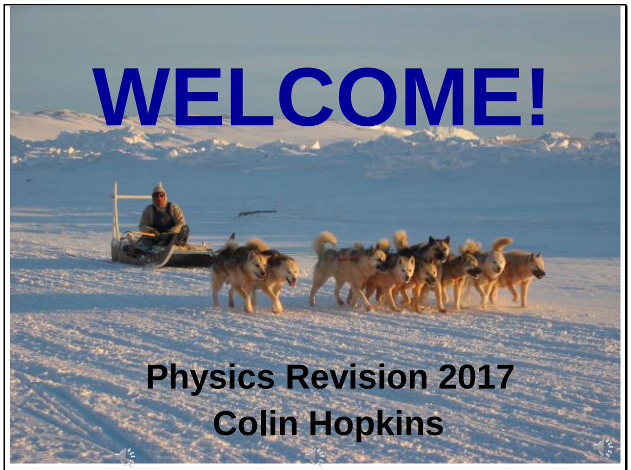



You need to work smarter, not harder.

You need to know what you know, and know what you don't know. Then work on your areas of weakness.

Quality, not quantity, is the secret.

You need to practise the way you intend to perform on the exam.

The examination will consist of two sections.

**Section A** will consist of 20 multiple-choice questions worth 1 mark each and will be worth a total of 20 marks.

**Section B** will consist of short-answer and extended-answer questions, including questions with multiple parts. The number of questions may vary from year to year. Section B will be worth a total of 110 marks.

The examination may include questions that refer to visual and/or written material, including scenarios and/or experiments.

All questions will be compulsory. The total marks for the examination will be 130.

A formula sheet will be provided with the examination.

Answers to Section A are to be recorded on the answer sheet provided for multiple-choice questions.

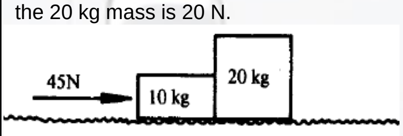
Answers to Section B are to be recorded in the spaces provided in the question and answer book.


**Example 1.6: 2001 Question 1 (2 m, 46%)**
A cyclist pedals up a $15^0$ slope at a constant speed as shown. The total mass of rider and bicycle is 100 kg.

What is the magnitude of the **net** force on the bicycle and rider when travelling up the slope?



Two masses, 10 kg and 20 kg, are placed in contact on a rough surface as shown. A person exerts a force of 45 N on the 10 kg mass. The magnitude of the frictional force acting on the 10 kg mass is 10 N and the magnitude of the frictional force acting on the 20 kg mass is 20 N.




**Example 1.10: 1984 Question 28 (1 m, 90%)**
What is the acceleration of the system of two masses?

**Example 1.11: 1984 Question 29 (1 m, 21%)**
What is the force exerted by the 20 kg mass on the 10 kg mass while they are in motion?



**Connected Bodies**

Consider the vertical direction first $m_1g - T = m_1a$

This leads to: $T = m_1g - m_1a$

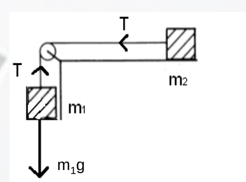
The tension in the string is the same in both directions, therefore

$T = m_2a$.

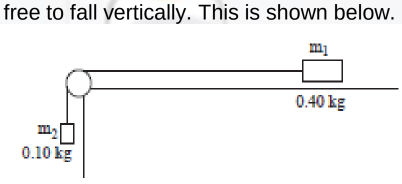
Since both bodies are connected by an inextensible string, both bodies must have the same acceleration.

$$a = \frac{m_1}{m_1 + m_2} g$$

$$T = \frac{m_1 m_2}{m_1 + m_2} g$$



Two physics students are conducting an experiment in which a block, $m_1$, of mass 0.40 kg is being pulled by a string across a frictionless surface. The string is attached over a frictionless pulley to another mass, $m_2$ of 0.10 kg. The second mass, $m_2$, is free to fall vertically. This is shown below.



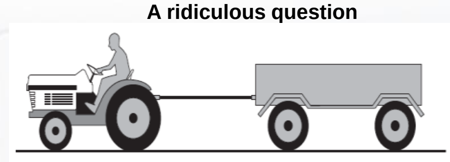

The block is released from rest.

**Example 1.19: (2010 Question 3, 2 marks, 35%)**

What is the acceleration of the block $m_1$?



**A ridiculous question**



A tractor, including the driver, has a mass of 500 kg and is towing a trailer of mass 2000 kg as shown above. The tractor and the trailer are accelerating at 0.50 $ms^{-2}$. Ignore any retarding friction forces. Ignore the mass of the towing rope. The tractor and the trailer start from rest.

**Example 1.20: 2011 Question 2 2 marks, 55%**

What is the tension in the rope connecting the tractor and trailer?

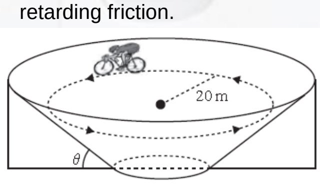


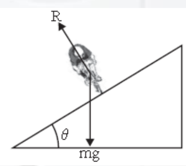
**Another ridiculous question**

A demonstration at a show involves a bike being ridden around a circular banked track.

The horizontal path the bike takes is a circle of radius 20 m, and the bike travels at a constant speed of 15 m/s.

The bike and the rider have a total mass of 300 kg. Ignore retarding friction.



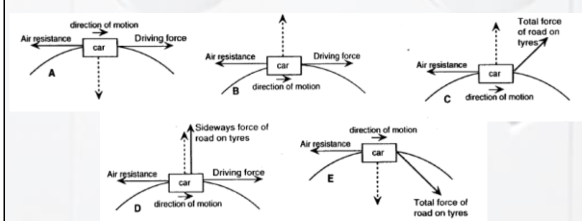

**2011 Question 4 1 mark, 90%**

What is the magnitude of the net force on the bike and rider?

**Example 1.28 1992 Trial 2 marks**

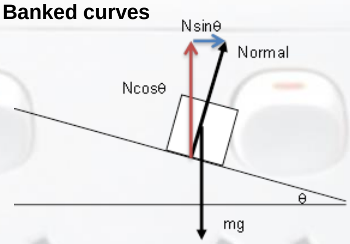
A car is travelling in a horizontal path around a circular curve. The car's speed is constant and it is travelling from left to right in the diagrams below.

Which of the following diagrams best shows the horizontal forces (shown as solid lines) and their resultant force (shown as a dashed line)? Give reasons for your choice.






**Banked curves**




Here $N\cos\theta = mg$ and the unbalanced force is $N\sin\theta$.

$N\sin\theta = \frac{mv^2}{R}$ dividing by $N\cos\theta = mg$ gives

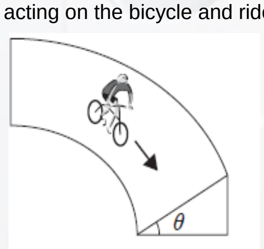
$$\frac{N\sin\theta}{N\cos\theta} = \frac{mv^2}{R} \times \frac{1}{mg} \quad \text{and so } \tan\theta = \frac{v^2}{Rg}$$

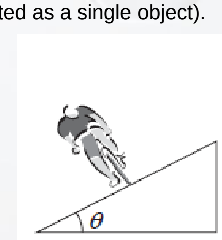


In designing a bicycle track at a racing track, the designer wants to bank the track on a particular corner so that the bicycles will go around the corner with no sideways frictional force required between the tyres and the track at 10 m $s^{-1}$.

**Example 1.30: 2010 Question 5 (2 marks, 45%)**

On the second figure draw two arrows to show the two forces acting on the bicycle and rider (treated as a single object).



You feel your ‘weight’ as the normal reaction of the surface on you, because you can only feel things that act on you. So if the normal reaction increases you ‘feel’ heavier, and if the normal reaction decreases you ‘feel’ lighter.

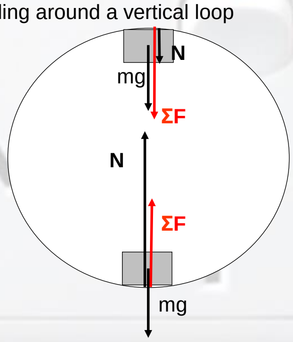
Consider an object travelling around a vertical loop

**At the top**

$$\Sigma F = N + mg = \frac{mv^2}{r}$$

**At the bottom**

$$\Sigma F = N - mg = \frac{mv^2}{r}$$






## Projectile motion

**Horizontal**: velocity always = $v_{horizontal}$

acceleration = 0

displacement $x = v_{horizontal} \times t$

**Vertical**: Velocity changing $v = u - gt$

acceleration $= -g$

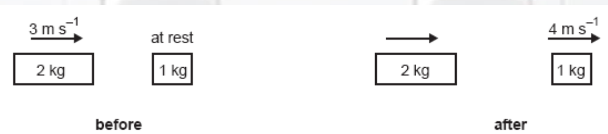
displacement $y = ut - \frac{1}{2} gt^2$

To find the 'total' velocity, add $v_{vertical}$ and $v_{horizontal}$

**Symmetrical flights** Range = $\frac{v^2 \sin 2\theta}{g}$



Meredith and Hilary are studying collisions by sliding blocks together on a frictionless table. Meredith slides a block of mass 2 kg with a speed of 3 m s$^{-1}$ that collides with a block of mass 1 kg, which was at rest. After the collision the 1 kg block has a speed of 4 m s$^{-1}$. The situations before and after are shown below.




**Example 1.62: 2007 Question 3** **2 marks, 62%**

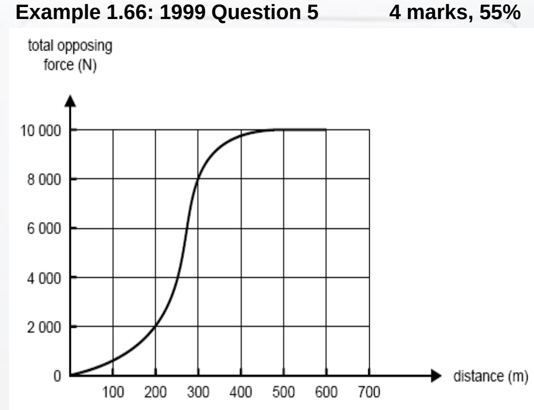
Show that, after the impact, the velocity of the 2 kg block is 1 ms$^{-1}$.

**Example 1.63: 2007 Question 5** **2 marks, 62%**

What average force does the 2 kg block exert on the 1 kg block during the contact time of 0.01 s?



**Example 1.66: 1999 Question 5** **4 marks, 55%**

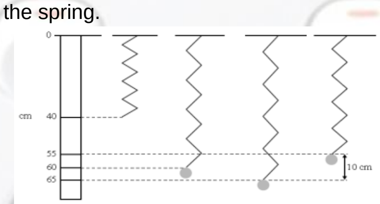





**Momentum – Energy conversion**

A novelty toy consists of a metal ball of mass 0.20 kg hanging from a spring of spring constant k = 10 N m$^{-1}$.

The spring is attached to the ceiling of a room as shown. Ignore the mass of the spring.



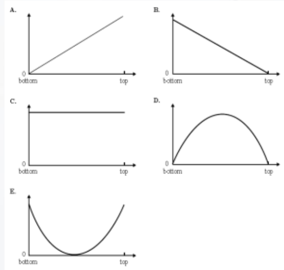

Without the ball attached, the spring has an unstretched length of 40 cm. When the ball is attached, but not oscillating, the spring stretches to 60 cm.

**Example 1.73: 2008 Question 12** **2 marks, 55%**

How much energy is stored in the spring when the ball is hanging stationary on it? You must show your working.

The ball is now pulled down a further 5 cm and released so that it oscillates vertically over a range of approximately 10 cm.

Gravitational potential energy is measured from the level at which the ball is released. Ignore air resistance.




**Example 1.74: 2008 Question 13**

**2 marks, 40%**

Which of the graphs best represents the shape of the graph of **kinetic** energy of the system as a function of height?

**Example 1.75: 2008 Question 14 2 marks, 50%**

Which of the graphs best represents the **gravitational potential** energy of the system as a function of height?



**Einstein's postulates**

**The Principle of Relativity**

All the laws of physics are the same in all inertial frames. (This compares with Newton's assumptions that the laws of <u>mechanics</u> are the same in all inertial frames)

**The Constancy of the Speed of Light**

The speed of light in vacuum is the same ($3 \times 10^8$ m $s^{-1}$) in all inertial frames [i.e. there is no ether and the speed of light is the same regardless of the motion and the source of light].



**Example 1.99: 2010 Question 5 (2 marks)**

Two physics students are conducting accurate experiments to test Newton's second law of motion ($\Sigma F = ma$). Each student is in a windowless railway carriage. One carriage (carriage A) is moving at a constant velocity of 0.9c. The other carriage (carriage B) is moving at 10 m $s^{-1}$ and decelerating.

Which one of the following best describes the likely results of their experiments?

**A.** Only the experiment in carriage A confirms Newton's second law of motion.

**B.** Only the experiment in carriage B confirms Newton's second law of motion.

**C.** Neither experiment confirms Newton's second law of motion.

**D.** Both experiments confirm Newton's second law of motion



**Example 1.100: 2012 Question 1 (2 marks)**

Which of the following factors affects the speed of light?

**A.** the electrical properties of the medium through which light is travelling

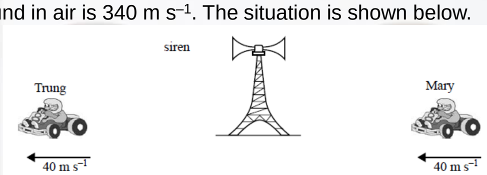
**B.** the speed of the observer of the light

**C.** the speed of the light-emitting source

**D.** none of the above; the speed of light never changes



Trung and Mary are driving along a road at 40 m $s^{-1}$ in the same direction. A stationary siren is situated between them. The speed of sound in air is 340 m $s^{-1}$. The situation is shown below.



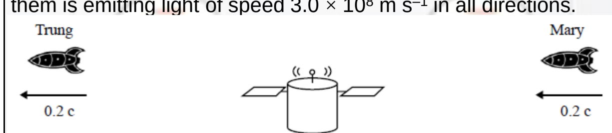

**Example 1.102: 2008 Question 7 (2 marks)**

Which one of the following gives the speed of sound from the siren, in m $s^{-1}$, as measured by Trung and Mary?

| | Trung | Mary |
|---|---|---|
| **A.** | 340 | 340 |
| **B.** | 300 | 380 |
| **C.** | 380 | 300 |
| **D.** | 320 | 320 |



A similar situation now occurs in space, except that Trung and Mary are travelling in two rocket ships in the same direction at 0.2 c. Instead of the siren, a stationary space station between them is emitting light of speed $3.0 \times 10^8$ m $s^{-1}$ in all directions.




**Example 1.103: 2008 Question 8 (2 marks)**

Which one of the following gives the speed of light from the space station as measured by Trung and Mary?

| | Trung | Mary |
|---|---|---|
| **A.** | 1.2 c | 0.8 c |
| **B.** | c | c |
| **C.** | 0.8 c | 1.2 c |
| **D.** | 1.1 c | 1.1 c |

An electron with a Lorentz factor of 4 travels in a straight line a distance of 600 m as measured in the laboratory frame of reference.

**Example 1.122: 2008 Question 11 (2 marks)**

Which one of the following best gives the speed of the electron?

**A.** 0.25 c **B.** 0.94 c
**C.** 0.97 c **D.** 0.99 c

**Example 1.123: 2008 Question 12 (2 marks)**

As measured in the electron's frame of reference, what would be the approximate length of the linear section?

**A.** 2 400 m **B.** 600 m
**C.** 300 m **D.** 150 m



**Example 1.124: 2012 Question 8 (2 marks)**

Which of the following statements about the **proper time** between two events is the most accurate?

**A.** It is always shorter than or equal to another measurement of the time interval between the two events.
**B.** It is always longer than or equal to another measurement of the time interval between the two events.
**C.** It may be greater than, equal to or less than another measurement of the time interval between the two events.
**D.** It can never be measured by an observer who is located at the same position as the two events.



**Example 1.131: 2008 Question 13 (2 marks)**

In the fusion process, a proton of rest mass $1.673 \times 10^{-27}$ kg and a neutron of rest mass $1.675 \times 10^{-27}$ kg combine to form a deuterium nucleus of rest mass $3.344 \times 10^{-27}$ kg, with a release of energy.

According to Einstein's postulate of the equivalence of mass and energy, which one of the following is the best estimate of the energy released in this interaction?

**A.** $1.2 \times 10^{-21}$ J
**B.** $3.6 \times 10^{-13}$ J
**C.** $4.0 \times 10^{-3}$ J
**D.** $3.6 \times 10^{14}$ J



**Example 1.132: 2010 Question 11 (2 marks)**

In a particle accelerator, an alpha particle of mass $6.64424 \times 10^{-27}$ kg is accelerated from rest to high speed. The total work done on the alpha particle is equal to $7.714 \times 10^{-10}$ J. Which one of the following is closest to its final speed?

**A.** 0.90*c*
**B.** 0.95*c*
**C.** 0.85*c*
**D.** 0.80*c*



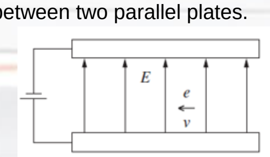
**Fields**

When drawing field lines there are four basic principles.

1. Field lines do not touch or cross each other
2. The arrow shows the direction of the field
3. The further the field lines are apart, the weaker the field.
4. Field lines start and end perpendicular to the surface.



An electron, e, travelling with a velocity, v, passes through an electric field, E, between two parallel plates.

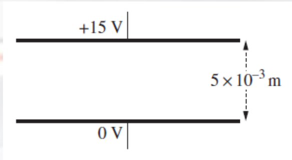



**Example 2.4: NSW 2011 Question 19 (1 mark)**

What is the direction of the force that this electric field exerts on the electron?

**A.** ↑
**B.** ↖
**C.** ↙
**D.** ↓

The diagram shows two parallel charged plates 5 × $10^{-3}$ m apart.




**Example 2.6: NSW 2016 Question 5 (1 mark)**

What is the magnitude of the electric field between the plates in V $m^{-1}$?

A. 3.3 × $10^{-4}$

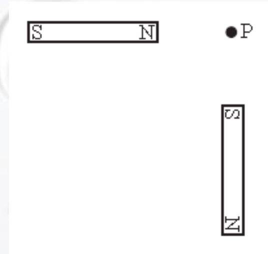
B. 0.33

C. 3

D. 3000



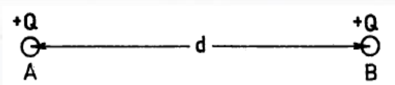
Two identical bar magnets of the same strength are arranged at right angles and are equidistant from point P, as shown below.




**Example 2.9: 2011 Question 1 (1 mark)**

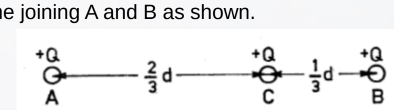
At point P on the diagram, draw an arrow indicating the direction of the combined magnetic field of the bar magnets. (Ignore Earth's magnetic field.)






Two small identical metal spheres A and B carry equal positive charges +Q so that they repel each other with a force of 4 x $10^{-5}$ newton when placed a distance d apart.

A third identical sphere C, also carrying a charge +Q, is placed on the line joining A and B as shown.



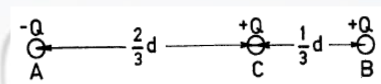

**Example 2.13: 1970 Question 64 (1 mark)**

What is the value of the electrical force on C?

Specify the direction of the force.



The charge on A is now made equal to -Q.




**Example 2.14: 1970 Question 65 (1 mark)**

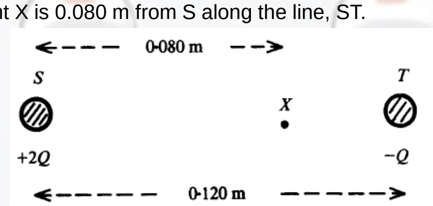
What is the value of the electrical force now on C?

Specify the direction of the force.



Two small, identical, conducting spheres carrying charges of +2Q and -Q respectively are placed at S and T with their centres 0.120 m apart as shown.

The point X is 0.080 m from S along the line, ST.




The potential at X due to the charge +2Q at S is *V* volt.

Answer must be given in terms of *V*.

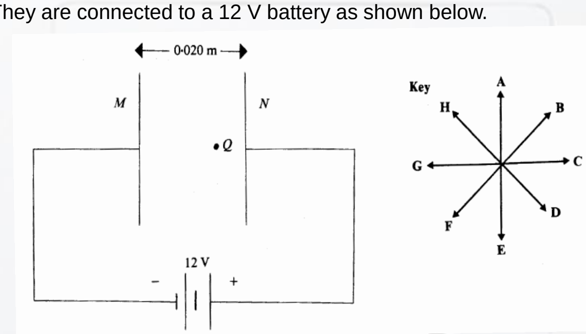
**Example 2.19: 1986 Question 51 (1 mark)**

What is the magnitude of the electric field at X due to the charge +2Q at S?



Two metal plates M and N, are separated by 0.020 m.

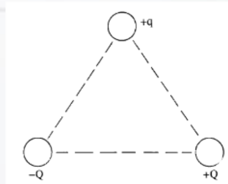
They are connected to a 12 V battery as shown below.




**Example 2.24: 1987 Question 59 (1 mark)**

Which of the directions **(A – H)** shown in the key above best shows the direction of the electric field at the point Q?

Three electric charges, +Q, -Q and +q are placed at the vertices of an equilateral triangle as shown.




**Example 2.29: 1989 Question 52**

Which of the statements **(A - E)** below correctly describes the direction of the total force exerted on the charge, +q?

**A.** Its direction is towards charge +Q.
**B.** Its direction is towards charge -Q.
**C.** Its direction is away from charge +Q.
**D.** Its direction is at right angles to the line joining charges +Q and -Q.
**E.** Its direction is parallel to the line joining charges +Q and -Q.



The equation $Bqv = \frac{mv^2}{r}$

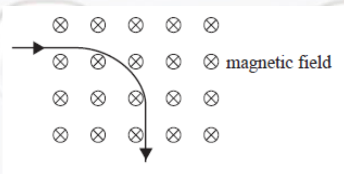
can also be simplified by cancelling v from both sides

$$\therefore Bq = \frac{mv}{r}$$

where mv is the momentum of the electron



An electron with a speed of $4.6 \times 10^7$ m s$^{-1}$ then enters a uniform magnetic field and moves in a circular path. The radius of the path is 0.40 m. This is shown below.



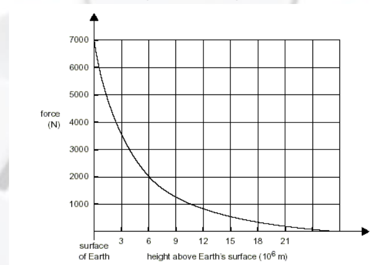

**Example 2.51: 2010 Question 3 (Synchrotron), 2 marks**

What is the magnitude of the magnetic field required to achieve this path?

**A.** $4.2 \times 10^{-3}$ T
**B.** $6.5 \times 10^{-4}$ T
**C.** $1.5 \times 10^{3}$ T
**D.** $3.0 \times 10^{4}$ T



The Mars Odyssey spacecraft was launched from Earth on 7 April 2001 and arrived at Mars on 23 October 2001. The figure below is a graph of the gravitational force acting on the 700 kg Mars Odyssey spacecraft plotted against height above Earth's surface.




**Example 2.58: 2002 Question 1 (3 marks)**

Estimate the minimum launch energy needed for Mars Odyssey to escape Earth's gravitational attraction.



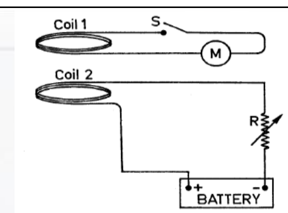
Assume that somewhere in space there is a small spherical planet with a radius of 30 km. By some chance a person living on this planet visits Earth. He finds that he weighs the same on Earth as he did on his home planet, even though Earth is so much larger. Earth has a radius of $6.37 \times 10^6$ m and a mass of $5.98 \times 10^{24}$ kg. The universal gravitational constant, G, is $6.67 \times 10^{-11}$ N m$^2$ kg$^{-2}$.

The acceleration due to gravity (g), or the gravitational field at the surface of Earth, is approximately 10 N kg$^{-1}$.

**Example 2.65: 2011 Question 21 (1 mark, 74%)**

What is the value of the gravitational field on the surface of the visitor's planet?





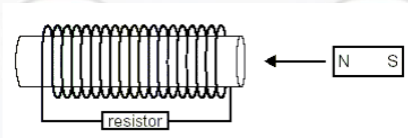

**Example 3.1: 1970 Question 90 (1 mark, 20%)**

Two flat, horizontal coils are mounted as shown. Which one or more of the following actions will cause the sensitive current meter M to register?

**A.** Coil 2 stationary and coil 1 moving upwards with S kept closed.
**B.** Both coils stationary and S switched on and off.
**C.** Coil 1 stationary with S closed and Coil 2 moving to the right.
**D.** With S closed, a variable resistance R is increased and decreased

*(One or more answers)*

Jackie and Jim are studying electromagnetic induction. They have a small permanent magnet and a coil of wire wound around a hollow cylinder.



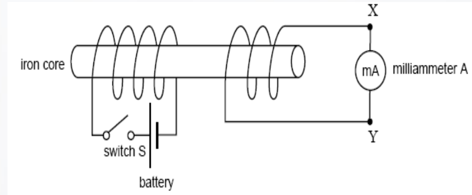

Jackie moves the magnet through the coil in the direction shown at constant speed.

**Example 3.7: 2002 Question 9 2 marks, 24%**

Indicate on the diagram the direction of the induced current that flows in the resistor. Explain the physics reason for your choice.



To study Lenz's law, students set up the following experiment using the circuit shown below. Initially switch S is open.




**Example 3.16: 2007 Question 14 2 marks, 45%**

Which one of the following **(A - D)** will best describe the current through the milli-ammeter A, when the switch S is closed?

**A.** current flows momentarily in the direction X to Y

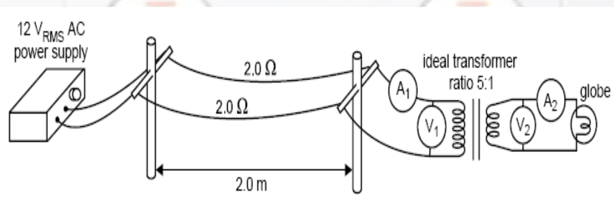
**B.** current flows momentarily in the direction Y to X

**C.** current flows continuously in the direction X to Y

**D.** current flows continuously in the direction Y to X



Assume that the transformer acts as an ideal transformer (no energy losses in transformer) of ratio primary to secondary windings of 5:1. The current through ammeter $A_1$ is 0.50 A.

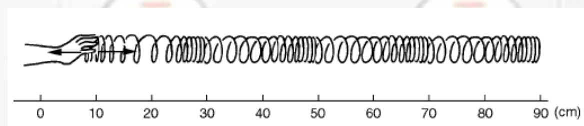



**Example 3.56: 2007 Question 11 (3 marks, 57%)**

What would be the reading on each of the meters $A_2$, $V_1$ and $V_2$?



A teacher uses longitudinal waves on a very long spring to demonstrate travelling sound waves. The first part of the spring is shown below.




**Example 4.17: 1999 Question 1 (1 mark, 85%)**

Estimate the wavelength of this wave.

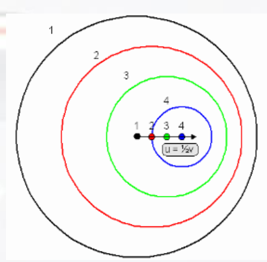
**Example 4.18: 1999 Question 2 (2 marks, 85%)**

What is the speed of this wave if its frequency is 4.0 Hz? Give your answer in **cm/s**.



The Doppler effect is when the source of the sound wave is moving with respect to the observer.

As the source moves away from the observer there is an apparent increase in the wavelength and a decrease in the frequency.

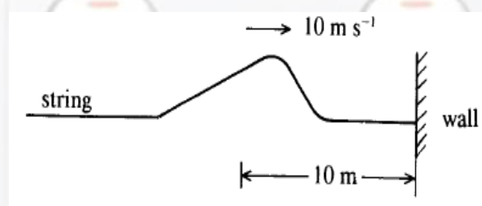



As the source moves towards the observer, there is an apparent shortening of the wavelength and hence an increase in the frequency.

Since the medium the wave is travelling in doesn't change, the speed of the wave remains constant. The wavefronts remain circular but the centre of the circle moves.

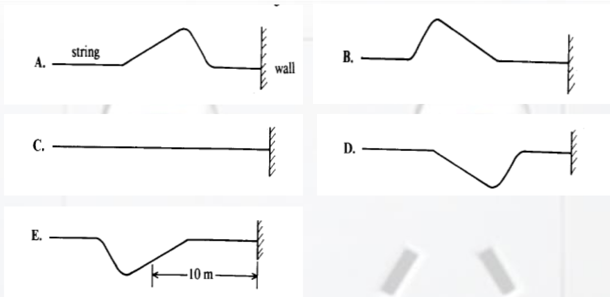


A heavy string is anchored to a wall and a pulse travels along it at a speed of 10 m $s^{-1}$ towards the wall. The figure below shows the string at time t = 0.



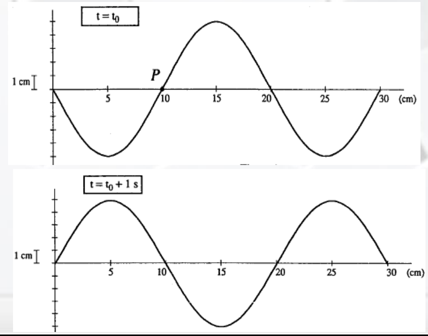

**Example 4.36: 1985 Question 38 (1 mark)**

Which of the diagrams (**A - E**) below best represents the shape of the string at time t = 2 s?






A travelling wave, moving to the right, is set up on a long string. The wave has a wavelength of 20 cm, and an amplitude of 5.0 cm. The first figure below shows a section of the string at a particular time $t_0$, and the second figure shows the same section 1.0 second later.






**Example 4.50: 1991 Question 40 (1 mark)**

Which of the statements (**A - G**) below best describes the motion of the string at point P at time $t_0$?

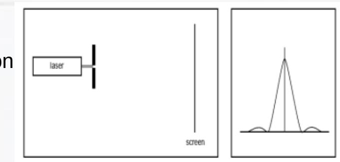
**A.** It is stationary, and will remain so.
**B.** It is stationary, and about to move up.
**C.** It is stationary, and about to move down.
**D.** It is moving upward.
**E.** It is moving downward.
**F.** It is moving to the right.
**G.** It is moving to the left.

**Example 4.51: 1991 Question 41 (1 mark)**

If, instead, the wave shown in the figures was a stationary wave with the same amplitude, wavelength and frequency, which of the statements (**A - G**) above would best describe the motion of the string at point P?

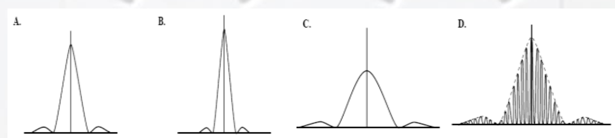


In an experiment, monochromatic laser light of wavelength 600nm shines through a narrow slit, and the intensity of the transmitted light is recorded on the screen some distance away.



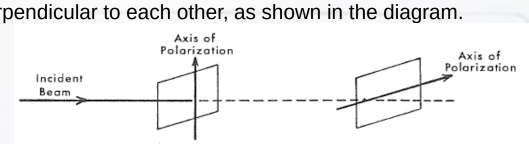

**Example 4.60: 2007 Question 6 (2 marks, 50%)**

Which one of the intensity patterns **(A - D)** below best indicates the pattern that would be seen if a wider slit was used?






The axes of polarization of two perfect polarizers are perpendicular to each other, as shown in the diagram.



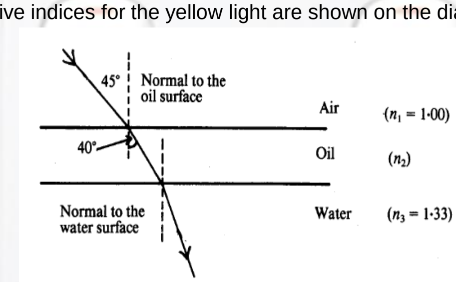

**Example 4.66: 1977 Question 74 (1 mark)**

Which of the following statements correctly describes the effect of the polarizers on the beam?

**A.** The transmitted light will be unpolarized.
**B.** The light transmitted by the first polarizer will be stopped by the second.
**C.** The light transmitted by the first polarizer will also be transmitted by the second.
**D.** Light transmitted through the first polarizer will be de-polarized by the second one.



A ray of monochromatic yellow light passes from air into a layer of oil floating on the water surface as shown in the diagram. The light then emerges from the oil into the water below. The refractive indices for the yellow light are shown on the diagram.




**Example 4.96: 1986 Question 33 (1 mark)**

Calculate the value of $n_2$, the absolute index of refraction for the oil.

**Example 4.97: 1986 Question 34 (1 mark)**

Calculate the value of the ratio: $\frac{\text{speed of the yellow light in water}}{\text{speed of the yellow light in air}}$

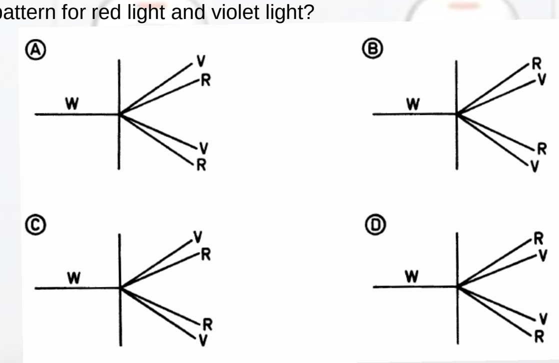
**Example 4.98: 1986 Question 35 (1 mark)**

What is the value of the ratio: $\frac{\text{frequency of the yellow light in water}}{\text{frequency of the yellow light in air}}$



**Example 4.106: 1976 Question 54 (1 mark)**

A beam of white light.is incident upon a single slit. Which diagram the first best shows the directions of the first order diffraction pattern for red light and violet light?

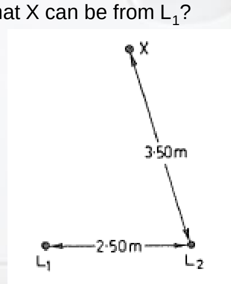




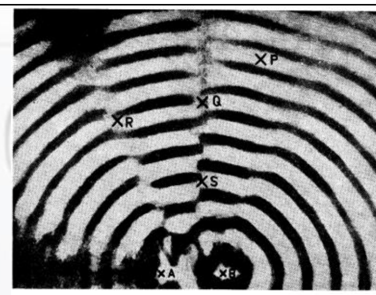

Two small identical loudspeakers, $L_1$ and $L_2$, are placed 2.50 m apart. They both emit sound uniformly in all directions.
The wavelength of the sound is 1.00 m. They are in phase.
Point X, a nodal point, is 3.50 m from $L_2$ and *at least* 3.50 m from $L_1$.

**Example 4.118: 1972 Question 59 (1 mark) 57%**

What is the smallest distance that X can be from $L_1$?






Two point sources, vibrating with the same frequency, produce an interference pattern in a ripple tank.
Answer the following questions in numbers of wavelengths.

**Example 4.124: 1973 Question 52 (1 mark)**

What is the length of QS?



**Example 4.125: 1973 Question 53 (1 mark)**

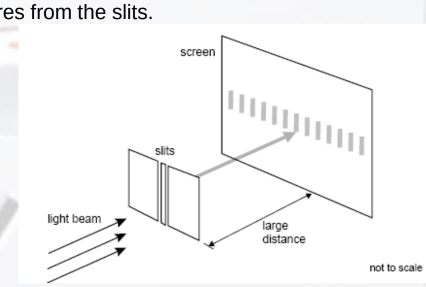
What is the length of (BR - AR)?

**Example 4.126: 1973 Question 54 (1 mark)**

What is the length of (AP - BP)?



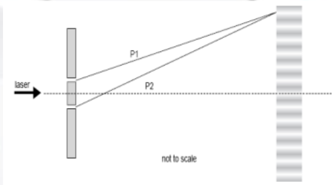
When light of single wavelength passes through two close, narrow slits a pattern of light and dark bands is observed on a screen that is about 2 metres from the slits.




**Example 4.138: 1997 Question 4 (3 marks, 40%)**

Explain, giving reasons, whether the particle model or the wave model for light best explains the observations of this experiment.

Jac and Jules are observing a demonstration of Young's double slit experiment. Their teacher, Mel, has set up a He-Ne laser of wavelength 632 nm and directed the beam onto a set of two parallel slits. A pattern from these slits has been projected onto a distant wall.



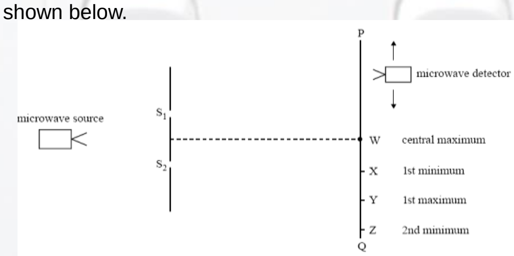

The teacher asks each student to estimate the difference between the length of the lines P1 and P2, which are the lines between the centre of each slit and the 6th bright spot.

**Example 4.138: 2004 Pilot Question 10 (3 marks, 65%)**

Estimate the difference in length between P1 and P2.



A group of students is studying Young's double slit experiment using microwaves (λ = 3.0 cm) instead of light. A microwave detector is moved along the line PQ, and the maxima and minima in microwave intensity are recorded. The experimental apparatus is shown below.




**Example 4.141: 2008 Question 3 (2 marks, 45%)**

What is the path difference $S_1Z - S_2Z$ in cm?



**Example 4.142: 2008 Question 4 ( 2 marks, 50%)**

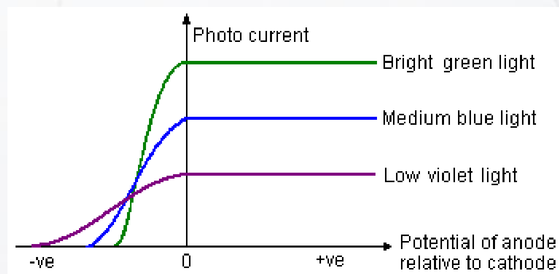
Explain why there is a maximum in microwave intensity detected at point Y.

The students reduce the separation of the slits $S_1$ and $S_2$.

**Example 4.143: 2008 Question 5 (2 marks, 65%)**

Explain the effect of this change on the pattern of maxima and minima along the line PQ.

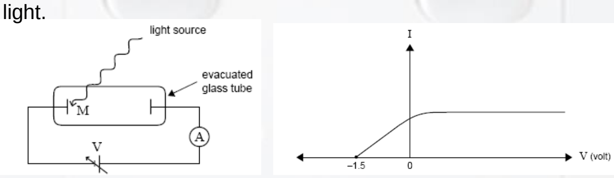







An experiment is carried out to investigate the photoelectric effect. Light of a single frequency shines onto a clean metal plate M inside an evacuated glass tube.

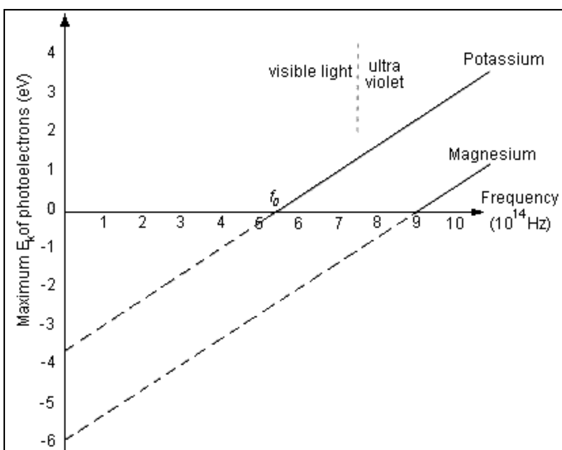
When the voltage V between the plates is varied, the current measured by the ammeter varies as shown below. V is the voltage of the right-hand plate relative to the plate receiving light.




**Example 5.4: 1997 Question 2 (1 mark, 42%)**

What is the maximum kinetic energy of electrons ejected from the plate M? Give your answer in joule.





**Example 5.39: 1998 Question 8 (3 marks, 39%)**
Calculate the de Broglie wavelength of electrons with a speed of $1.0 \times 10^7$ m s$^{-1}$.

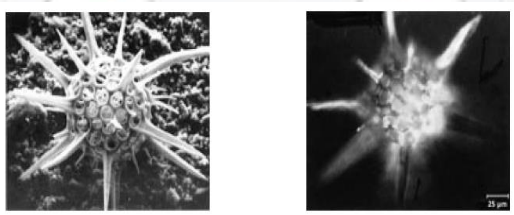
($m_e = 9.1 \times 10^{-31}$ kg, $h = 6.63 \times 10^{-34}$ J s)



**Example 5.40: 2001 Question 2 (3 marks, 45%)**
Calculate the de Bröglie wavelength of an electron after being accelerated across 10 kV.



The two images below show a radiolarian, a unicellular organism, taken with an electron microscope and an optical microscope. The electron microscope gives a clearer image than the optical microscope.

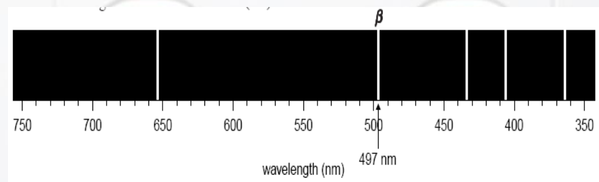



radiolarian, electron microscope    radiolarian, optical microscope

**Example 5.42: 2001 Question 3 (3 marks, 17%)**
Explain why the electron microscope gives a clearer image than the optical microscope.



The figure below is part of the emission spectrum for hydrogen taken from sunlight. Each emission line is displayed with the wavelength in units of nanometres (nm).

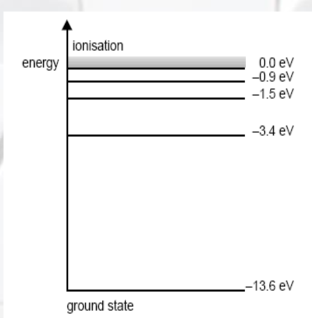



**Example 564: 2001 Question 6 (2 marks, 60%)**
Calculate the energy of the photon, in eV, that is indicated by the spectral line marked $\beta$ in the figure.



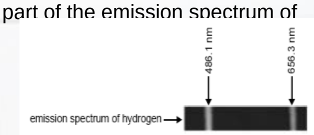
**Example 5.65: 2001 Question 7 (2 marks, 40%)**

On the energy level diagram for hydrogen below, indicate with an arrow (↓) the energy level transition for the spectral line marked $\beta$ above.

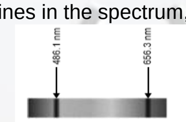





The figure below shows part of the emission spectrum of hydrogen in more detail.



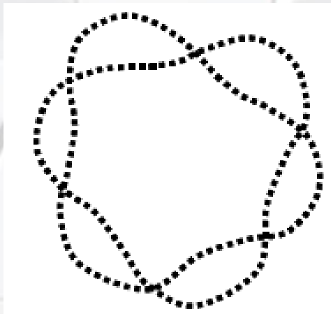

With a spectroscope, Val examines the spectrum of light from the sun. The spectrum is continuous, with colours ranging from red to violet. However there were black lines in the spectrum, as shown below.



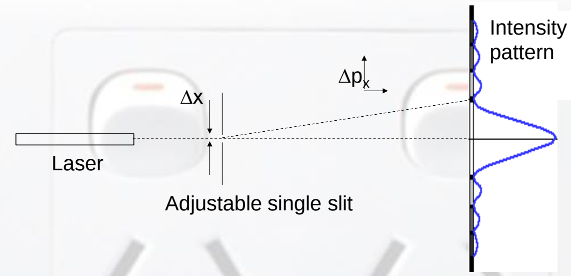

**Example 5.67: 2007 Question 9 (3 marks, 51%)**
Explain why these dark lines are present in the spectrum from the sun.

**Example 5.72: 2004 Sample Question 11 (2 marks)**

The pattern below is meant to represent the 'standing wave-state' of an electron in a hydrogen atom. Which value of 'n' would best describe this pattern?



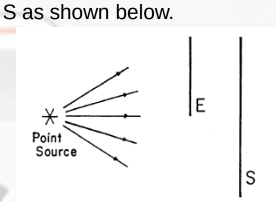





$$\Delta x \times \Delta p_x \geq \frac{h}{4\pi}$$



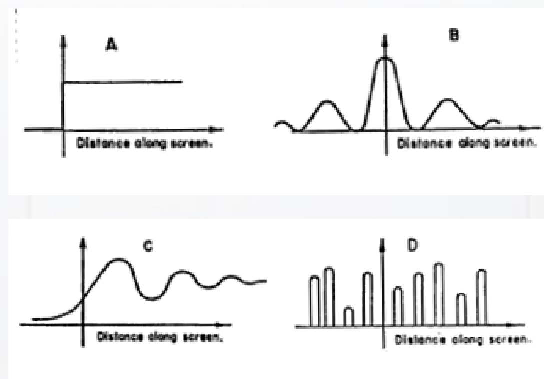
Light from an *Intense* point source is directed at a straight edge E and the variation of light intensity is recorded photographically on the screen S as shown below.




**Example 5.78: 1969 Question 107 (1 mark)**

A photon counting device (e.g. a photo-cell) traverses the screen extremely slowly, recording the photons striking a small area. Which of the following graphs best represents the number of photons detected per unit time as a function of position along the screen?








**Example 5.79: 1969 Question 108 (1 mark)**

If the photon counting device is held in a fixed position it would be found that:

**A.** the time between successive photon arrivals would be constant.

**B.** the time taken to count the first five photons would be the same as that taken to count the second five photons and so on.

**C.** the photons arrive at random times.



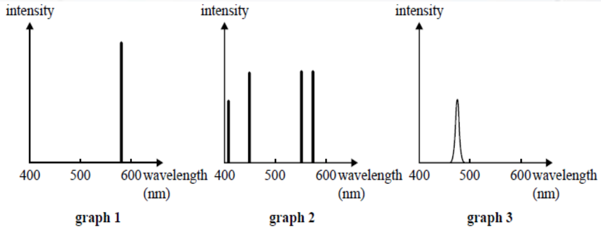
**Example 5.80: 1969 Question 109 (1 mark)**

The light intensity is now reduced so that there is usually only one photon between the source and the screen at a particular time. A photographic plate, placed on the screen, is exposed *for a long time.* Which of the above graphs best represents the light intensity distribution recorded by the photograph?

**Example 5.81: 1969 Question 110 (1 mark)**

Instead of photons, an intense narrow beam of electrons is directed at a straight edge as shown above. Which of the above graphs best represents the electron intensity on the screen, plotted against distance along the screen?

The spectra in the visible region produced by three light sources are shown in graphs 1, 2 and 3 below.




The light sources are a laser, a LED and a mercury vapour lamp (not in this order).

**Example 5.88: 2008 Question 1 (Photonics) (2 marks)**

Which one of the following boxes correctly matches each graph with its source?



**Example 5.88: 2008 Question 1 (Photonics) (2 marks)**

Which one of the following boxes correctly matches each graph with its source?

| | LED | laser | mercury vapour lamp |
|---|---|---|---|
| **A.** | graph 1 | graph 3 | graph 2 |
| **B.** | graph 2 | graph 1 | graph 3 |
| **C.** | graph 3 | graph 2 | graph 1 |
| **D.** | graph 3 | graph 1 | graph 2 |



**Definitions**

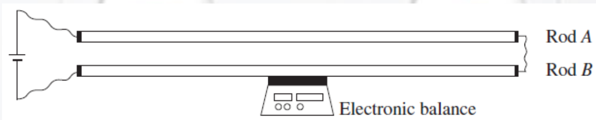
**Independent, dependent and controlled variables**

The independent variable is the variable that the experimenter changes, to find out what changes occur to the dependent variable.

Controlled variables are unchanged throughout the experiment.



A student performed an experiment using two identical metal rods connected to a power supply.
Rod *A* was placed at different distances from Rod *B*, and the measurements on the electronic balance were recorded.




**Example 6.1: NSW 2011 Question 10 (1 mark)**

Which is the independent variable?

**A** The length of the rods

**B** The current in Rod *A*

**C** The mass recorded on the balance

**D** The distance between the two rods



A student performed an experiment using two identical metal rods connected to a power supply.
Rod *A* was placed at different distances from Rod *B*, and the measurements on the electronic balance were recorded.



**Definitions**

**Precision, accuracy, reliability and validity of data;**

Precision is the closeness of the data to itself. Accuracy is the closeness to the true value.
Reliability is a measure of close repeated experiments give the same result. Validity refers to how well a test measures what it is purported to measure.

**Uncertainty and error**

Uncertainty is the margin of error of a measurement. Error is the difference between a measured value and the true value.

**Hypothesis, model or theory**

A hypothesis is an idea that can be tested experimentally. A model is an evidence based representation of something that cannot be displayed directly. It is often said that a good model predicts things that are previously unknown. A theory is often a set of principles used to explain a set of facts or phenomena, it is based on repeated verification.

**Types of error**

**Random**

Caused by unknown and unpredictable changes in the experiment. Random error can occur in measuring instruments or environmental conditions. The amount of random error limits the precision of the experiment.

**Systematic**

Systematic errors usually come from measuring instruments, for example if there is something wrong with the instrument/data handling, or if the instrument is used incorrectly. The amount of systematic error limits the accuracy of the experiment. Systematic errors can be more difficult to detect than random errors.



**Definitions**

**Uncertainties**

No measurement is exact. When a quantity is measured, the outcome depends on the measuring system, the measurement procedure, the skill of the operator, the environment, and other effects. Even if the quantity were to be measured several times, in the same way and in the same circumstances, a different measured value would in general be obtained each time, assuming the measuring system has sufficient resolution to distinguish between the values.

Measuring devices:

Different measuring devices have different levels of uncertainty. The standard rule is ± ½ the smallest division.



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**Question 6.9**

Four students carried out an experiment using a thermometer to record the temperature of a solution. The students repeated the experiment four times. Their teacher suggested that their results showed evidence of a systematic error. A systematic error

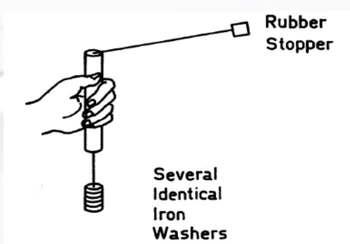
**A.** may have been caused by using an incorrectly calibrated thermometer throughout the experiment.

**B.** will be shown by large variations in the individual temperature readings obtained by the students.

**C.** can be reduced if the students gathered more data by repeating the experiment many more times.

**D.** happens when the students take turns recording the temperature of the solution.






A rubber stopper of mass m is whirled in a horizontal circle of radius r.
An experiment is performed to investigate the relationship between m, r, the speed of the stopper v, and the centripetal force, F, acting on the stopper.



**Example 6.22: 1976 Question 26 (1 mark)**

The centripetal force acting on the stopper can be measured during the experiment by

**A.** finding the mass of the stopper and multiplying by g, the acceleration due to gravity.

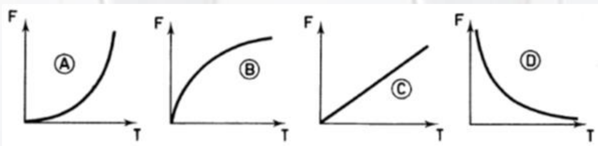
**B.** finding the mass of the stopper and multiplying by $\frac{v^2}{r}$

**C.** multiplying the weight, mg, of the stopper by $\frac{v^2}{r}$

**D.** counting the number of iron washers on the end of the string.

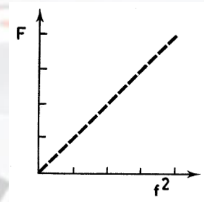
**Example 6.23: 1976 Question 27 (1 mark)**

In one series of measurements, r and m were kept constant, and the relationship between the force F and the period T is investigated. Which of the graphs (**A - D**) below best represents the relationship between F and T?





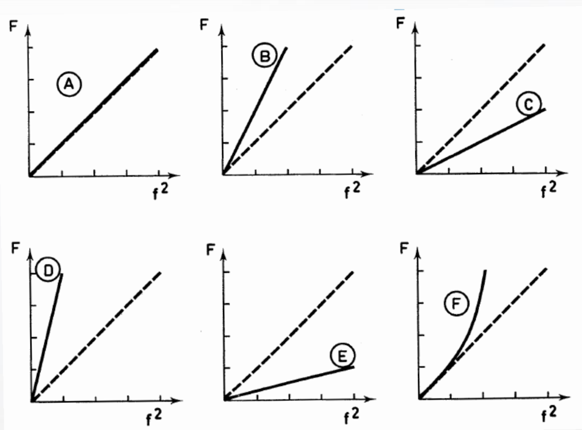

The graph shows the relationship between F and the particular square of the frequency of revolution , f, for values of r and m.




**Example 6.24: 1976 Question 28 (1 mark)**

If the radius were now doubled, what would the new graph of F versus $f^2$ be?








**Example 6.25: 1976 Question 29 (1 mark)**

In another series of measurements, *r* and v are kept constant, and the mass *m* is varied. What is the relationship between *F* and *m*?

**A.** F α m.

**B.** F α $m^2$.

**C.** F α $\frac{1}{m}$

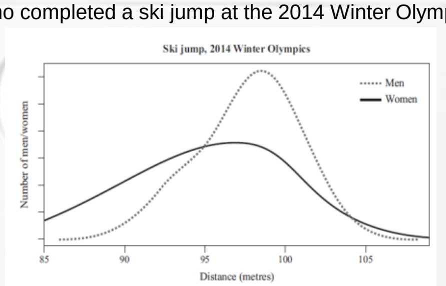
**D.** F α $\frac{1}{m^2}$

**E.** F = mg.

**F.** None of these. F is independent of m.



The graphs below show the distance recorded for men and women who completed a ski jump at the 2014 Winter Olympics.




**Example 6.26: Qld 2015 Question 1 (2 marks)**

Label each statement below as either supported (S) or unsupported (U) by the data in the graphs.

**a.** Men generally reached a higher altitude during the jump.



**Example 6.26: Qld 2015 Question 1 (2 marks)**

Label each statement below as either supported (S) or unsupported (U) by the data in the graphs.

**b.** A larger number of women than men jumped more than 105 m.

**c.** In terms of distance jumped, the mode for women is less than the mode for men.

**d.** The average velocity of the men was higher than the average velocity of the women.

A series of measurements were taken during an experiment to determine the power delivered by an engine. The equation used to determine the power is

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

where, in this case
power (*P*) = ? work (*W*) = 102.5 J time (*t*) = 0.05 s

**Example 6.34: Qld 2015 Question 1 (1 mark)**

How many significant figures should be present in the answer?

**A** 1
**B** 2
**C** 3
**D** 4



**Example 6.38: Qld 2014 Question 2 (2 marks)**

Convert the percentage error below into an absolute error.
423.6 ± 2.0% m



- Other resources:

http://engageeducation.org.au/
(trial papers with solutions)

www.tsfx.com.au
(trial papers with solutions)

www.vicphysics.org
(Excellent information, VCAA exam solutions back to 1999)

www.vcaa.vic.edu.au
(Exam papers and examiners reports back to 2002)