proper length of the rocket?

A. 50 m
B. 18 m
C. 36 m
D. 30 m

Question 5
The same rocket from question 4 passes over the field. If the proper length of the field is 1500 m, how long does it take to pass from one end of the field to the other?

A. 2.80 μs
B. 6.35 μs
C. 3.75 μs
D. 4.40 μs

Question 6
The fusion of helium-4 from deuterium and hydrogen is a two-step process, as shown below. The energy released at each step is shown.



Find the total mass deficit between reactant particles and produced particles during the fusion of a single helium-4 nucleus from deuterium and hydrogen.

A. 2.04×10^{-16} kg
B. 4.25×10^{-26} kg
C. 2.04×10^{-16} g
D. 4.25×10^{-26} g

Question 7
It is now known that the speed of light is independent of both its source and the speed of the medium in which it moves. Which of the following first predicted this?

A. Maxwell's equations
B. Galilean relativity
C. Special relativity
D. the Michelson-Morley experiment

Question 8
A European swallow flies past a tower at a speed of 0.6*c*, tangential to the earth's surface. If the bird perceives the height of the tower to be 54 meters high, what is its proper height?

A. 67.5 m
B. 43.2 m
C. 54 m
D. 27 m

Question 9
Which of the following requires the most work?

i. accelerating a proton from rest to 0.9*c*
ii. accelerating an alpha particle from rest to 0.5*c*
iii. accelerating a deuterium atom from 0.9*c* to 0.95*c*

A. i
B. ii
C. iii
D. i and ii are equal

Question 10
Which of the following are inertial reference frames?

i. The earth's surface
ii. The interior of the ISS (international space station)

A. only i
B. only ii
C. both i and ii
D. neither i nor ii

Question 11
Tau particles are produced in high energy electron-antielectron collisions. Suppose during one such collision, a tau particle is emitted with a Lorentz factor of 25, relative to an observer. If it travels 87 μm in its own frame of reference before decaying, what is its observed decay time?

A. 7.25×10^{-12} s
B. 1.51×10^{-13} s
C. 2.90×10^{-13} s
D. 3.78×10^{-12} s

Question 12
If the total energy of the tau particle from question 11 is 7.11×10^{-9} J, what is the kinetic energy of the tau particle?

A. 2.33×10^{-9} J
B. 6.83×10^{-9} J
C. 2.84×10^{-10} J
D. 4.15×10^{-10} J

Materials and their use in structures

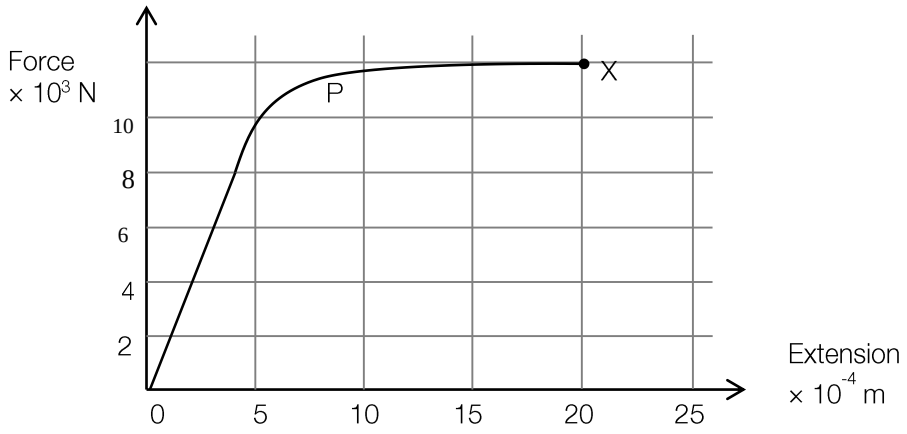
The following information relates to questions 1 to 5:

Engineers are designing a bridge and are investigating different steels for use in its construction. They test a sample of material P, measuring the extension as tensile force is applied.

A force-extension graph is shown below.

The material breaks at X.

The sample has an unstretched length of 12 cm and a cross-sectional area of 2.5 x 10^{-5} m.



Question 1

Which of the following is closest to the strain in the sample when a force of 1.0 x 10^4 N is applied?

A. 4.2 x 10^{-3}
B. 4.2 x 10^{-5}
C. 5.0 x 10^{-4}
D. 5.0 x 10^{-3}

Question 2

Which of the following is closest to the stress in the sample when a force of 1.0 x 10^4 N is applied?

A. 3.3 x 10^8 N m^{-2}
B. 3.3 x 10^3 N m^{-2}
C. 4.0 x 10^3 N m^{-2}
D. 4.0 x 10^8 N m^{-2}

Question 3

Which of the following gives the best estimate of the Young's modulus for material P?

A. 6.6 x 10^{10} N m^{-2}
B. 7.9 x 10^8 N m^{-2}
C. 7.9 x 10^{10} N m^{-2}
D. 9.5 x 10^{10} N m^{-2}

Question 4

Which of the following is the best estimate for the amount of energy stored in the sample when a force of 1.0×10^4 N is applied?

A. 5.0 J
B. 2.5 J
C. 347 J
D. 174 J

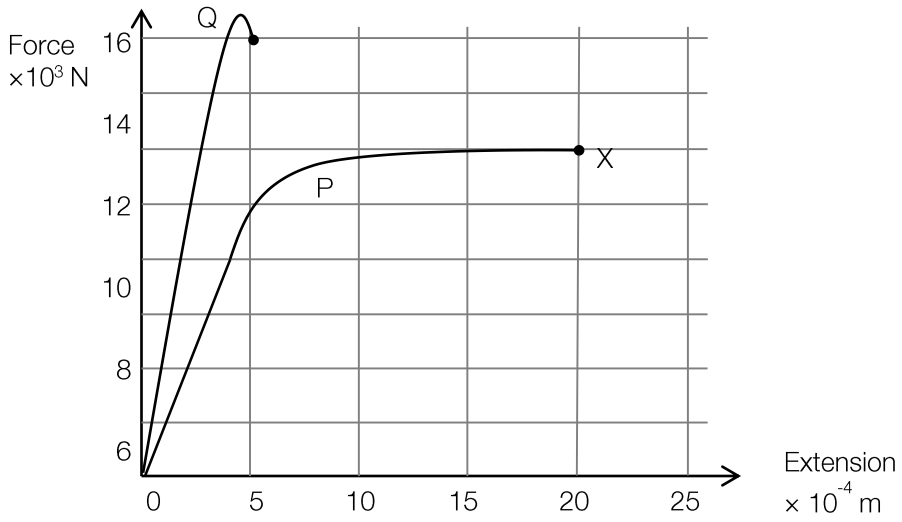
Question 5

Which of the following is the best estimate of the toughness of material P?

A. 3.3×10^6 J m^{-3}
B. 6.7×10^{10} J m^{-3}
C. 6.7×10^6 J m^{-3}
D. 3.3×10^8 J m^{-3}

The following information relates to questions 6 and 7:

The engineers also tested a sample of material Q. The samples of P and Q had the same dimensions. They selected P instead of Q. The force-extension graph for materials P and Q are shown in the figure below.



Question 6
Which of the following is a possible reason for selecting P instead of Q.

A. Q is stronger than P
B. P is tougher than Q
C. P stretches more than Q, and the engineers want to reduce stretching.
D. Q is more brittle than P

Question 7
Which of the following statements is false?

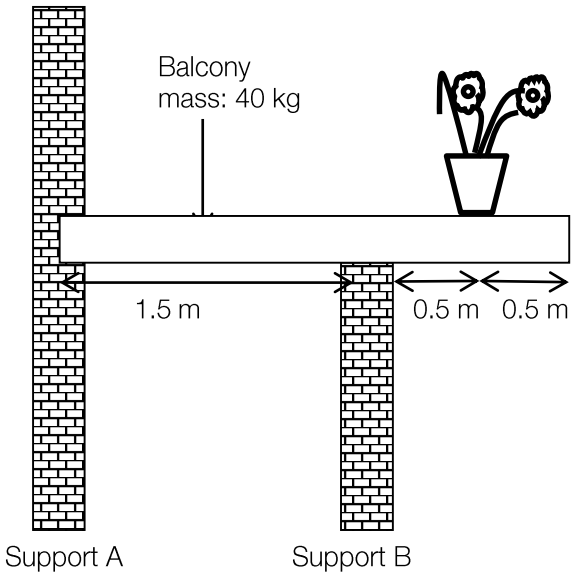
A. P is tougher than Q
B. P is not as strong as Q
C. P has a higher Young's modulus than Q
D. Q is stiffer than P

Question 8
Tension was applied to a material to stretch it. The tensile force was maintained for 5 minutes and then removed. The material did not contract back completely to its initial length. A possible reason for this is

A. The material was stretched beyond its elastic limit
B. The material's length was measured less than 5 minutes after the force was removed. The material will take 5 minutes to contract.
C. The material was not tough enough to withstand the applied force.
D. You must apply compression to a material for its length to decrease.

The following information relates to questions 9 to12:

A man keeps a pot-plant on his balcony. The pot-plant has a mass of 5 kg. Its position on the balcony is shown in Figure 3.



Question 9
What is the magnitude of the force in Support B?

A. 400 N
B. 600 N
C. 40 N
D. 60 N

Question 10
What is the magnitude of the force in Support A?

A. 150 N
B. 50 N
C. 5 N
D. 15 N

Question 11

Consider the following statements:

i. Supports A and B are both in compression
ii. Support A is in tension and support B is in compression
iii. If the pot-plant were moved to the very edge of the balcony, the magnitude of the force in B would increase

Which of the statements is true?

A. i only
B. i and iii only
C. ii and iii only
D. ii only

Question 12

The balcony is made of concrete, which is strong under compression, but not under tension. To reinforce the concrete, steel wires (strong under tension) are set inside the concrete.

Which of the following describes the best placement of the steel wires in the balcony?

A. Near the bottom of the concrete slab between the support A and B, but near the top between support B and the end of the balcony
B. In the centre of the concrete slab
C. Near the bottom of the concrete slab for the whole length
D. Near the top of the concrete slab for the whole length

Further electronics

The following information relates to questions 1 and 2:

The input voltage to a transformer is 120 V_{RMS}, and there are 800 turns in the primary winding. The peak voltage measured at the output terminals is 30 V.

Question 1

The number of turns in the secondary winding is closest to:

A. 140
B. 200
C. 3200
D. 4500

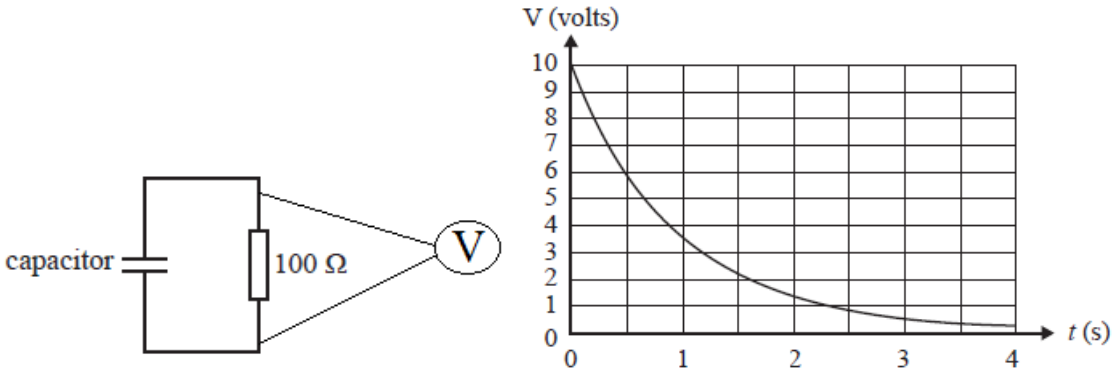
Question 2

What effect does this transformer have on the frequency at the output terminals, compared to the frequency at the input terminals?

A. Frequency has increased
B. Frequency has decreased
C. More information is needed
D. Frequency is unchanged

Question 3

A fully charged capacitor is placed in the following circuit and the voltage over time is recorded.

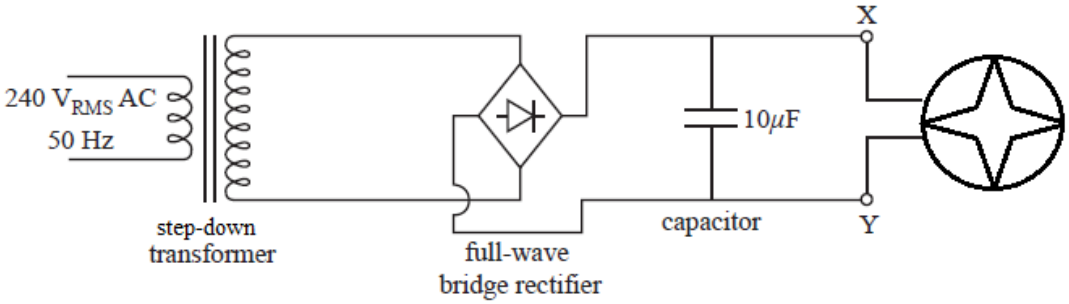


Which one of the following best gives the value of the capacitor?

A. 9000 μF
B. 90 F
C. 111 F
D. Can't know because there is no power supply in this circuit

The following information relates to questions 4 to 8:

John is building, designing and testing an AC to DC power supply system for an electric motor. The DC voltage has to be approximately 50 V and the effective resistance of the motor is 1 kΩ.



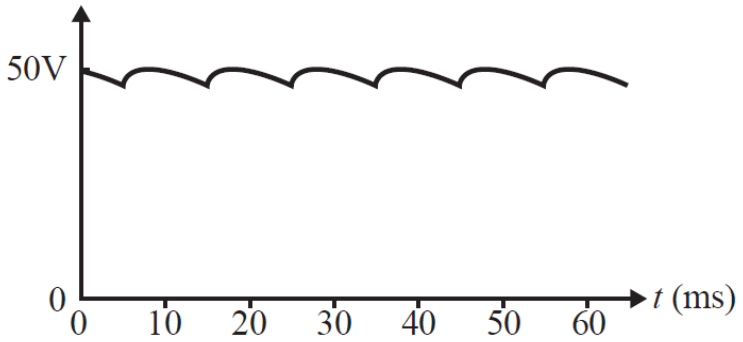
Question 4

For the circuit containing the smoothing capacitor and the electric motor, which of the following is the closest to the time constant τ?

A. 10^{-8} s
B. 0.01 s
C. 1 s
D. 10^{8} s

Question 5

John obtains the following signal:



John wanted a smooth signal instead of a bumpy one, which of the following could not affect the smoothness of the signal?

A. The capacitance of the capacitor
B. The resistance of electric motor
C. The power rating of the transformer
D. Using a full wave bridge rectifier instead of a single diode

Question 6
John has to select the power-rating of the transformer. His provider sells four transformers with power ratings.

Which of the following will be the **minimum** power rating transformer to meet the task?

A. 2 W
B. 5 W
C. 10 W
D. 100 W

Question 7
What is the approximate power dissipated by the electric motor?

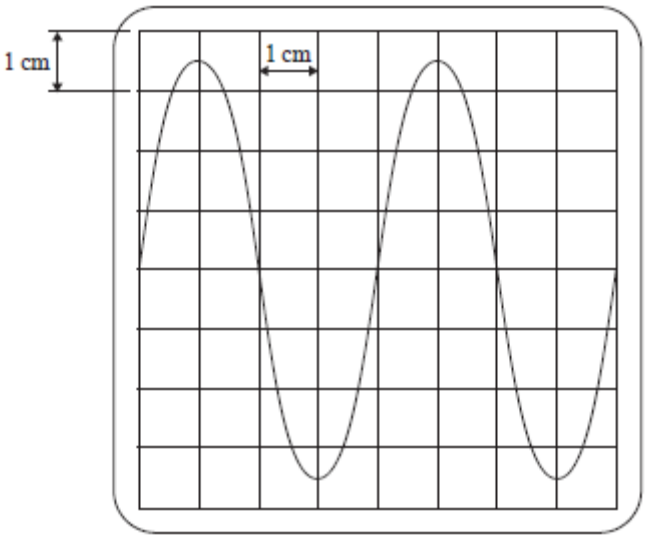
A. 0.05 W
B. 2.5 W
C. 50 W
D. 2.5 kW

Question 8
If the motor is replaced with one with higher resistance (a more powerful motor), what will be the effect on the signal?

A. It will be smoother.
B. It will be bumpier.
C. There will be no change.
D. Half of the signal will not appear.

The following information applies to questions 9 to 12:

Wayne found an old transformer in the garage and, being the curious physics student he is, he decides to test its characteristics. He hooks it to an oscilloscope and observes the following graph.



The vertical scale is set to 2.5 V/cm and the horizontal scale is set to 5 ms/cm.

Question 9

Which one of the following gives the closest value of the peak-to-peak voltage of the signal?

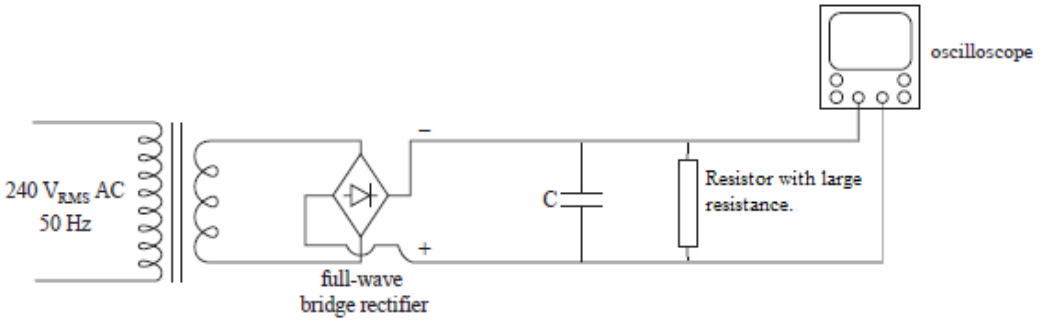
A. 3.5 V
B. 9 V
C. 18 V
D. 240 V

Question 10

Which one of the following gives the closest value of the frequency of the signal?

A. 0.01 Hz
B. 0.02 Hz
C. 25 Hz
D. 50 Hz

Satisfied with the transformer, Wayne now sets up a rectifier with a capacitor and a load resistor with capacitance and resistance high enough such that τ is much greater than the period of the power supply.

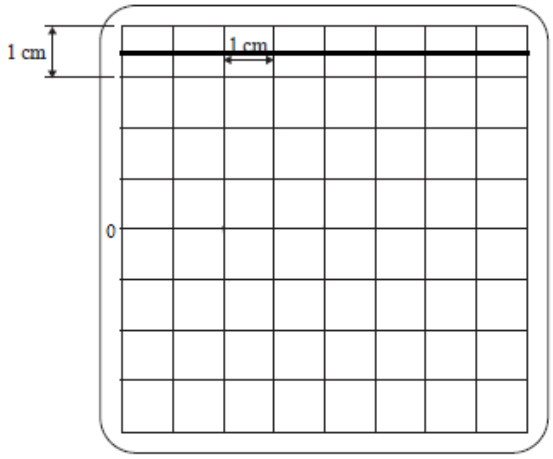


He uses the oscilloscope calibrated in the same way as questions 9 and 10: the vertical being 2.5 V/cm and the horizontal being 5 ms/cm.

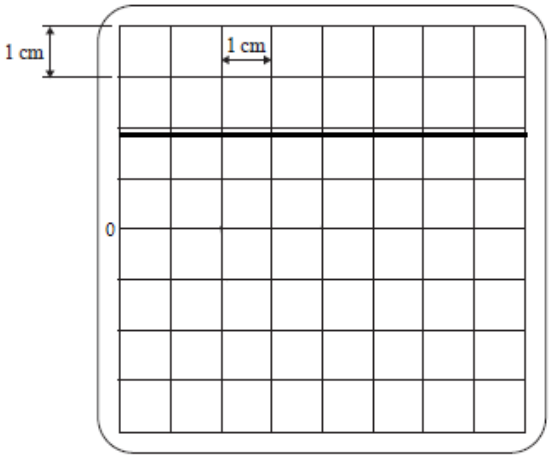
Question 11

The output will be closest to:

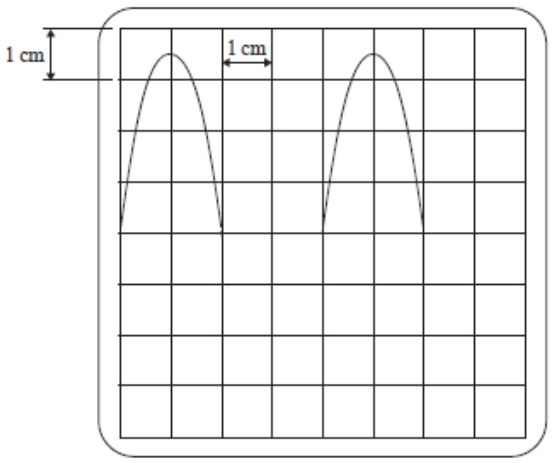
A.



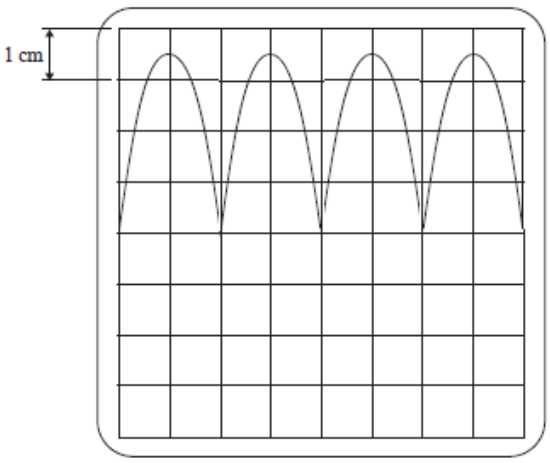
B.



C.

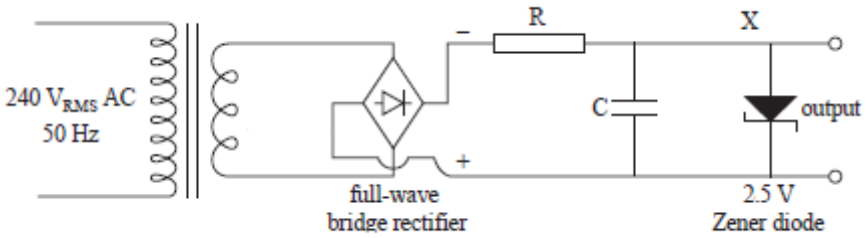


D.



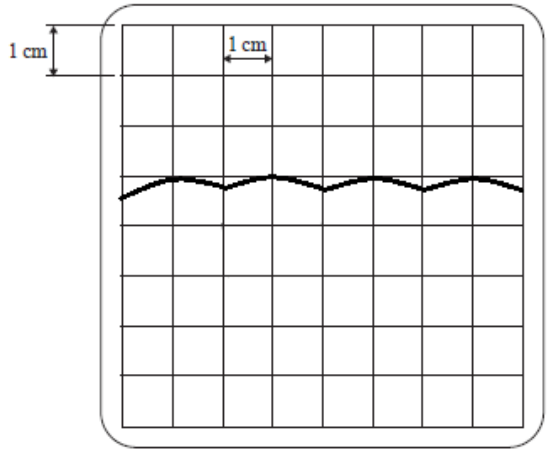
Question 12

Wayne incorporated a 2.5 V Zener diode into his circuit backwards, replacing the resistor.

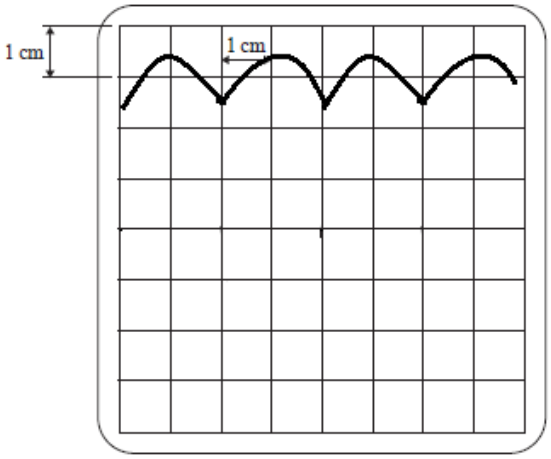


What could the output of the oscillator look like?

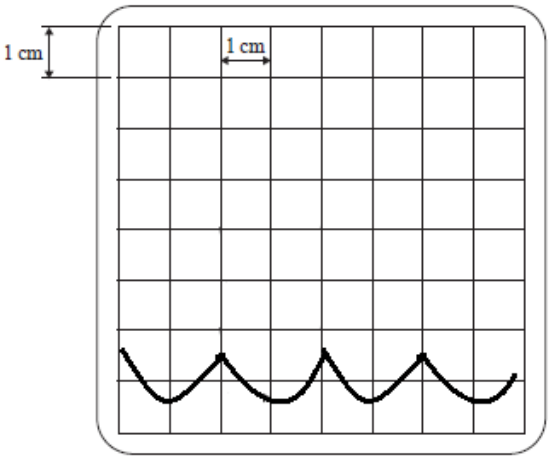
A.



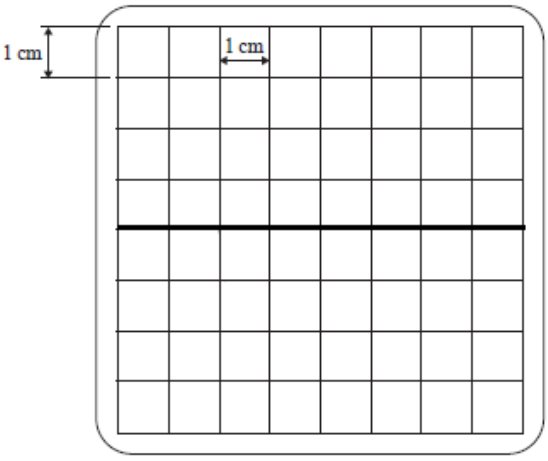
B.



C.



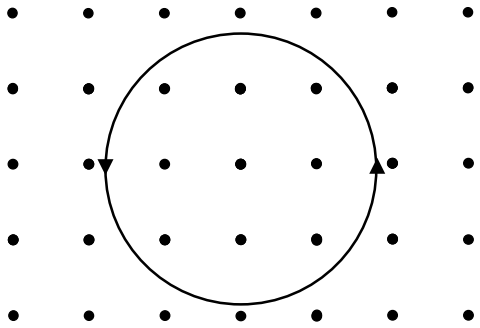
D.



Synchrotron and its applications

Use the information below to answer questions 1 and 2:

An electron travels in a circular path due to a perpendicular, uniform magnetic field, as shown below.



Question 1

If the radius of the circular path is$10.0cm$, and the electron is moving at $2.0 \times 10^7\ m\ s^{-1}$, what is the strength of the magnetic field?

A. $2.08 \times 10^{-3}\ T$
B. $1.14 \times 10^{-3}\ T$
C. $0.87 \times 10^{-3}\ T$
D. $8.71 \times 10^{-3}\ T$

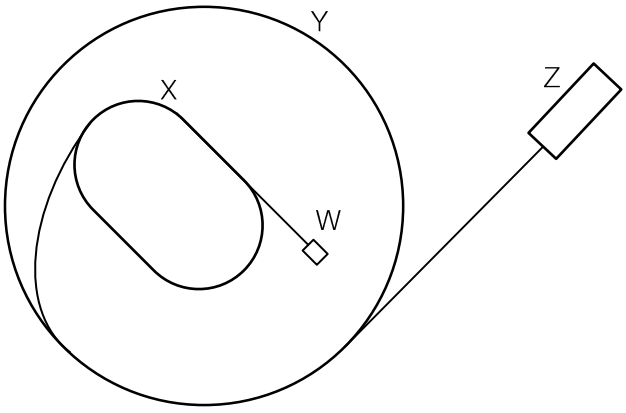
Question 2

The magnetic field strength is now increased to $\mathbf{5.0\ mT}$. If the electron is moving in the same plane, at the same speed as before, what is the magnitude of the force it experiences?

A. $2.4 \times 10^{-7}\ N$
B. $1.8 \times 10^{-14}\ N$
C. $1.8 \times 10^{-7}\ N$
D. $2.0 \times 10^{-7}\ N$

Question 3

A diagram of the Australian synchrotron is shown below.



Which of the following labels W, X, Y and Z in the correct order?

A. Beamline, booster ring, storage ring, linac
B. Beamline, storage ring, booster ring, linac
C. Linac, booster ring, storage ring, beamline
D. Linac, storage ring, booster ring, beamline

Question 4

An electron gun is a type of linac. It consists of a filament, which emits electrons at near resting velocity, and an electric potential, which accelerates the electrons. If the electrons are accelerated through a voltage of $6000V$ in the electron gun, what is the approximate speed of the emitted electrons? (ignore relativistic effects)

A. $4.6 \times 10^7 ms^{-1}$
B. $3.2 \times 10^7 ms^{-1}$
C. $5.5 \times 10^7 ms^{-1}$
D. $1.1 \times 10^7 ms^{-1}$

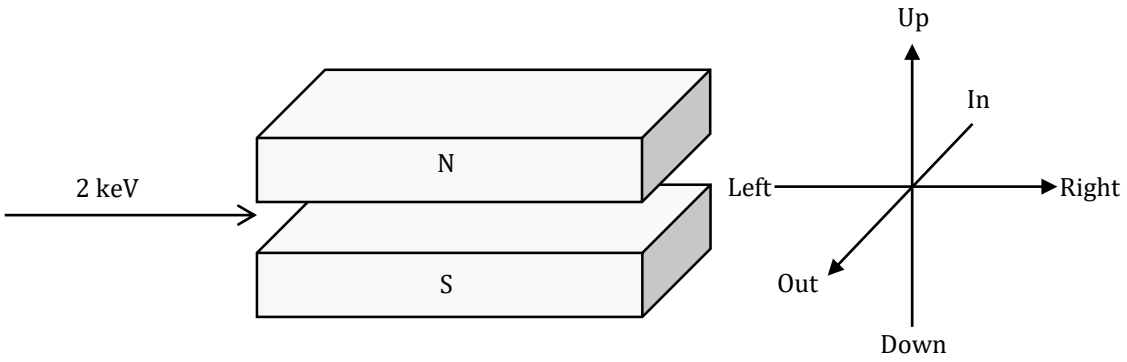
Question 5

The accelerating voltage is now reduced. If the kinetic energy of the electrons is found to be $5.1 \times 10^{-17}\ J$, which of the following is closest to the accelerating voltage?

A. $3000\ V$
B. $520\ V$
C. $320\ V$
D. $150\ V$

Question 6

A beam of $2\ keV$ electrons enters a bending magnet of uniform strength $5.0\ T$.

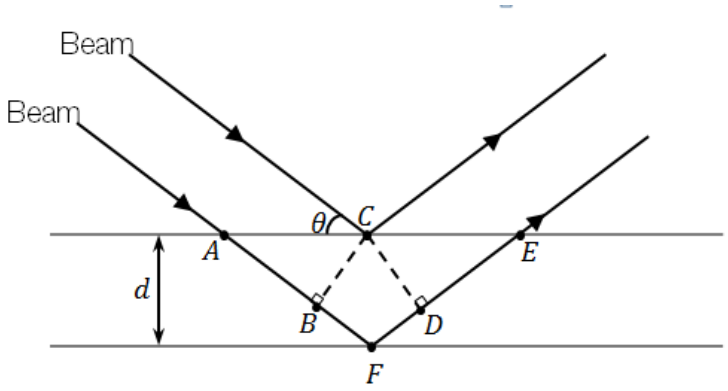


Which of the following correctly identifies the direction in which the beam is bent?

A. In
B. Out
C. Up
D. Down

Use the information below to answer questions 7 to 12:

X-rays of wavelength $1.0 \times 10^{-10} Hz$ are being used in a crystallography experiment to determine the crystal spacing of an unknown sample. The x-rays are incident upon the crystal surface; two such beams are shown below. Beam 1 is reflected by the crystal surface; beam 2 is transmitted through the first layer, and reflected by a second layer, d units, below the first.



Question 7

Prior to the experiment, it was debated whether an x-ray tube or a synchrotron would be a more suitable source of radiation. Eventually, it was decided that synchrotron radiation would be used. Which of the following best describes why?

A. Synchrotrons emit more intense x-rays, which improve resolution and contrast of diffraction patterns
B. Synchrotrons are capable of producing a wider range of wavelengths of light
C. Synchrotrons are more compact than x-ray tubes
D. Synchrotrons emit strongly polarized x-rays

Question 8

Which of the following is the closest to the energy of each photon?

A. $6.63 \times 10^{-24}\ J$
B. $6.63 \times 10^{-15}\ J$
C. $4.03 \times 10^{-15}\ J$
D. $1.99 \times 10^{-15}\ J$

Question 9

The path difference between beam 1 and beam 2 results in a phase shift of the reflected beams that can be used to determine the crystal spacing. Which of the following represents the path difference?

A. $\overline{AC} + \overline{CE}$
B. $\overline{AB} + \overline{DE}$
C. $\overline{BF} + \overline{FD}$
D. $\overline{CF}$

Question 10
The when the path difference is an integer multiple of the wavelength, constructive interference of the reflected beams occurs, resulting in a bright peak on the diffraction pattern. If the first bright peak occurs at $22.7°$, what is the spacing between the crystal layers?

A. $1.3 \times 10^{-10}\ m$
B. $2.6 \times 10^{-10}\ m$
C. $5.4 \times 10^{-11}\ m$
D. $3.0 \times 10^{-10}\ m$

Question 11
At what angle will the third bright peak be observed?

A. $45.4°$
B. $73.3°$
C. $81.1°$
D. No third peak is observed

Question 12
It is observed that some of the x-rays detected are of a longer wavelength than those originally emitted. This is an example of:

A. Compton scattering, because kinetic energy has been conserved
B. Thompson scattering, because kinetic energy has been conserved
C. Compton scattering, because kinetic energy has not been conserved
D. Thompson scattering, because kinetic energy has not been conserved

Photonics

Question 1

Which of the following statements is true?

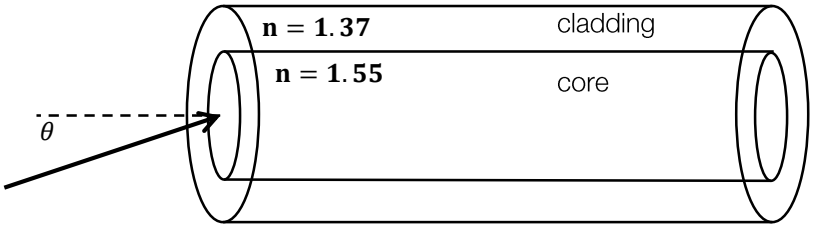
A. Electromagnetic radiation from a laser is monochromatic and wide spectrum.
B. Electromagnetic radiation from a laser is monochromatic and incoherent.
C. Electromagnetic radiation from a laser is monochromatic and coherent.
D. Electromagnetic radiation from a laser is not monochromatic.

Question 2

Which of the following statements is true?

A. Candles, stars, and lasers all produce wide spectrum incoherent light
B. The sun, candles, and light bulbs all produce wide spectrum incoherent light
C. Light bulbs, lasers, and sodium lamps all produce wide spectrum coherent light
D. Candles, light bulbs, and lasers all produce monochromatic light

Use the diagram below to answer questions 3 to 6:



Question 3

What is the critical angle for total internal reflection between the cladding and the core of the waveguide?

A. 28°
B. 90°
C. 62°
D. 16°

Question 4

Which of the following is the acceptance angle θ that will allow the waveguide to operate correctly?

A. 47°
B. 43°
C. 28°
D. 35°

Question 5

The refractive index of water is 1.33. If the step-index fibre-optic waveguide is immersed in water, which of the following statements is true?

A. The critical angle between cladding and waveguide and θ are unchanged.
B. The critical angle between cladding and waveguide increases, θ is unchanged.
C. The critical angle between cladding and waveguide decreases, θ increases.
D. The critical angle between cladding and waveguide is unchanged, θ decreases.

Question 6

If a different material were chosen to use for the core of the step-index fibre-optic waveguide, suggest a refractive index for this material that would result in a critical angle of 70°

A. 1.00
B. 1.45
C. 1.33
D. 1.65

Question 7
Which of the following best describes modal dispersion?

A. Some of the light travelling along the fibre is absorbed by the glass, so energy is lost.
B. Different frequencies of light travel at different speeds along the fibre, which can lead to a pulse spreading out.
C. If the fibre is cracked or damaged, this will affect the signal.
D. Rays travelling down a fibre of significant diameter can travel different distances, which can distort the signal.

Question 8
Which of the following best describes material dispersion?

A. Some of the light travelling along the fibre is absorbed by the glass, so energy is lost.
B. Different frequencies of light travel at different speeds along the fibre, which can lead to a pulse spreading out.
C. If the fibre is cracked or damaged, this will affect the signal.
D. Rays travelling down a fibre of significant diameter can travel different distances, which can distort the signal.

Question 9
Which of the following will reduce modal dispersion and material dispersion, respectively?

A. Use a fibre with a wider diameter; use brighter light
B. Use a fibre with a diameter of the same order of magnitude as the wavelength used; use a monochromatic light source
C. Increase the intensity of the light used; use a monochromatic light source
D. Increase the intensity of the light used; use a fibre with a wider diameter

Question 10
For a receiver at the end of a 4.0 km long fibre optic cable to detect a signal properly, the signal must have a power of at least 5.0 μW. Every kilometre, the signal power decreases by 50%. What is the minimum starting power for the signal to be received?

A. 40 μW
B. 15 μW
C. 30 μW
D. 20 μW

Question 11
Which of the following is an advantage of using a graded-index optical fibre over using a step-index fibre?

A. There are no advantages
B. Reduction in modal dispersion
C. Reduction in material dispersion
D. Reduction in absorption along the length of the fibre

Question 12

Which of the following statements is true?

A. An amplifier can be used to correct for the effects of modal dispersion
B. An amplifier can be used to correct for the effects of material dispersion
C. An amplifier can be used to correct for the effects of attenuation
D. An amplifier can be used to correct for the effects of modal and material dispersion and attenuation

Sound

Take the speed of sound in air to be 340 m s^{-1}.

Question 1

A loudspeaker emits sound with a wavelength of 60 cm. What is the frequency of this sound?

A. 5.67 kHz
B. 204 Hz
C. 20.4 kHz
D. 567 Hz

Question 2

Which of the following statements best describes the movement of a dust particle in front of the speaker?

A. The dust particle oscillates perpendicular to the direction of motion of the sound wave
B. The dust particle is motionless
C. The dust particle oscillates in line with the direction of motion of the sound wave
D. The dust particle is travelling at constant speed away from the speaker

Question 3

Cassandra is standing still on the pavement when an ambulance drives past her with its siren on. Which of the following statements is most accurate?

A. She observes a change in pitch of the siren when the ambulance passes her, due to diffraction effects
B. She observes a change in pitch of the siren when the ambulance passes her, due to the Doppler effect
C. She and the driver both observe a change in pitch of the siren when the ambulance passes Cassandra, due to the Doppler effect
D. No change in pitch is observed

Question 4

As the ambulance approaches Cassandra, it is travelling at 60 km h^{-1}, and she observes the average frequency of the siren as 500 Hz. What average frequency would the driver of the ambulance hear?

A. 500 Hz
B. A frequency lower than 500 Hz
C. A frequency higher than 500 Hz
D. More information is needed

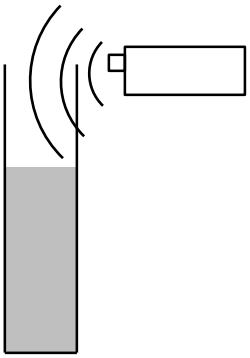
Question 5

The ambulance arrives at its destination, but for a few minutes the siren remains on. During those minutes, Cassandra starts to walk towards the ambulance, stops, and realizes she is late, so turns around and walks away. Which of the following best describes the frequencies she observed once the ambulance had stopped?

A. Slightly higher than 500 Hz, 500 Hz, slightly lower than 500 Hz
B. Slightly lower than 500 Hz, 500 Hz, slightly higher than 500 Hz
C. She heard exactly 500 Hz throughout her movement
D. 600 Hz, 500 Hz, 400 Hz

Use the information below to answer questions 6 to 8:

Sam is pouring water into a PVC pipe (shown in the diagram below). At the mouth of the pipe is placed a machine that produces sound at variable frequencies.



Question 6

When the water is 16 cm from the mouth of the pipe, Sam adjusts the frequency until there is the first noticeable increase in the volume of sound from the pipe setup. What is the frequency of the sound when this occurs?

A. 2.12 kHz
B. 1.06 kHz
C. 708 Hz
D. 531 Hz

Question 7

Sam now sets the frequency at a constant 800 Hz. How far from the mouth of the pipe would you expect the water level to be when there is an increase in volume?

A. 8.00 cm
B. 800 cm
C. 10.6 cm
D. 34 cm

Question 8

Which of the following statements is true?

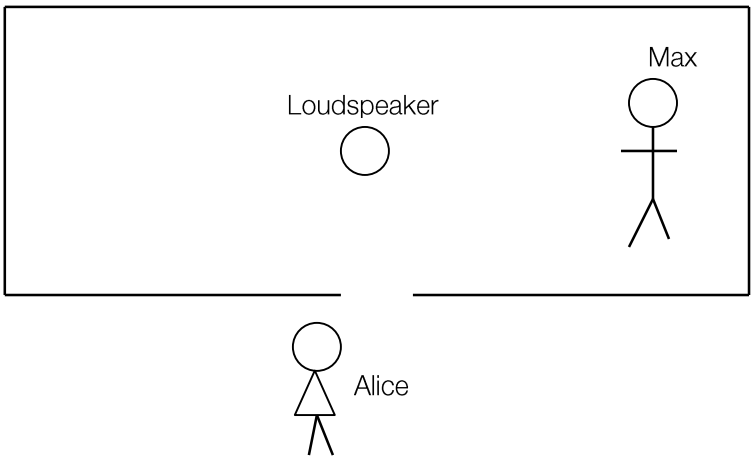
A. At the surface of the water there is a displacement node and a pressure node
B. At the surface of the water there is a displacement node and a pressure antinode
C. At the mouth of the pipe there is a displacement node and a pressure antinode
D. At the mouth of the pipe there is a displacement antinode and a pressure antinode

Question 9

Which of the following statements is true?

A. Sound waves are longitudinal waves. This means the particles oscillate in line with the direction of propagation
B. Sound waves are longitudinal waves. This means the particles oscillate up and down to transmit a wave from left to right
C. Sound waves are different to electromagnetic waves because only energy is transmitted, and there is no net movement of matter
D. The frequency that the particles in a travelling sound wave oscillate with depends on where they are positioned along the wave

Use the information below to answer questions 10 to 12:



Question 10

Max is standing 12 m away from the loudspeaker, which is emitting sound with a wavelength of 80 cm equally in all directions. He hears the sound at 60 dB. What is the intensity of the sound where Max is standing?

A. 10×10^{-6} W m^{-2}
B. 5.0×10^{-6} W m^{-2}
C. 6.0×10^{-6} W m^{-2}
D. 1.0×10^{-6} W m^{-2}

Question 11

Which is the best estimate for the intensity of the sound heard by someone standing 1 m away from the source?

A. 1.20×10^{-4} W m^{-2}
B. 6.94×10^{-4} W m^{-2}
C. 1.44×10^{-4} W m^{-2}
D. 5.80×10^{-4} W m^{-2}

Question 12

Instead of producing sound at a constant frequency, the loudspeaker now begins to play a song. Alice is shown standing just outside the door. Which of the following is true for Alice?

A. She does not hear the sound it produces
B. She hears the song perfectly
C. She hears the song, but distorted: the higher frequencies are louder
D. She hears the song, but distorted: the lower frequencies are louder

Formula sheet

1	velocity; acceleration	$v = \frac{\Delta x}{\Delta t}$; $a = \frac{\Delta v}{\Delta t}$
2	equations for constant acceleration	$v = u + at$ $x = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2ax$ $x = \frac{1}{2}(v + u)t$
3	Newton's second law	$\Sigma F = ma$
4	circular motion	$a = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$
5	Hooke's law	$F = -kx$
6	elastic potential energy	$\frac{1}{2}kx^2$
7	gravitational potential energy near the surface of the Earth	mgh
8	kinetic energy	$\frac{1}{2}mv^2$
9	Newton's law of universal gravitation	$F = G\frac{M_1 M_2}{r^2}$
10	gravitational field	$g = G\frac{M}{r^2}$
11	acceleration due to gravity at Earth's surface	$g = 10$ m s^{-1}
12	voltage; power	$V = RI$; $P = VI = I^2R$
13	resistors in series	$R_T = R_1 + R_2$
14	resistors in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$
15	transformer action	$\frac{V_1}{V_2} = \frac{N_1}{N_2}$
16	AC voltage and current	$V_{RMS} = \frac{1}{2\sqrt{2}}V_{\text{p-p}}$; $I_{RMS} = \frac{1}{2\sqrt{2}}I_{\text{p-p}}$
17	magnetic force	$F = IlB$
18	electromagnetic induction	emf: $\epsilon = -N\frac{\Delta\phi}{\Delta t}$; flux: $\phi = BA$

19	transmission losses	$V_{drop} = I_{line}R_{line}$ $P_{loss} = I_{line}^2 R_{line}$
20	mass of the electron	$m_e = 9.1 \times 10^{-31}$ kg
21	charge on the electron	$e = -1.6 \times 10^{-19}$ C
22	Planck's constant	$h = 6.63 \times 10^{-34}$ J s $h = 4.14 \times 10^{-15}$ eV s
23	speed of light	$c = 3.0 \times 10^{8}$ m s^{-1}
24	photoelectric effect	$E_{K\max} = hf - W$
25	photon energy	$E = hf$
26	photon momentum	$p = \frac{h}{\lambda}$
27	de Broglie wavelength	$\lambda = \frac{h}{p}$
28	speed, frequency and wavelength	$v = f\lambda$
29	energy transformations for electrons in an electron gun (<100 keV)	$\frac{1}{2}mv^2 = eV$
30	radius of electron path	$r = \frac{mv}{eB}$
31	magnetic force on a moving electron	$F = evB$
32	Bragg's law	$b\lambda = 2d \sin\theta$
33	electric field between charged plates	$E = \frac{V}{d}$
34	band gap energy	$E = \frac{hc}{\lambda}$
35	Snell's law	$n_1 \sin\theta_1 = n_2 \sin\theta_2$
36	intensity and level	sound intensity level (in dB) $L = 10 \log_{10}\left(\frac{I}{I_0}\right)$ where $I_0 = 1.0 \times 10^{-12}\ W\ m^{-2}$
37	Lorentz factor	$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}}$
38	time dilation	$t = t_0\gamma$

39	length contraction	$L = \frac{L_0}{\gamma}$
40	relativistic mass	$m = m_0\gamma$
41	total energy	$E_{total} = E_k + E_{rest} = mc^2$
42	stress	$\sigma = \frac{F}{A}$
43	strain	$\epsilon = \frac{\Delta L}{L}$
44	Young's modulus	$E = \frac{\text{stress}}{\text{strain}}$
45	capacitors	time constant: $\tau = RC$
46	universal gravitational constant	$G = 6.67 \times 10^{-11}$ N m^{2}kg^{-2}
47	mass of Earth	$M_E = 5.98 \times 10^{24}$ kg
48	radius of Earth	$R_E = 6.37 \times 10^6$ m
49	mass of the electron	$m_e = 9.1 \times 10^{-31}$ kg
50	charge on the electron	$e = -1.6 \times 10^{-19}$ C
51	speed of light	$c = 3.0 \times 10^8$ m s^{-1}

Prefixes / units

p = pico = 10^{-12}

n = nano = 10^{-9}

μ = micro = 10^{-6}

m = milli = 10^{-3}

k = kilo = 10^3

M = mega = 10^6

G = giga = 10^9

t = tonne = 10^3 kg

End of Booklet

Looking for solutions? Visit www.engageeducation.org.au/practice-exams

To enrol in one of our Physics lectures head to: http://engageeducation.org.au/lectures