Unit 4 Physics Past Paper Questions

Mechanics Questions

Q1. A girl kicks a ball along the ground at a wall 2.0 m away. The ball strikes the wall normally at a velocity of 8.0 m s^{-1} and rebounds in the opposite direction with an initial velocity of 6.0 m s^{-1}. The girl, who has not moved, stops the ball a short time later.

(a) Explain why the final displacement of the ball is not 4.0 m.

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(1)

(b) Explain why the average velocity of the ball is different from its average speed.

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(2)

(c) The ball has a mass of 0.45 kg and is in contact with the wall for 0.10 s. For the period of time the ball is in contact with the wall,

(i) calculate the average acceleration of the ball.

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(ii) calculate the average force acting on the ball.

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(iii) state the direction of the average force acting on the ball.

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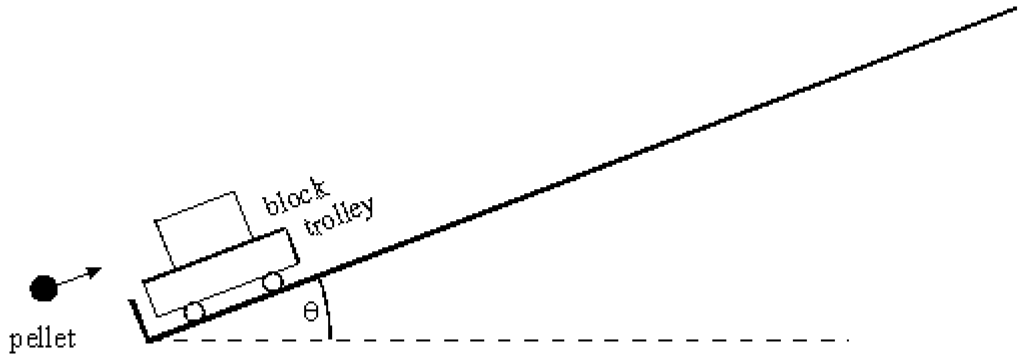
(5)
(Total 8 marks)

Q2. The diagram represents part of an experiment that is being used to estimate the speed of an air gun pellet.



The pellet which is moving parallel to the track, strikes the block, embedding itself. The trolley and the block then move along the track, rising a vertical height, *h*.

(a) Using energy considerations explain how the speed of the trolley and block immediately after it has been struck by the pellet, may be determined from measurements of *h.* Assume frictional forces are negligible.

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(3)

(b) The following data is collected from the experiment

mass of trolley and block	0.50 kg
mass of pellet	0.0020 kg
speed of trolley and block immediately after impact	0.40 m s^{-1}

Calculate

(i) the momentum of the trolley and block immediately after impact,

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(ii) the speed of the pellet just before impact.

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(c) (i) State what is meant by an inelastic collision.

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(ii) Use the data from part (b) to show that the collision between the pellet and block is inelastic.

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(4)
(Total 11 marks)

Q3. A golf club undergoes an *inelastic* collision with a golf ball and gives it an initial velocity of 60 m s^{-1}. The ball is in contact with the club for 15 ms and the mass of the ball is
4.5×10^{-2} kg.

(a) Explain what is meant by an inelastic collision.

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.... **(1)**

(b) Calculate

(i) the change in momentum of the ball,

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(ii) the average force the club exerts on the ball.

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(c) (i) State the value of the force exerted by the ball on the club and give its direction.

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(ii) Explain how your answer to part (i) follows from an appropriate law of motion.

You may be awarded marks for the quality of written communication in your answer.

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(Total 9 marks)

Q4. In a football match, a player kicks a stationary football of mass 0.44 kg and gives it a speed of 32 m s^{-1}.

(a) (i) Calculate the change of momentum of the football.

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(ii) The contact time between the football and the footballer's boot was 9.2 m s. Calculate the average force of impact on the football.

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(3)

(b) A video recording showed that the toe of the boot was moving on a circular arc of radius 0.62 m centred on the knee joint when the football was struck. The force of the impact slowed the boot down from a speed of 24 m s^{-1} to a speed of 15 m s^{-1}.

Figure 1

(i) Calculate the deceleration of the boot along the line of the impact force when it struck the football.

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(ii) Calculate the centripetal acceleration of the boot just before impact.

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(iii) Discuss briefly the radial force on the knee joint before impact and during the impact.

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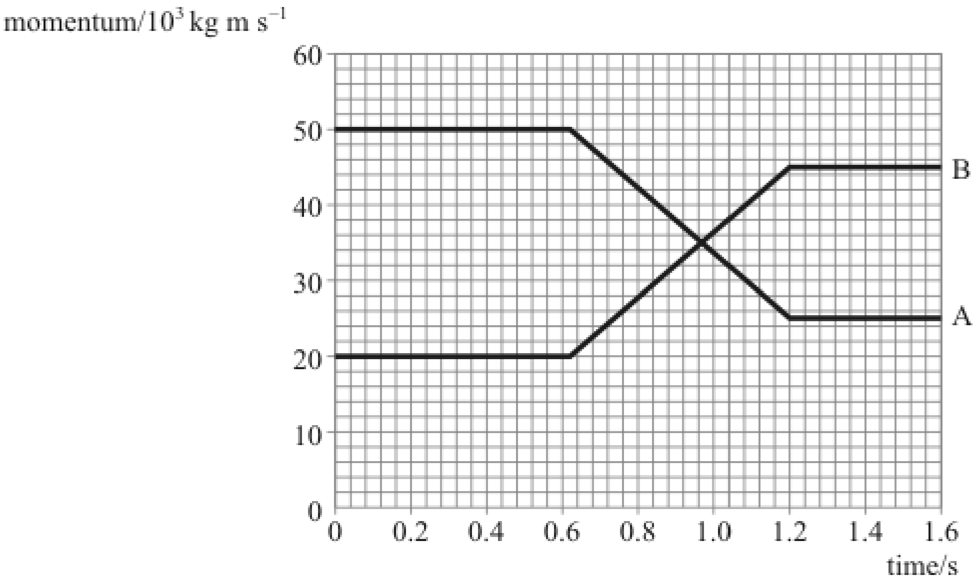
(4)
(Total 7 marks)

Q5. The graph shows how the momentum of two colliding railway trucks varies with time. Truck **A** has a mass of 2.0×10^4 kg and truck **B** has a mass of 3.0×10^4 kg. The trucks are travelling in the same direction.



(a) Calculate the change in momentum of

(i) truck **A**,

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(ii) truck **B.**

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(4)

(b) Complete the following table.

	Initial velocity/m s^{-1}	Final velocity/m s^{-1}	Initial kinetic energy/J	Final kinetic energy/J
truck **A**				
truck **B**				

(4)

(c) State and explain whether the collision of the two trucks is an example of an elastic collision.

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(3)
(Total 11 marks)

Q6. (a) State **two** quantities that are conserved in an elastic collision.

quantity 1: ....

quantity 2: ....

(2)

(b) A gas molecule makes an elastic collision with the walls of a gas cylinder. The molecule is travelling at 450 m s^{-1} at right angles towards the wall before the collision.

(i) What is the magnitude and direction of its velocity after the collision?

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(ii) Calculate the change in momentum of the molecule during the collision if it has a mass of 8.0×10^{-26} kg.

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(4)

(c) Use Newton's laws of motion to explain how the molecules of a gas exert a force on the wall of a container.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

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(4)
(Total 10 marks)

Q7. Communications satellites are usually placed in a *geo-synchronous* orbit.

(a) State two features of a geo-synchronous orbit.

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(2)

(b) The mass of the Earth 6.00×10^{24} kg and its mean radius is 6.40×10^{6} m.

(i) Show that the radius of a geo-synchronous orbit must be 4.23×10^{7} m,

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(ii) Calculate the increase in potential energy of a satellite of 750 kg when it is raised from the Earth's surface into a geo-synchronous orbit.

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(6)

(c) Satellites in orbits nearer the Earth than geo-synchronous satellites may be used in the future to track road vehicles.

(i) State and explain **one** reason why geo-synchronous satellites would not be suitable for such a purpose.

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(ii) Give **two** points you would make in arguing for or against tracking road vehicles.
Explain your answers.

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(4)
(Total 12 marks)

Q8. (a) A spring, which hangs from a fixed support, extends by 40 mm when a mass of 0.25 kg is suspended from it.

(i) Calculate the spring constant of the spring.

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(ii) An additional mass of 0.44 kg is then placed on the spring and the system is set into vertical oscillation. Show that the oscillation frequency is 1.5 Hz.

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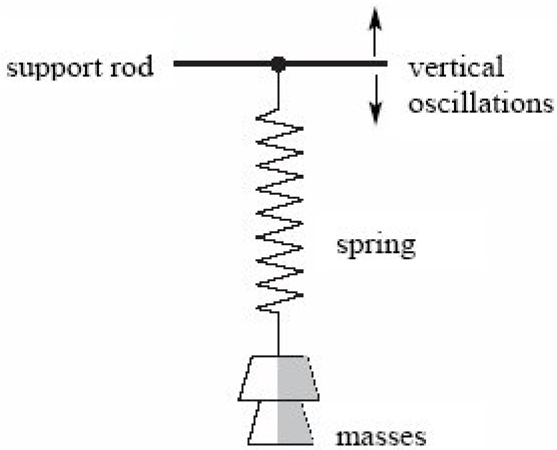
(b) With both masses still in place, the spring is now suspended from a horizontal support rod that can be made to oscillate vertically, as shown in the diagram below, with amplitude 30 mm at several different frequencies.



The response of the masses suspended from the spring to the vertical oscillations of the support rod varies with frequency. Describe and explain, as fully as you can, the motion of the masses when the support rod oscillates at a frequency of (i) 0.2 Hz, (ii) 1.5 Hz and (iii) 10 Hz.

The quality of your written answer will be assessed in this question.

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(6)
(Total 10 marks)

Q9. A golf club undergoes an *inelastic* collision with a stationary golf ball and gives it an initial velocity of 60 m s^{-1}. The ball is in contact with the club for 15 ms and the mass of the ball is
4.5×10^{-2} kg.

(a) Explain what is meant by an inelastic collision.

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(1)

(b) Calculate

(i) the change in momentum of the ball,

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(ii) the average force the club exerts on the ball.

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(4)
(Total 5 marks)

Q10. Near the surface of a planet the gravitational field strength is uniform and for two points, 10 m apart vertically, the gravitational potential difference is 3 J kg^{-1}. How much work must be done in raising a mass of 4 kg vertically through 5 m?

A 3 J

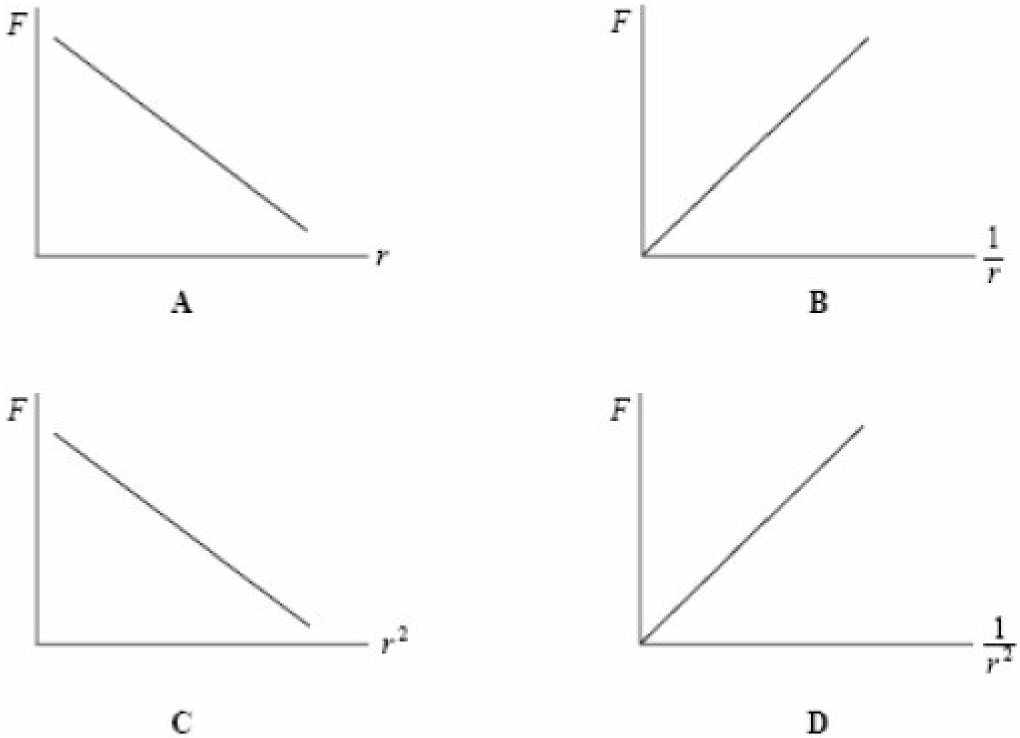
B 6 J

C 12 J

D 15 J

(Total 1 mark)

Q11. Which one of the following graphs correctly shows the relationship between the gravitational force, *F*, between two masses and their separation, *r*?



(Total 1 mark)

Q12. The Earth has density ρ and radius R. The gravitational field strength at the surface is g.
What is the gravitational field strength at the surface of a planet of density 2ρ and radius $2R$?

A g

B $2\,g$

C $4\,g$

D $16\,g$

(Total 1 mark)

Q13. Which one of the following statements is not true for a body vibrating in simple harmonic motion when damping is present?

A The damping force is always in the opposite direction to the velocity.

B The damping force is always in the opposite direction to the displacement.

C The presence of damping gradually reduces the maximum potential energy of the system.

D The presence of damping gradually reduces the maximum kinetic energy of the system.

(Total 1 mark)

Q14. The time period of a simple pendulum is doubled when the length of the pendulum is increased by 3.0 m. What is the original length of the pendulum?

A 1.0 m

B 1.5 m

C 3.0 m

D 6.0 m

(Total 1 mark)

Q15. A body moves with simple harmonic motion of amplitude 0.50 m and period 4π seconds.
What is the speed of the body when the displacement of the body from the equilibrium position is 0.30 m?

A 0.10 m s^{-1}

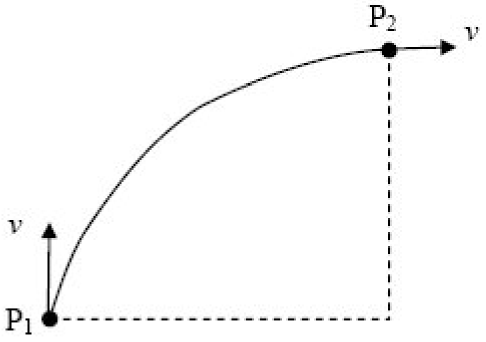
B 0.15 m s^{-1}

C 0.20 m s^{-1}

D 0.40 m s^{-1}

(Total 1 mark)

Q16. A particle of mass m moves horizontally at constant speed v along the arc of a circle from P_1 to P_2 under the action of a force. What is the work done on the particle by the force during this displacement?



A zero

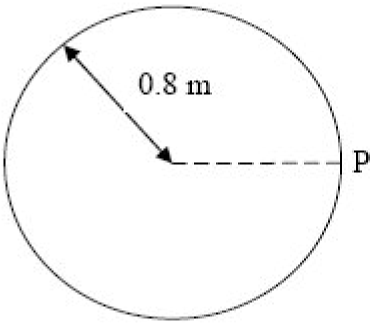
B $\frac{\pi m v^2}{2}$

C $mv^2\sqrt{2}$

D $2\,mv^2$

(Total 1 mark)

Q17.



A model car moves in a circular path of radius 0.8 m at an angular speed of $\frac{\pi}{2}$ rad s^{-1}.
What is its displacement from point P, 6 s after passing P?

A zero

B 1.6 m

C 0.4 πm

D 1.6 πm

(Total 1 mark)

Q18. What is the value of the angular velocity of a point on the surface of the Earth?

A 1.2×10^{-5} rad s^{-1}

B 7.3×10^{-5} rad s^{-1}

C 2.6×10^{-1} rad s^{-1}

D 4.6×10^{2} rad s^{-1}

(Total 1 mark)

Q19. The rate of change of momentum of a body falling freely under gravity is equal to its

A weight.

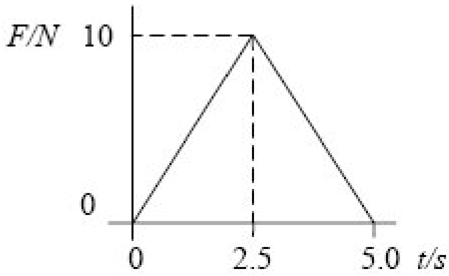
B power.

C kinetic energy.

D potential energy.

(Total 1 mark)

Q20.



A force, *F*, varies with time, *t*, as shown by the graph and is applied to a body initially at rest on a smooth surface. What is the momentum of the body after 5.0 s?

A zero.

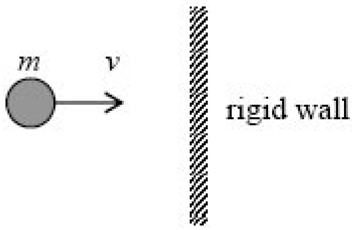
B 12.5 N s.

C 25 N s.

D 50 N s.

(Total 1 mark)

Q21. A particle of mass *m* strikes a rigid wall perpendicularly from the left with velocity *v*.



If the collision is perfectly elastic, the change in momentum of the particle which occurs as a result of the collision is

A 2*mv* to the right.

B 2*mv* to the left.

C *mv* to the left.

D zero.

(Total 1 mark)

Q22. For the two physical quantities, impulse and force, which one of the following is correct?

A Impulse is a scalar and force is a scalar.

B Impulse is a scalar and force is a vector.

C Impulse is a vector and force is a scalar.

D impulse is a vector and force is a vector.

(Total 1 mark)

Q23. Which row, **A** to **D**, in the table correctly shows the quantities conserved in an inelastic collision?

	mass	**momentum**	**kinetic energy**	**total energy**
A	conserved	not conserved	conserved	conserved
B	not conserved	conserved	conserved	not conserved
C	conserved	conserved	conserved	conserved
D	conserved	conserved	not conserved	conserved

(Total 1 mark)

Q24. Water of density 1000 kg m^{-3} flows out of a garden hose of cross-sectional area 7.2 × 10^{-4} m^2 at a rate of 2.0 × 10^{-4} m^3 per second. How much momentum is carried by the water leaving the hose per second?

A 5.6 × 10^{-5} N s

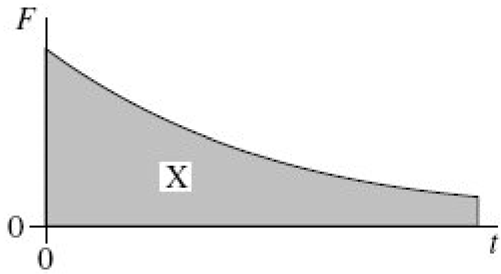
B 5.6×10^{-2} N s

C 0.20 N s

D 0.72 N s

(Total 1 mark)

Q25. The graph shows the variation with time, *t*, of the force, *F*, acting on a body.



What physical quantity does the area X represent?

A the displacement of the body

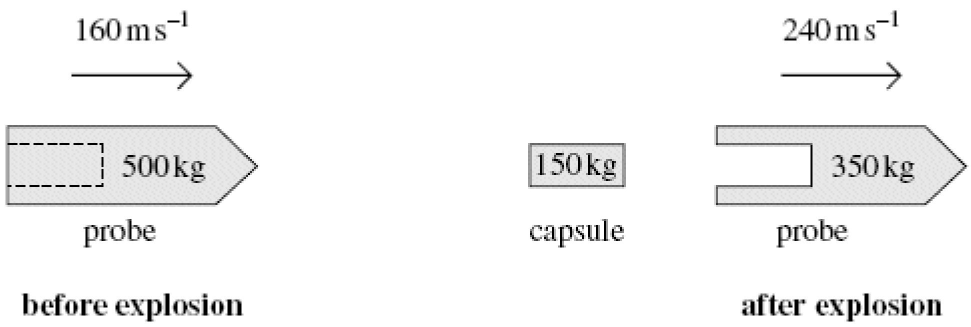
B the acceleration of the body

C the change in momentum of the body

D the change in kinetic energy of the body

(Total 1 mark)

Q26. Deep space probes often carry modules which may be ejected from them by an explosion. A space probe of total mass 500 kg is travelling in a straight line through free space at 160 m s^{-1} when it ejects a capsule of mass 150 kg explosively, releasing energy. Immediately after the explosion the probe, now of mass 350 kg, continues to travel in the original straight line but travels at 240 m s^{-1}, as shown in the figure below.



(a) Discuss how the principles of conservation of momentum and conservation of energy apply in this instance.

The quality of your written communication will be assessed in this question.

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(6)

(b) (i) Calculate the magnitude of the velocity of the capsule immediately after the explosion and state its direction of movement.

magnitude of velocity = ... m s^{-1}

direction of movement ....

(3)

(ii) Determine the total amount of energy given to the probe and capsule by the explosion.

answer = ... J

(4)
(Total 13 marks)

Q27. A projectile moves in a gravitational field. Which one of the following is a correct statement about the gravitational force acting on the projectile?

A The force is in the direction of the field.

B The force is in the opposite direction to that of the field.

C The force is at right angles to the field.

D The force is at an angle between 0° and 90° to the field.

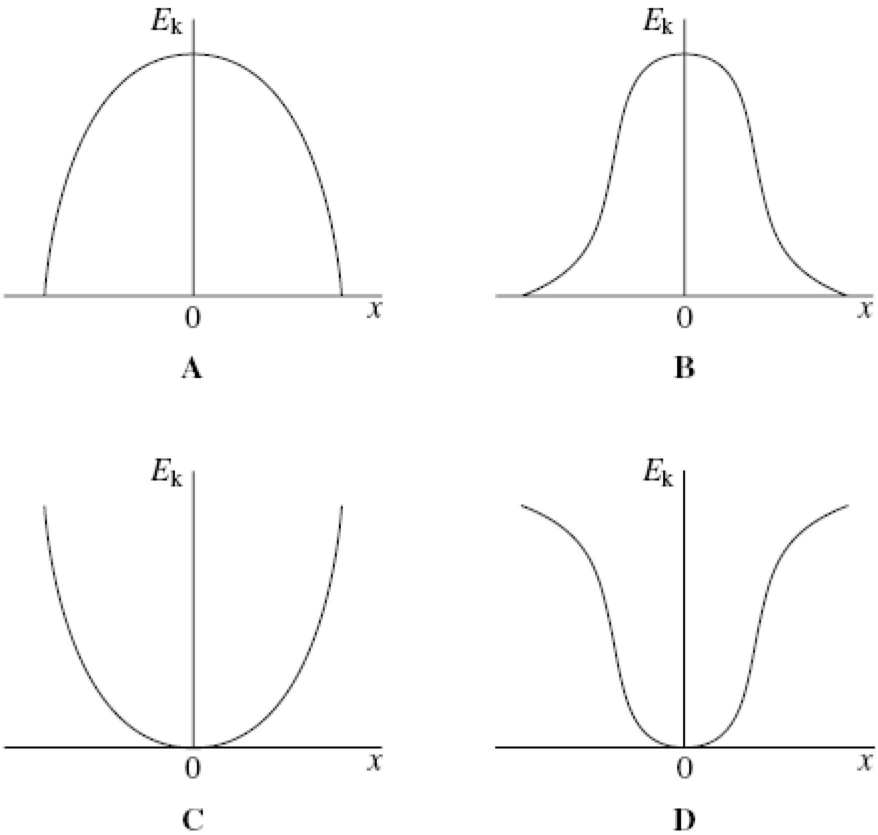
(Total 1 mark)

Q28. The time period of oscillation of a simple pendulum of length *l* is the same as the time period of oscillation of a mass *M* attached to a vertical spring. The length and mass are then changed.
Which row, **A** to **D**, in the table would give a simple pendulum with a time period twice that of the spring oscillations?

	new pendulum length	**new mass on spring**
A	$2l$	$2M$
B	$2l$	$\frac{M}{2}$
C	$\frac{l}{2}$	$2M$
D	$\frac{l}{2}$	$\frac{M}{2}$

(Total 1 mark)

Q29. Which graph, **A** to **D**, shows the variation of the kinetic energy, E_k, with displacement x for a particle performing simple harmonic motion?



(Total 1 mark)

Q30. A body moves with simple harmonic motion of amplitude 0.90 m and period 8.9 s. What is the speed of the body when its displacement is 0.70 m?

A 0.11 m s^{-1}

B 0.22 m s^{-1}

C 0.40 m s^{-1}

D 0.80 m s^{-1}

(Total 1 mark)

Q31. A particle of mass *m* moves in a circle of radius *r* at uniform speed, taking time ***T*** for each revolution. What is the kinetic energy of the particle?

A $\frac{\pi^2 mr}{T^2}$

B $\frac{\pi^2 mr^2}{T^2}$

C $\frac{2\pi^2 mr^2}{T}$

D $\frac{2\pi^2 mr^2}{T^2}$

(Total 1 mark)

Q32. A mass on the end of a string is whirled round in a horizontal circle at increasing speed until the string breaks. The subsequent path taken by the mass is

A a straight line along a radius of the circle.

B a horizontal circle.

C a parabola in a horizontal plane.

D a parabola in a vertical plane.

(Total 1 mark)

Q33. A gas molecule of mass *m* in a container moves with velocity *v*. If it makes an elastic collision at right angles to the walls of the container, what is the change in momentum of the molecule?

A zero

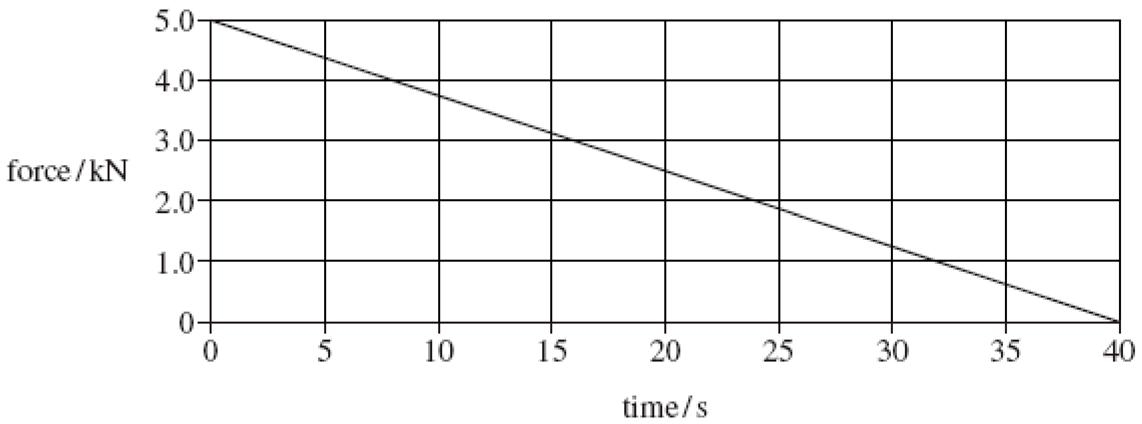
B $\frac{1}{2}$ *mv*

C *mv*

D 2 *mv*

(Total 1 mark)

Q34. The graph shows how the force on a glider of mass 2000 kg changes with time as it is launched from a level track using a catapult.



Assuming the glider starts at rest what is its velocity after 40 s?

A 2.5 m s^{-1}

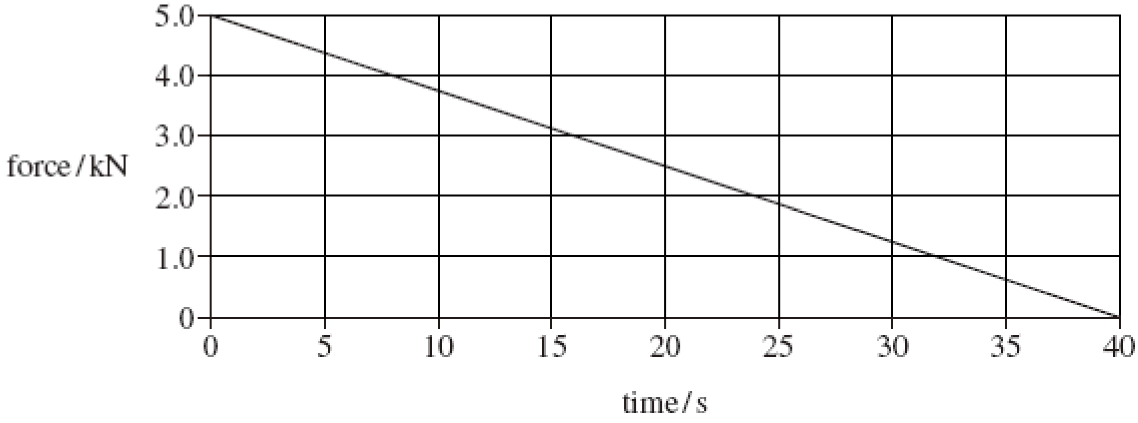
B 10 m s^{-1}

C 50 m s^{-1}

D 100 m s^{-1}

(Total 1 mark)

Q35. The graph shows how the force on a glider of mass 2000 kg changes with time as it is launched from a level track using a catapult.



Assuming the glider starts at rest what is its velocity after 40 s?

A 2.5 m s^{-1}

B 10 m s^{-1}

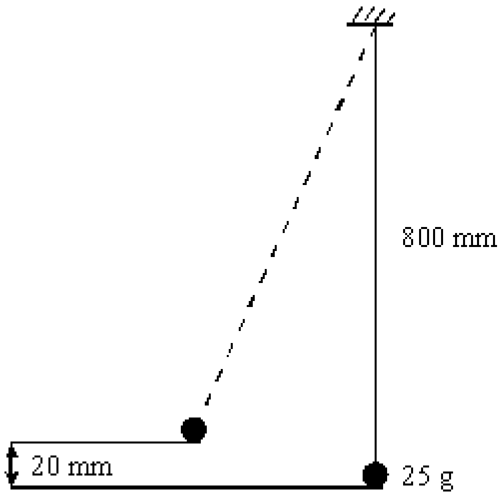
C 50 m s^{-1}

D 100 m s^{-1}

(Total 1 mark)

Oscillations & Waves Questions

Q1. A simple pendulum consists of a 25 g mass tied to the end of a light string 800 mm long. The mass is drawn to one side until it is 20 mm above its rest position, as shown in the diagram. When released it swings with simple harmonic motion.



(a) Calculate the period of the pendulum.

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(b) Show that the initial amplitude of the oscillations is approximately 0.18 m, and that the maximum speed of the mass during the first oscillation is about 0.63 m s^{-1}.

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(c) Calculate the magnitude of the tension in the string when the mass passes through the lowest point of the first swing.

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(2)
(Total 8 marks)

Q2. A particle oscillates with undamped simple harmonic motion. Which one of the following statements about the acceleration of the oscillating particle is true?

A It is least when the speed is greatest.

B It is always in the opposite direction to its velocity.

C It is proportional to the frequency.

D It decreases as the potential energy increases.

(Total 1 mark)

Q3. Which one of the following gives the phase difference between the particle velocity and the particle displacement in simple harmonic motion?

A $\frac{\pi}{4}$ rad

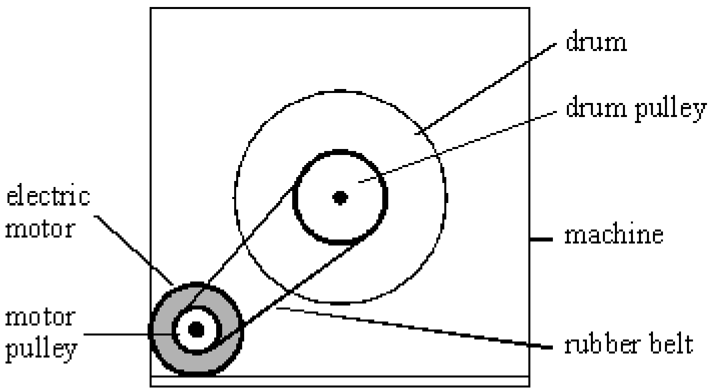
B $\frac{\pi}{2}$ rad

C $\frac{3\pi}{4}$ rad

D 2π rad

(Total 1 mark)

Q4. An electric motor in a machine drives a rotating drum by means of a rubber belt attached to pulleys, one on the motor shaft and one on the drum shaft, as shown in the diagram below.



(a) The pulley on the motor shaft has a diameter of 24 mm. When the motor is turning at 50 revolutions per second, calculate

(i) the speed of the belt,

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(ii) the centripetal acceleration of the belt as it passes round the motor pulley.

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(5)

(b) When the motor rotates at a particular speed, it causes a flexible metal panel in the machine to vibrate loudly. Explain why this happens.

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(2)
(Total 7 marks)

Q5. A wave of frequency 5 Hz travels at 8 km s^{-1} through a medium. What is the phase difference, in radians, between two points 2 km apart?

A 0

B $\frac{\pi}{2}$

C π

D $\frac{3\pi}{2}$

(Total 1 mark)

Q6. When the length of a simple pendulum is decreased by 600 mm, the period of oscillation is halved. What is the original length of the pendulum?

A 800 mm

B 1000 mm

C 1200 mm

D 1400 mm

(Total 1 mark)

Q7. A particle of mass 5.0×10^{-3} kg performing simple harmonic motion of amplitude 150 mm takes 47 s to make 50 oscillations. What is the maximum kinetic energy of the particle?

A 2.0×10^{-3} J

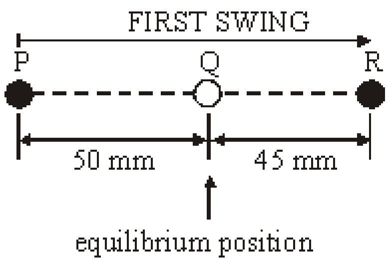
B 2.5×10^{-3} J

C 3.9×10^{-3} J

D 5.0×10^{-3} J

(Total 1 mark)

Q8. A particle, whose equilibrium position is at Q, is set into oscillation by being displaced to P, 50 mm from Q, and then released from rest. Its subsequent motion is simple harmonic, but subject to damping. On the first swing, the particle comes to rest momentarily at R, 45 mm from Q.



During this first swing, the greatest value of the acceleration of the particle is when it is at

A P.

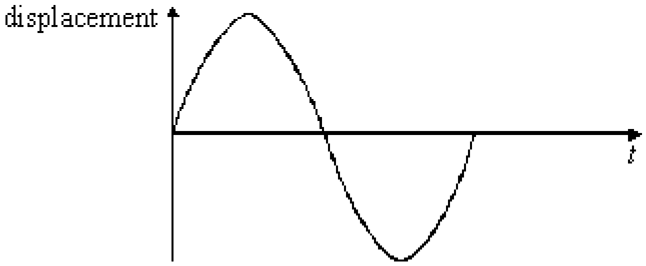
B Q.

C R.

D P and R.

(Total 1 mark)

Q9. The top graph is a displacement/time graph for a particle executing simple harmonic motion. Which one of the other graphs shows correctly how the kinetic energy, E_k, of the particle varies with time?



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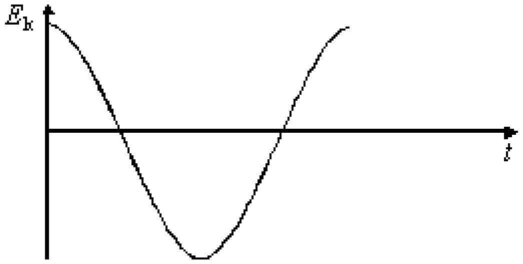

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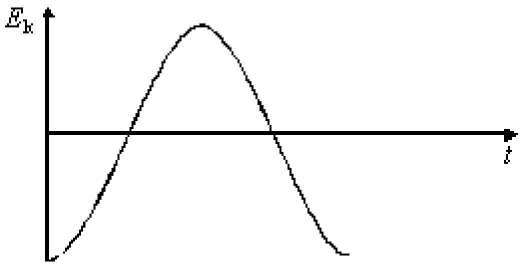

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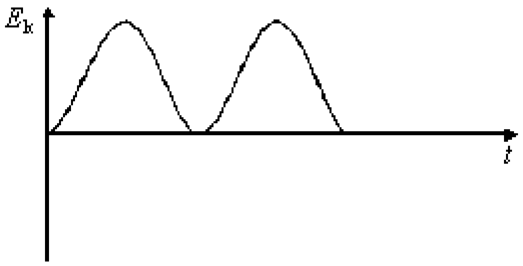

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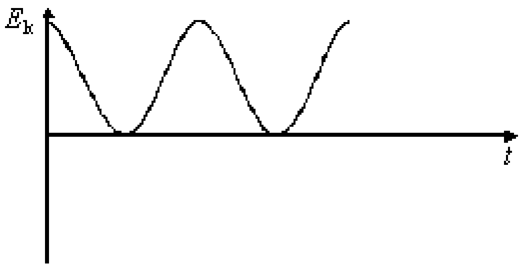


(Total 1 mark)

Q10. To find a value for the acceleration of free fall, *g*, a student measured the time of oscillation, *T*, of a simple pendulum whose length, *l*, is changed. The student used the results to plot a graph of T^2 (*y* axis) against *l* (*x* axis) and found the slope of the line to be *S*. It follows that *g* is

A $\frac{4\pi^2}{S}$.

B $4\pi^2S$.

C $\frac{2\pi}{S}$.

D $2\pi S$.

(Total 1 mark)

Q11. A body moves in simple harmonic motion of amplitude 0.90 m and period 8.9 s. What is the speed of the body when its displacement is 0.70 m?

A 0.11 m s^{-1}

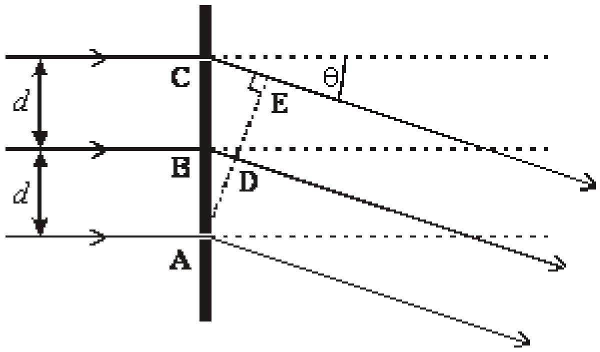
B 0.22 m s^{-1}

C 0.40 m s^{-1}

D 0.80 m s^{-1}

(Total 1 mark)

Q12. The diagram below shows a section of a diffraction grating. Monochromatic light of wavelength λ is incident normally on its surface. Light waves diffracted through angle θ form the **second** order image after passing through a converging lens (not shown). **A**, **B** and **C** are adjacent slits on the grating.



(a) (i) State the phase difference between the waves at **A** and **D**.

....

(ii) State the path length between **C** and **E** in terms of λ.

....

(iii) Use your results to show that, for the second order image, $2\lambda = d \sin \theta$, where d is the distance between adjacent slits.

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(3)

(b) A diffraction grating has 4.5×10^5 lines m^{-1}. It is being used to investigate the line spectrum of hydrogen, which contains a visible blue-green line of wavelength 486 nm. Determine the highest order diffracted image that could be produced for this spectral line by this grating.

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(2)
(Total 5 marks)

Q13. Which one of the following statements about an oscillating mechanical system at resonance, when it oscillates with a constant amplitude, is **not** correct?

A The amplitude of oscillations depends on the amount of damping.

B The frequency of the applied force is the same as the natural frequency of oscillation of the system.

C The total energy of the system is constant.

D The applied force prevents the amplitude from becoming too large.

(Total 1 mark)

Q14. A body is in simple harmonic motion of amplitude 0.50 m and period 4π seconds. What is the speed of the body when the displacement of the body is 0.30 m?

A 0.10 m s^{-1}

B 0.15 m s^{-1}

C 0.20 m s^{-1}

D 0.40 m s^{-1}

(Total 1 mark)

Q15. (a) A body is moving with simple harmonic motion. State **two** conditions that must be satisfied concerning the *acceleration* of the body.

condition 1 ....

....

condition 2 ....

....

(2)

(b) A mass is suspended from a vertical spring and the system is allowed to come to rest.
When the mass is now pulled down a distance of 76 mm and released, the time taken for 25 oscillations is 23 s.

Calculate

(i) the frequency of the oscillations,

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(ii) the maximum acceleration of the mass,

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(iii) the displacement of the mass from its rest position 0.60 s after being released. State the direction of this displacement.

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(6)

(c)

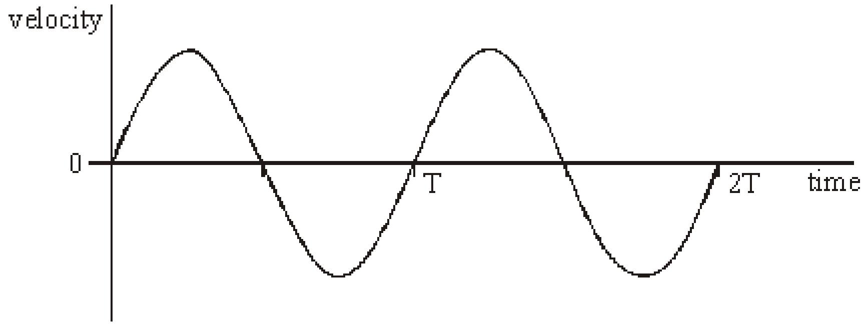


Figure 1

Figure 1 shows qualitatively how the velocity of the mass varies with time over the first two cycles after release.

(i) Using the axes in **Figure 2**, sketch a graph to show qualitatively how the displacement of the mass varies with time during the same time interval.

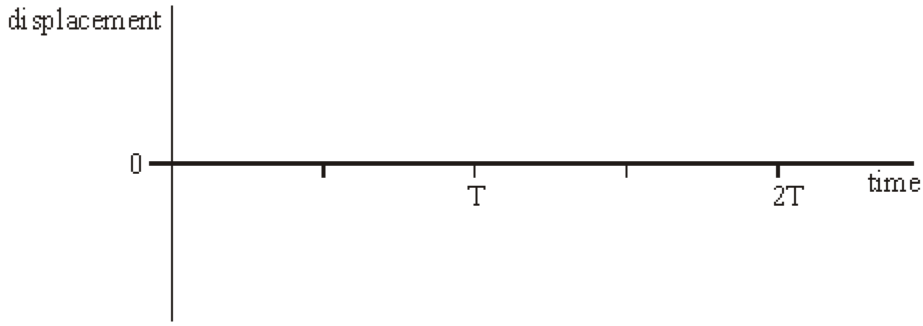


Figure 2

(ii) Using the axes in **Figure 3**, sketch a graph to show qualitatively how the potential energy of the mass-spring system varies with time during the same time interval.

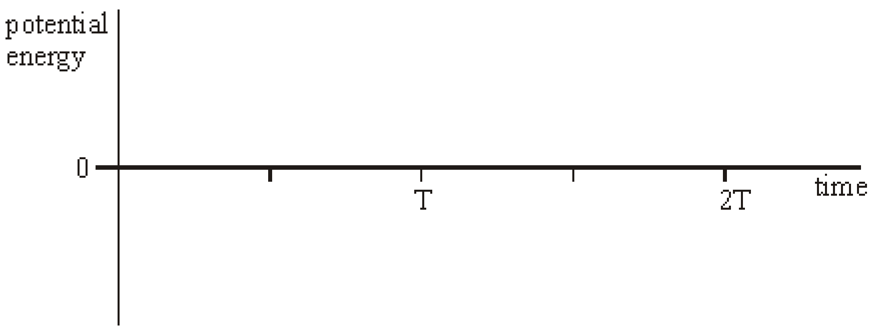


Figure 3

(4)
(Total 12 marks)

Q16. Which one of the following statements always applies to a damping force acting on a vibrating system?

A It is in the same direction as the acceleration.

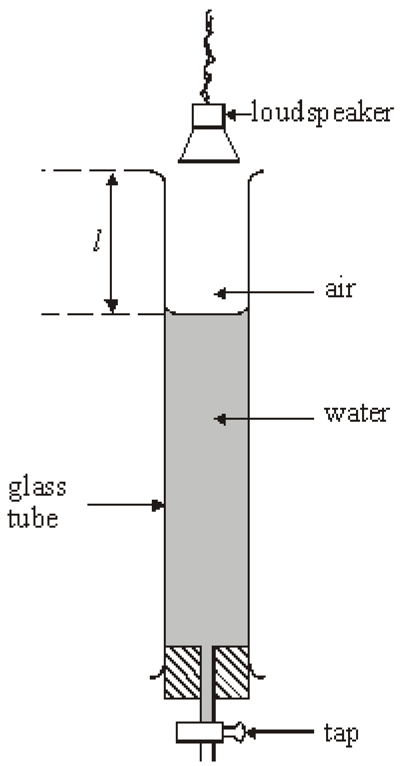
B It is in the opposite direction to the velocity.

C It is in the same direction as the displacement.

D It is proportional to the displacement.

(Total 1 mark)

Q17.



A small loudspeaker emitting sound of constant frequency is positioned a short distance above a long glass tube containing water. When water is allowed to run slowly out of the tube, the intensity of the sound heard increases whenever the length *l* (shown above) takes certain values.

(a) Explain these observations by reference to the physical principles involved.

You may be awarded marks for the quality of written communication in your answer.

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(4)

(b) With the loudspeaker emitting sound of frequency 480 Hz, the effect described in part (a) is noticed first when *l* = 168 mm. It next occurs when *l* = 523 mm.

Use both values of *l* to calculate

(i) the wavelength of the sound waves in the air column,

....

....

(ii) the speed of these sound waves.

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....

(4)
(Total 8 marks)

Q18. The time period of a simple pendulum is doubled when the length of the pendulum is increased by 3.0 m. What is the original length of the pendulum?

A 1.0 m

B 1.5 m

C 3.0 m

D 6.0 m

(Total 1 mark)

Q19. A spring is suspended from a fixed point. A mass attached to the spring is set into vertical undamped simple harmonic motion. When the mass is at its lowest position, which one of the following has its minimum value?

A the potential energy of the system

B the kinetic energy of the mass

C the acceleration of the mass

D the tension in the spring

(Total 1 mark)

Q20. (a) A spring, which hangs from a fixed support, extends by 40 mm when a mass of 0.25 kg is suspended from it.

(i) Calculate the spring constant of the spring.

....

....

(ii) An additional mass of 0.44 kg is then placed on the spring and the system is set into vertical oscillation. Show that the oscillation frequency is 1.5 Hz.

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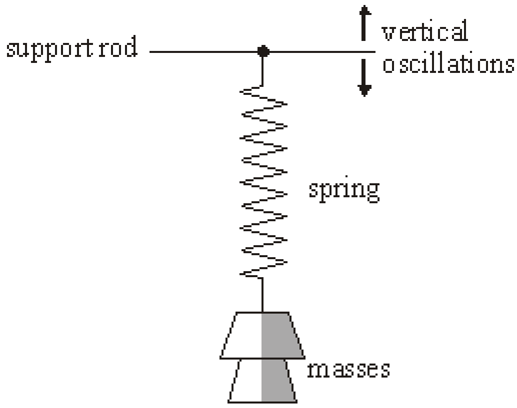
(4)

(b) With both masses still in place, the spring is now suspended from a horizontal support rod that can be made to oscillate vertically, as shown in the figure below, with amplitude 30 mm at several different frequencies.



Describe fully, with reference to amplitude, frequency and phase, the motion of the masses suspended from the spring in each of the following cases.

(i) The support rod oscillates at a frequency of 0.2 Hz.

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(ii) The support rod oscillates at a frequency of 1.5 Hz.

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(iii) The support rod oscillates at a frequency of 10 Hz.

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(6)
(Total 10 marks)

Q21. A body moves with simple harmonic motion of amplitude *A* and frequency $\frac{b}{2\pi}$.
What is the magnitude of the acceleration when the body is at maximum displacement?

A zero

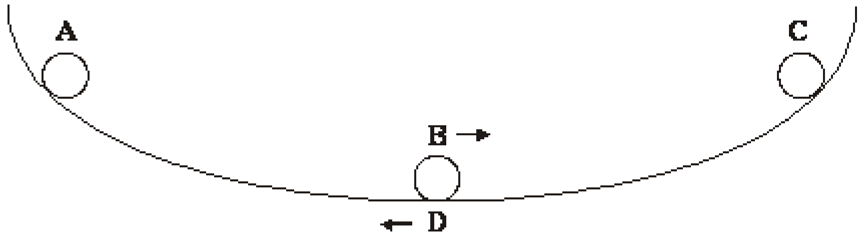
B $4\pi^2 A b^2$

C $A b^2$

D $\frac{4\pi^2 A}{b^2}$

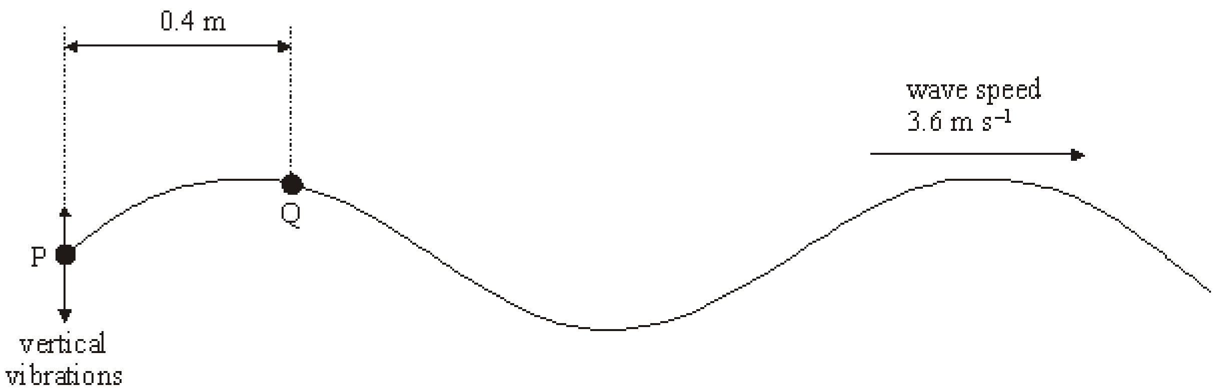
(Total 1 mark)

Q22. A ball bearing rolls on a concave surface, as shown in the diagram, in approximate simple harmonic motion. It is released from **A** and passes through the lowest point **B** before reaching **C**. It then returns through the lowest point **D**. At which stage, **A**, **B**, **C** or **D**, does the ball bearing experience maximum acceleration to the left?



(Total 1 mark)

Q23. Progressive waves are generated on a rope by vibrating vertically the end, P, in simple harmonic motion of amplitude 90 mm, as shown in the figure below. The wavelength of the waves is 1.2 m and they travel along the rope at a speed of 3.6 m s^{-1}. Assume that the wave motion is not damped.



(a) Point Q is 0.4 m along the rope from P. Describe the motion of Q in as much detail as you can and state how it differs from the motion of P. Where possible, give quantitative values in your answer.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

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(5)

(b) Calculate the maximum speed of point P.

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(3)
(Total 8 marks)

Q24. (a) Give an equation for the frequency, *f*, of the oscillations of a simple pendulum in terms of its length, *l*, and the acceleration due to gravity, *g*.

....

....

State the condition under which this equation applies.

....

....

(2)

(b) The bob of a simple pendulum, of mass 1.2×10^{-2} kg, swings with an amplitude of 51 mm. It takes 46.5 s to complete 25 oscillations. Calculate

(i) the length of the pendulum,

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(ii) the magnitude of the restoring force that acts on the bob when at its maximum displacement.

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(6)
(Total 8 marks)

Q25. A particle of mass *m* oscillates with amplitude *A* at frequency *f*. What is the maximum kinetic energy of the particle?

A $\frac{1}{2}\pi^2 mf^2A^2$

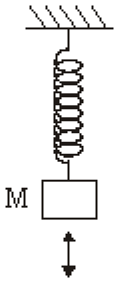
B $\pi^2 mf^2A^2$

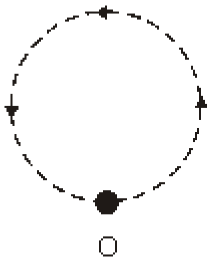
C $2\pi^2 mf^2A^2$

D $4\pi^2 mf^2A^2$

(Total 1 mark)

Q26. A mass M on a spring oscillates along a vertical line with the same period T as an object O in uniform circular motion in a vertical plane. When M is at its highest point, O is at its lowest point.





What is the least time interval between successive instants when the acceleration of M is exactly in the opposite direction to the acceleration of O?

A $\frac{T}{4}$

B $\frac{T}{2}$

C $\frac{3T}{4}$

D T

(Total 1 mark)

Q27. (a) Describe the energy changes that take place as the bob of a simple pendulum makes one complete oscillation, starting at its maximum displacement.

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....

(2)

(b)

Figure 1

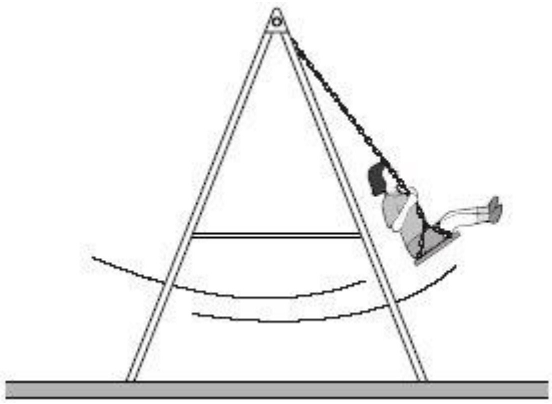


Figure 1 shows a young girl swinging on a garden swing. You may assume that the swing behaves as a simple pendulum. Ignore the mass of chains supporting the seat throughout this question, and assume that the effect of air resistance is negligible.
15 complete oscillations of the swing took 42s.

(i) Calculate the distance from the top of the chains to the centre of mass of the girl and seat. Express your answer to an appropriate number of significant figures.

answer = ... m

(4)

(ii) To set her swinging, the girl and seat were displaced from equilibrium and released from rest. This initial displacement of the girl raised the centre of mass of the girl and seat 250 mm above its lowest position. If the mass of the girl was 18 kg, what was her kinetic energy as she first passed through this lowest point?

answer = ... J

(2)

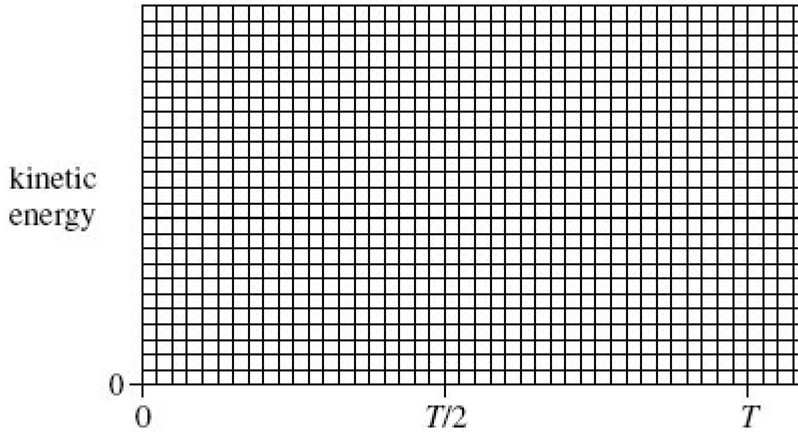
(iii) Calculate the maximum speed of the girl during the first oscillation.

answer = ... m s^{-1}

(1)

(c)

Figure 2



On **Figure 2** draw a graph to show how the kinetic energy of the girl varied with time during the first complete oscillation, starting at the time of her release from maximum displacement. On the horizontal axis of the graph, *T* represents the period of the swing. You do not need to show any values on the vertical axis.

(3)
(Total 12 marks)

Q28. Which one of the following statements concerning forced vibrations and resonance is correct?

A An oscillating body that is not resonating will return to its natural frequency when the forcing vibration is removed.

B At resonance, the displacement of the oscillating body is 180° out of phase with the forcing vibration.

C A pendulum with a dense bob is more heavily damped than one with a less dense bob of the same size.

D Resonance can only occur in mechanical systems.

(Total 1 mark)

Q29. A mass *M* hangs in equilibrium on a spring. *M* is made to oscillate about the equilibrium position by pulling it down 10 cm and releasing it. The time for *M* to travel back to the equilibrium position for the first time is 0.50 s. Which row, **A** to **D**, in the table is correct for these oscillations?

	amplitude / cm	**period / s**
A	10	1.0
B	10	2.0
C	20	2.0
D	20	1.0

(Total 1 mark)

Q30. Which one of the following gives the phase difference between the particle velocity and the particle displacement in simple harmonic motion?

A $\frac{\pi}{4}$ rad

B $\frac{\pi}{2}$ rad

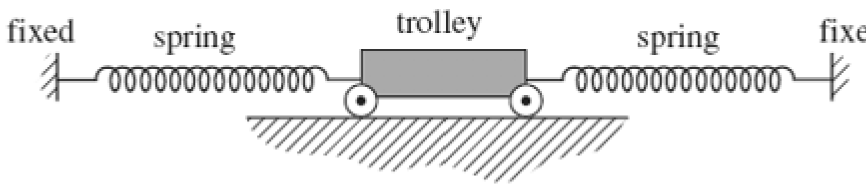
C $\frac{3\pi}{4}$ rad

D 2π rad

(Total 1 mark)

Q31. A trolley of mass 0.80 kg rests on a horizontal surface attached to two identical stretched springs, as shown in **Figure 1**. Each spring has a spring constant of 30Nm^{-1}, can be assumed to obey Hooke's law, and to remain in tension as the trolley moves.

Figure 1



(a) (i) The trolley is displaced to the left by 60 mm and then released. Show that the magnitude of the resultant force on it at the moment of release is 3.6 N.

(2)

(ii) Calculate the acceleration of the trolley at the moment of release and state its direction.

answer = ...m s^{-2}

direction ....

(2)

(b) (i) The oscillating trolley performs simple harmonic motion. State the **two** conditions which have to be satisfied to show that a body performs simple harmonic motion.

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(2)

(ii) The frequency f of oscillation of the trolley is given by

$$f = \frac{1}{2\pi}\sqrt{\frac{2k}{m}}$$

where m = mass of the trolley

k = spring constant of one spring.

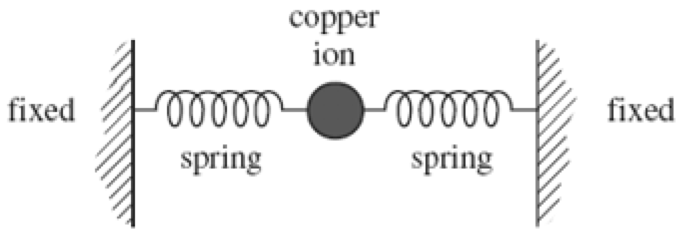
Calculate the period of oscillation of the trolley, stating an appropriate unit.

answer = ...

(3)

(c) Copper ions in a crystal lattice vibrate in a similar way to the trolley, because the inter-atomic forces act in a similar way to the forces exerted by the springs. **Figure 2** shows how this model of a vibrating ion can be represented.

Figure 2



(i) The spring constant of each inter-atomic 'spring' is about 200Nm^{-1}. The mass of the copper ion is 1.0 × 10^{-25} kg. Show that the frequency of vibration of the copper ion is about 10^{13} Hz.

(1)

(ii) If the amplitude of vibration of the copper ion is 10^{-11}m, estimate its maximum speed.

answer = ...m s^{-1}

(1)

(iii) Estimate the maximum kinetic energy of the copper ion.

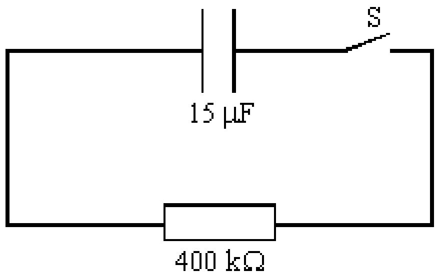
answer = ...J

(1)

(Total 12 marks)

Capacitance Questions

Q1. A capacitor of capacitance 15 μF is fully charged and the potential difference across its plates is 8.0 V. It is then connected into the circuit as shown.



The switch S is closed at time t = 0. Which one of the following statements is correct?

A The time constant of the circuit is 6.0 ms.

B The initial charge on the capacitor is 12 μC.

C After a time equal to twice the time constant, the charge remaining on the capacitor is Q_0e^{2}, where Q_0 is the charge at time t = 0.

D After a time equal to the time constant, the potential difference across the capacitor is 2.9 V.

(Total 1 mark)

Q2. A 10 mF capacitor is charged to 10 V and then discharged completely through a small motor. During this process, the motor lifts a weight of mass 0.10 kg. If 10% of the energy stored in the capacitor is used to lift the weight, through what approximate height will the weight be lifted?

A 0.05 m

B 0.10 m

C 0.50 m

D 1.00 m

(Total 1 mark)

Q3. A capacitor of capacitance 330 μF is charged to a potential difference of 9.0 V. It is then discharged through a resistor of resistance 470 kΩ.

Calculate

(a) the energy stored by the capacitor when it is fully charged,

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....

....

(2)

(b) the time constant of the discharging circuit,

....

....

(1)

(c) the p.d. across the capacitor 60 s after the discharge has begun.

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....

(3)
(Total 6 marks)

Q4. A capacitor of capacitance *C* discharges through a resistor of resistance *R*.

Which one of the following statements is **not** true?

A The time constant will increase if *R* is increased.

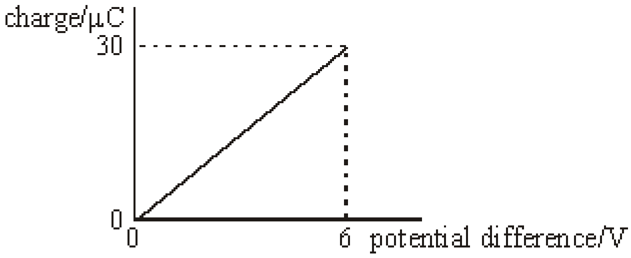
B The time constant will decrease if *C* increased.

C After charging to the same voltage, the initial discharge current will increase if *R* is decreased.

D After charging to the same voltage, the initial discharge current will be unaffected if *C* is increased.

(Total 1 mark)

Q5. The graph shows how the charge stored by a capacitor varies with the potential difference across it as it is charged from a 6 V battery.



Which one of the following statements is **not** correct?

A The capacitance of the capacitor is 5.0 μF.

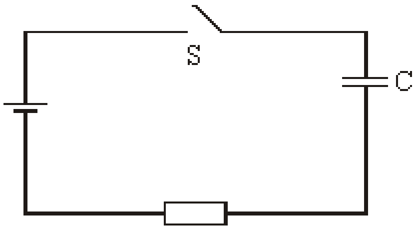
B When the potential difference is 2 V the charge stored is 10 μC.

C When the potential difference is 2 V the energy stored is 10 μJ.

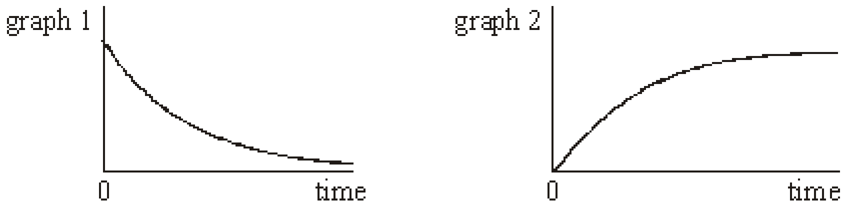
D When the potential difference is 6 V the energy stored is 180 μJ.

(Total 1 mark)

Q6. In the circuit shown, the capacitor C is charged to a potential difference *V* when the switch S is closed.



Which line, **A** to **D**, in the table gives a correct pair of graphs showing how the charge and current change with time after S is closed?



	charge	**current**
A	graph 1	graph 1
B	graph 1	graph 2
C	graph 2	graph 2
D	graph 2	graph 1

(Total 1 mark)

Q7. A 1.0 µF capacitor is charged by means of a **constant** current of 10 µA for 20 s. What is the energy finally stored in the capacitor?

A 4.0×10^{-4} J

B 2.0×10^{-3} J

C 2.0×10^{-2} J

D 4.0×10^{-2} J

(Total 1 mark)

Q8. A 680 μF capacitor is charged fully from a 12 V battery. At time t = 0 the capacitor begins to discharge through a resistor. When t = 25 s the energy remaining in the capacitor is one quarter of the energy it stored at 12 V.

(a) Determine the pd across the capacitor when t = 25s.

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....

(2)

(b) (i) Show that the time constant of the discharge circuit is 36 s.

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....

(ii) Calculate the resistance of the resistor.

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(4)
(Total 6 marks)

Q9. A 400 μF capacitor is charged so that the voltage across its plates rises at a constant

rate from
0 V to 4.0 V in 20 s. What current is being used to charge the capacitor?

A 5 µA

B 20 µA

C 40 µA

D 80 µA

(Total 1 mark)

Q10. In experiments to pass a very high current through a gas, a bank of capacitors of total capacitance 50 µF is charged to 30 kV. If the bank of capacitors could be discharged completely in 5.0 m s what would be the mean power delivered?

A 22 kW

B 110 kW

C 4.5 MW

D 9.0 MW

(Total 1 mark)

Q11. A 1000 µF capacitor, initially uncharged, is charged by a steady current of 50 µA. How long will it take for the potential difference across the capacitor to reach 2.5 V?

A 20 s

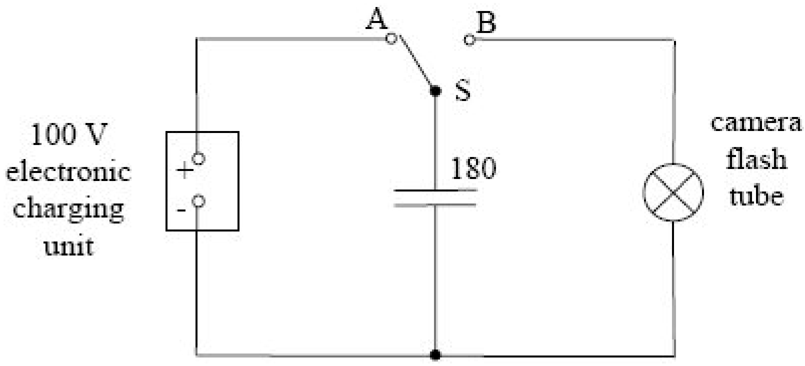
B 50 s

C 100 s

D 400 s

(Total 1 mark)

Q12. The flash tube in a camera produces a flash of light when a 180 μF capacitor is discharged across the tube.



(a) The capacitor is charged to a pd of 100 V from an electronic charging unit in the camera, as shown in the diagram above.
Calculate,

(i) the energy stored in the capacitor,

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(ii) the work done by the battery.

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(2)

(b) When a photograph is taken, switch S in the diagram above is automatically moved from A to B and the capacitor is discharged across the flash tube. The discharge circuit has a resistance of 1.5 Ω. Emission of light from the flash tube ceases when the pd falls below 30 V.

(i) Calculate the duration of the light flash.

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(ii) The capacitor in the circuit in the diagram above is replaced by a capacitor of greater capacitance. Discuss the effect of this change on the photograph image of a moving object.

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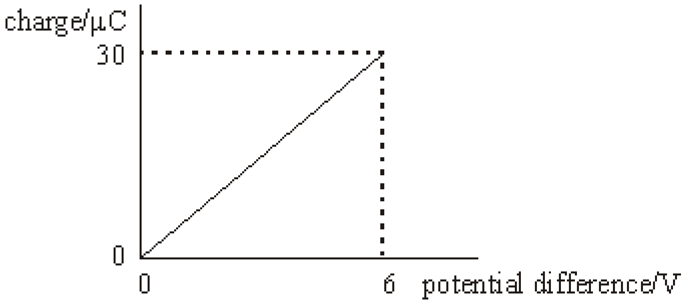
(4)
(Total 6 marks)

Q13. The graph shows how the charge stored by a capacitor varies with the potential difference across it as it is charged from a 6 V battery.



Which one of the following statements is **not** correct?

A The capacitance of the capacitor is 5.0 μF.

B When the potential difference is 2 V the charge stored is 10 μC.

C When the potential difference is 2 V the energy stored is 10 μJ.

D When the potential difference is 6 V the energy stored is 180 μJ.

(Total 1 mark)

Q14. In experiments to pass a very high current through a gas, a bank of capacitors of total capacitance 50 μF is charged to 30 kV. If the bank of capacitors could be discharged completely in 5.0 ms, what would be the mean power delivered?

A 22 kW

B 110 kW

C 4.5 MW

D 9.0 MW

(Total 1 mark)

Q15. A 1000 μF capacitor and a 10 μF capacitor are charged so that the potential difference across each of them is the same. The charge stored in the 100 μF capacitor is Q_1 and the charge

stored in the 10 μF capacitor is Q_2. What is the ratio $\frac{Q_1}{Q_2}$?

A 100

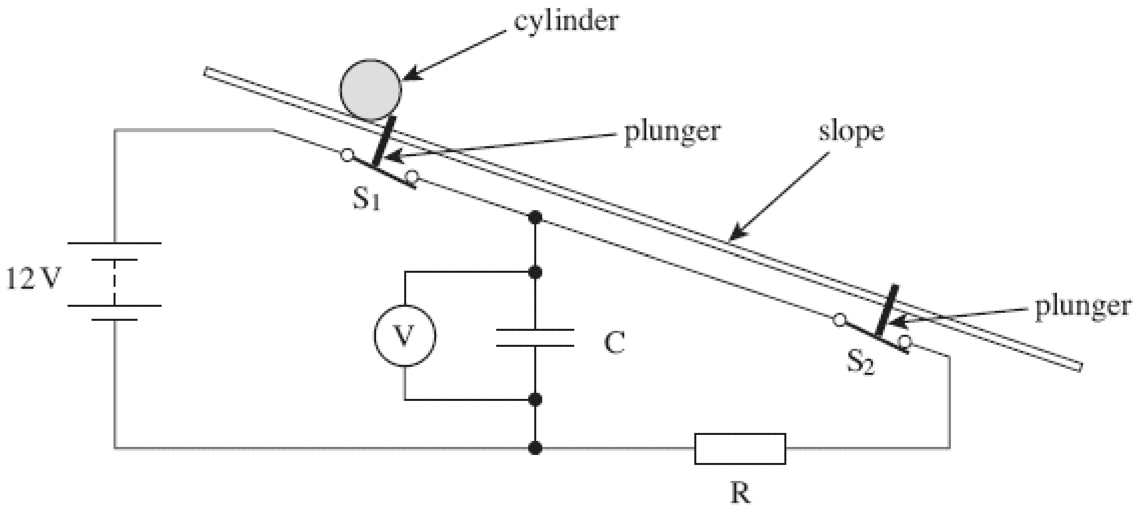
B 10

C 1

D $\frac{1}{100}$

(Total 1 mark)

Q16. A student was required to design an experiment to measure the acceleration of a heavy cylinder as it rolled down an inclined slope of constant gradient. He suggested an arrangement that would make use of a capacitor-resistor discharge circuit to measure the time taken for the cylinder to travel between two points on the slope. The principle of this arrangement is shown in the figure below.



S_1 and S_2 are two switches that would be opened in turn by plungers as the cylinder passed over them. Once opened, the switches would remain open. The cylinder would be released from rest as it opened S_1. The pd across the capacitator would be measured by the voltmeter.

(a) Describe the procedure the student should follow, including the measurements he should make, when using this arrangement. Explain how he should use the measurements taken to calculate the acceleration of the cylinder down the slope.

The quality of your written communication will be assessed in this question.

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(6)

(b) When the student set up his experiment using the arrangement shown in the figure above, he used a 22 μF capacitor, C, and a 200 kΩ resistor, R. In one of his results, the initial pd was 12.0 V and the final pd was 5.8 V. The distance between the plungers was 2.5 m.

(i) From the student's result, calculate the time taken for the cylinder to reach the second plunger.

answer = ... s

(3)

(ii) What value does this result give for the acceleration of the cylinder down the slope, assuming the acceleration is constant?

answer = ...m s^{-2}

(2)

(Total 11 marks)

Q17. A 10 mF capacitor is charged to 10 V and then discharged completely through a small motor. During the process, the motor lifts a weight of mass 0.10 kg. If 10% of the energy stored in the capacitor is used to lift the weight, through what approximate height will the weight be lifted?

A 0.05 m

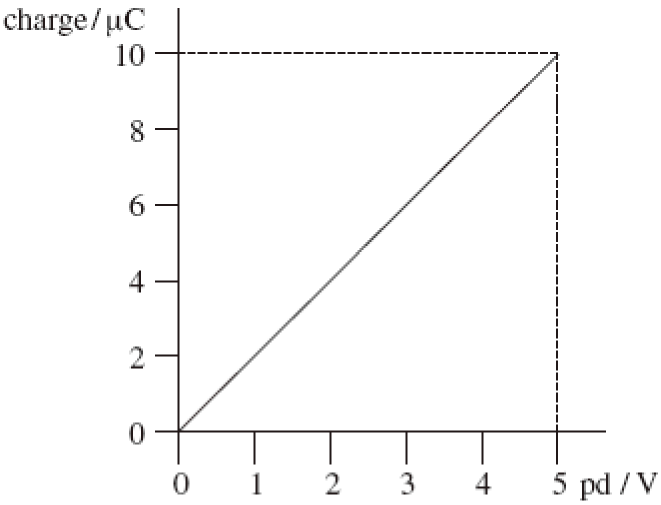
B 0.10 m

C 0.50 m

D 1.00 m

(Total 1 mark)

Q18. The graph shows how the charge stored by a capacitor varies with the pd applied across it.



Which line, **A** to **D**, in the table gives the capacitance and the energy stored when the potential difference is 5.0 V?

	capacitance/μF	energy stored/μJ
A	2.0	25
B	2.0	50
C	10.0	25

D	10.0	50

(Total 1 mark)

Q19. Capacitors and rechargeable batteries are examples of electrical devices that can be used repeatedly to store energy.

(a) (i) A capacitor of capacitance 70 F is used to provide the emergency back-up in a low voltage power supply.

Calculate the energy stored by this capacitor when fully charged to its maximum operating voltage of 1.2 V. Express your answer to an appropriate number of significant figures.

answer = ...J

(3)

(ii) A rechargeable 1.2 V cell used in a cordless telephone can supply a steady current of 55 mA for 10 hours. Show that this cell, when fully charged, stores almost 50 times more energy than the capacitor in part (a)(i).

(2)

(b) Give **two** reasons why a capacitor is **not** a suitable source for powering a cordless telephone.

Reason 1...

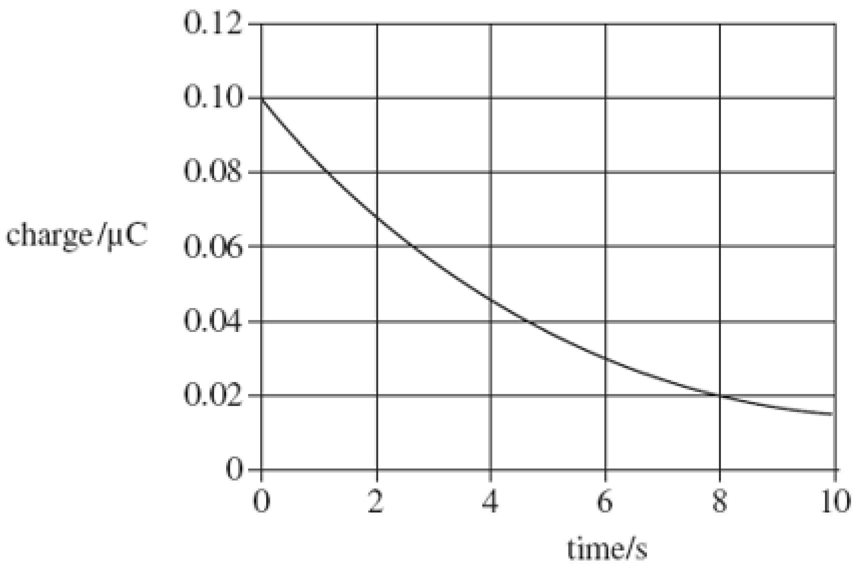
....

Reason 2...

....

(2)
(Total 7 marks)

Q20. The graph shows how the charge on a capacitor varies with time as it is discharged through a resistor.



What is the time constant for the circuit?

A 3.0 s

B 4.0 s

C 5.0 s

D 8.0 s

(Total 1 mark)

Q21. A capacitor of capacitance *C* discharges through a resistor of resistance *R*. Which one of the following statements is **not** true?

A The time constant will decrease if *C* is increased.

B The time constant will increase if *R* is increased.

C After charging to the same voltage, the initial discharge current will increase if *R* is decreased.

D After charging to the same voltage, the initial discharge current will be unaffected if *C* is increased.

(Total 1 mark)

Q22. A capacitor of capacitance *C* stores an amount of energy *E* when the pd across it is *V*. Which line, **A** to **D**, in the table gives the correct stored energy and pd when the charge is increased by 50%?

	energy	**pd**
A	1.5 *E*	1.5 *V*
B	1.5 *E*	2.25 *V*
C	2.25 *E*	1.5 *V*
D	2.25 *E*	2.25 *V*

(Total 1 mark)

Q23. A 400 μF capacitor is charged so that the voltage across its plates rises at a constant rate from 0 V to 4.0 V in 20 s. What current is being used to charge the capacitor?

A 5 μA

B 20 μA

C 40 μA

D 80 μA

(Total 1 mark)

[1]

Gravitational & Electric Fields Questions

Q1. An electron moving with a constant speed enters a uniform magnetic field in a direction at right angles to the field. What is the subsequent path of the electron?

A A straight line in the direction of the field.

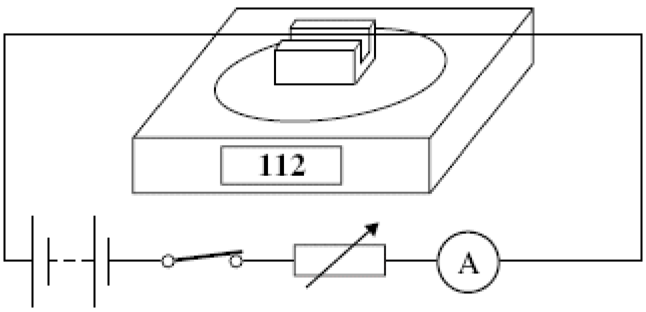
B A straight line in a direction opposite to that of the field.

C A circular arc in a plane perpendicular to the direction of the field.

D An elliptical arc in a plane perpendicular to the direction of the field.

(Total 1 mark)

Q2. The diagram shows a rigidly-clamped straight horizontal current-carrying wire held mid-way between the poles of a magnet on a top pan balance. The wire is perpendicular to the magnetic field direction.



The balance, which was zeroed before the switch was closed, reads 112 g after the switch is closed. If the current is reversed and doubled, what will be the new reading on the balance?

A –224 g

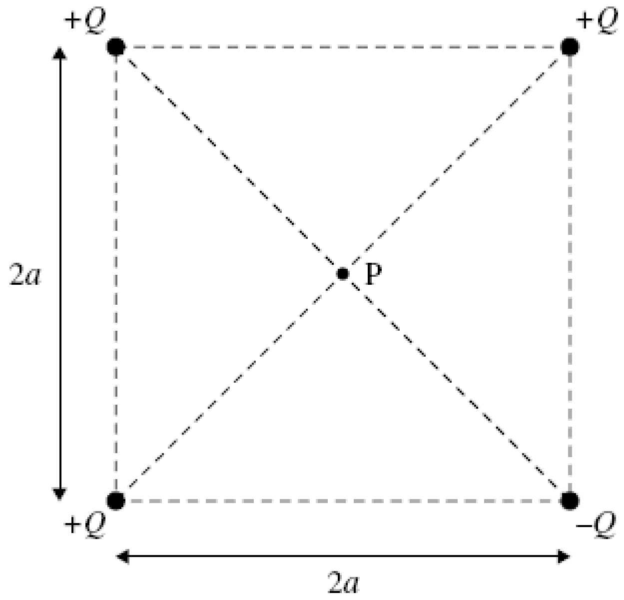
B –112 g

C zero

D 224 g

(Total 1 mark)

Q3. The diagram shows four point charges at the corners of a square of side 2*a*. What is the electric potential at P, the centre of the square?



A $\dfrac{Q}{2\sqrt{2}\pi\varepsilon_0 a}$

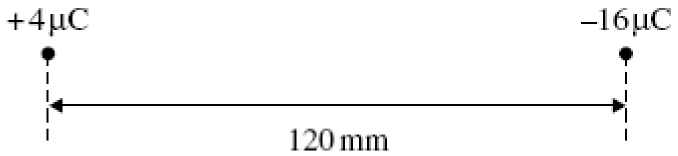
B $\dfrac{Q}{\sqrt{2}\pi\varepsilon_0 a}$

C $\dfrac{Q}{2\pi\varepsilon_0 a}$

D $\dfrac{Q}{4\pi\varepsilon_0 a}$

(Total 1 mark)

Q4.



The diagram shows two charges, +4 μC and –16 μC, 120 mm apart. What is the distance from the +4 μC charge to the point between the two charges where the resultant electric potential is zero?

A 24 mm

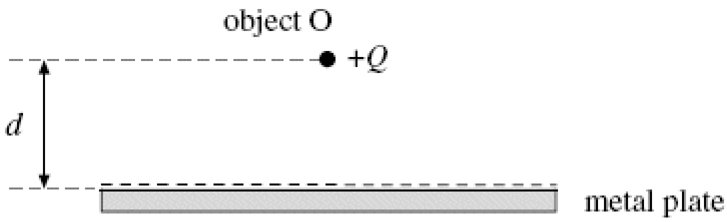
B 40 mm

C 80 mm

D 96 mm

(Total 1 mark)

Q5. A small object O carrying a charge +*Q* is placed at a distance *d* from a metal plate that has an equal and opposite charge. The object is acted on by an electrostatic force *F*.



Which one of the following expressions has the same unit as *F*?

A $\frac{\varepsilon_0 Q^2}{d}$

B $\frac{\varepsilon_0 Q^2}{d^2}$

C $\frac{Q^2}{\varepsilon_0 d}$

D $\frac{Q^2}{\varepsilon_0 d^2}$

(Total 1 mark)

Q6. An artificial satellite of mass *m* is in a stable circular orbit of radius *r* around a planet of mass *M*. Which one of the following expressions gives the speed of the satellite?
G is the universal gravitational constant.

A $\left(\frac{Gm}{r}\right)^{\frac{1}{2}}$

B $\left(\frac{GM}{r}\right)^{\frac{1}{2}}$

C $\frac{Gm}{r}$

D $\left(\frac{Gm}{r}\right)^{\frac{3}{2}}$

(Total 1 mark)

Q7. The gravitational potential difference between the surface of a planet and a point P, 10 m above the surface, is 8.0 J kg^{-1}. Assuming a uniform field, what is the value of the gravitational field strength in the region between the planet's surface and P?

A 0.80 N kg^{-1}

B 1.25 N kg^{-1}

C 8.0 N kg^{-1}

D 80 N kg^{-1}

(Total 1 mark)

Q8. A projectile moves in a gravitational field. Which one of the following is a correct statement about the gravitational force acting on the projectile?

A The force is in the direction of the field.

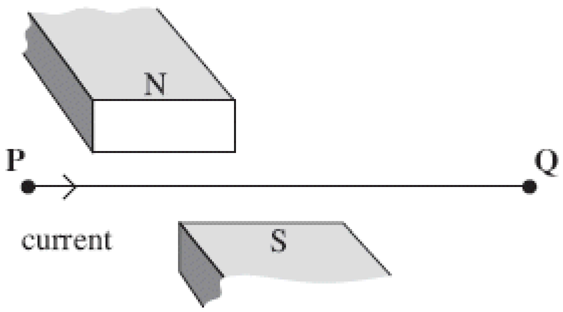
B The force is in the opposite direction to that of the field.

C The force is at right angles to the field.

D The force is at an angle between 0° and 90° to the field.

(Total 1 mark)

Q9. The figure below shows a horizontal wire, held in tension between fixed points at **P** and **Q**. A short section of the wire is positioned between the pole pieces of a permanent magnet, which applies a uniform horizontal magnetic field at right angles to the wire. Wires connected to a circuit at **P** and **Q** allow an electric current to be passed through the wire.



(a) (i) State the direction of the force on the wire when there is a direct current from **P** to **Q**, as shown in the figure above.

....

(1)

(ii) In a second experiment, an alternating current is passed through the wire. Explain why the wire will vibrate vertically.

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(3)

(b) The permanent magnet produces a uniform magnetic field of flux density 220 mT over a 55 mm length of the wire. Show that the maximum force on the wire is about 40 mN when there is an alternating current of rms value 2.4 A in it.

(3)

(c) The length of **PQ** is 0.40 m. When the wire is vibrating, transverse waves are propagated along the wire at a speed of 64 m s^{-1}. Explain why the wire is set into large amplitude vibration when the frequency of the a.c. supply is 80 Hz.

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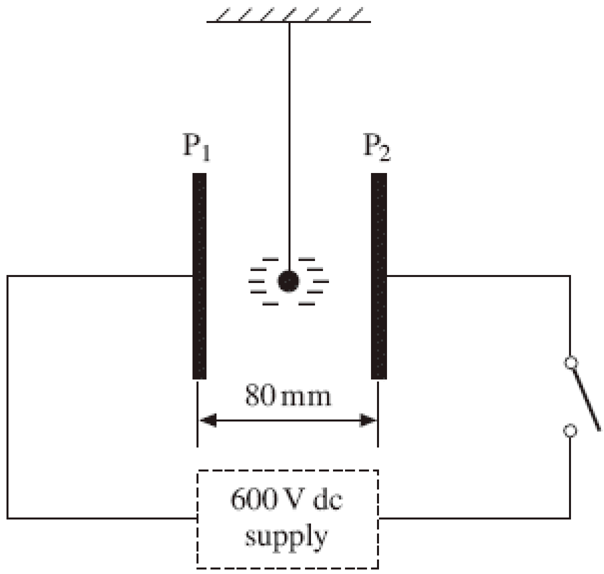
(3)
(Total 10 marks)

Q10. **Figure 1** shows a small polystyrene ball which is suspended between two vertical metal plates, $\mathbf{P_1}$ and $\mathbf{P_2}$, 80 mm apart, that are initially uncharged. The ball carries a charge of –0.17 μC.

Figure 1



(a) (i) A pd of 600 V is applied between $\mathbf{P_1}$ and $\mathbf{P_2}$ when the switch is closed. Calculate the magnitude of the electric field strength between the plates, assuming it is uniform.

answer = ...V m^{-1}

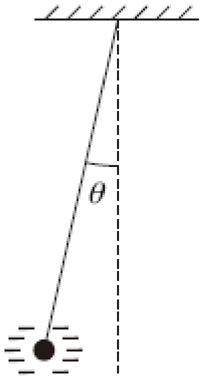
(2)

(ii) Show that the magnitude of the electrostatic force that acts on the ball under these conditions is 1.3 mN.

(1)

(b) Because of the electrostatic force acting on it, the ball is displaced from its original position. It comes to rest when the suspended thread makes an angle θ with the vertical, as shown in **Figure 2**.

Figure 2



(i) On **Figure 2**, mark and label the forces that act on the ball when in this position.

(2)

(ii) The mass of the ball is 4.8×10^{-4} kg. By considering the equilibrium of the ball, determine the value of θ.

answer = ... degrees

(3)
(Total 8 marks)

Q11. A transformer has 1200 turns on the primary coil and 500 turns on the secondary coil. The primary coil draws a current of 0.25 A from a 240 V ac supply. If the efficiency of the transformer is 83%, what is the current in the secondary coil?

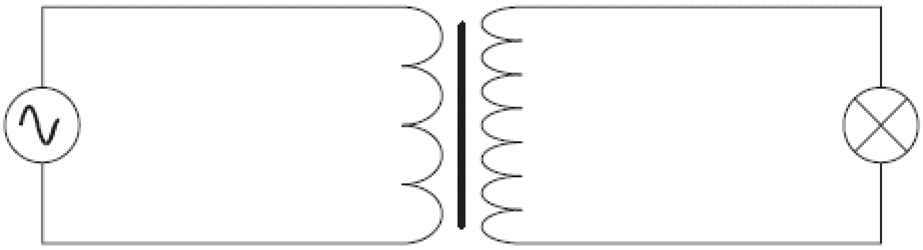
A 0.10 A

B 0.21 A

C 0.50 A

D 0.60 A

Q12. The primary coil of a step-up transformer is connected to a source of alternating pd. The secondary coil is connected to a lamp.

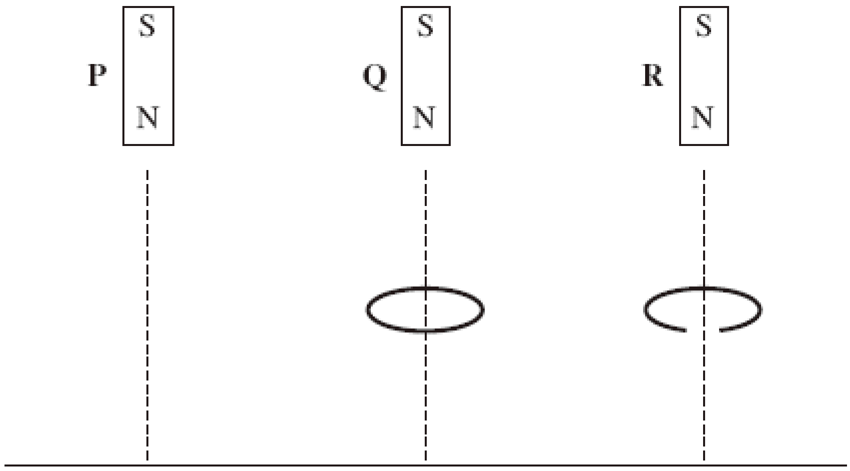


Which line, **A** to **D**, in the table correctly describes the flux linkage and current through the secondary coil in relation to the primary coil?

	$\frac{\text{secondary magnetic flux linkage}}{\text{primary magnetic flux linkage}}$	$\frac{\text{secondary current}}{\text{primary current}}$
A	>1	<1
B	<1	<1
C	>1	>1
D	<1	>1

(Total 1 mark)

Q13.



Three identical magnets **P**, **Q** and **R** are released simultaneously from rest and fall to the ground from the same height. **P** falls directly to the ground, **Q** falls through the centre of a thick conducting ring and **R** falls through a ring which is identical except for a gap cut into it. Which one of the statements below correctly describe the sequence in which the magnets reach the ground?

A **P** and **R** arrive together followed by **Q**.

B **P** and **Q** arrive together followed by **R**.

C **P** arrives first, follow by **Q** which is followed by **R**.

D All three magnets arrive simultaneously.

(Total 1 mark)

Q14. An aircraft, of wing span 60 m, flies horizontally at a speed of 150 m s^{-1}. If the vertical component of the Earth's magnetic field in the region of the plane is 1.0×10^{-5} T, what is the magnitude of the magnetic flux cut by the wings in 10 s?

A 1.0×10^{-5} Wb

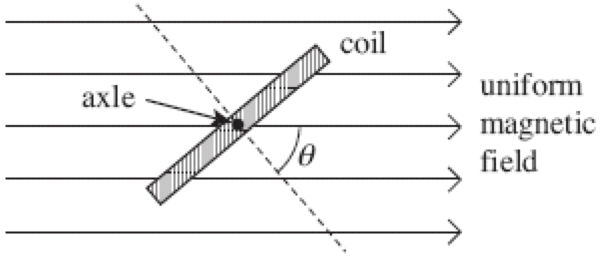
B 1.0×10^{-4} Wb

C 9.0×10^{-2} Wb

D 9.0×10^{-1} Wb

(Total 1 mark)

Q15.



A coil of 50 turns has a cross-sectional area of 4.2×10^{-3} m^2. It is placed at an angle to a uniform magnetic field of flux density 2.8×10^{-2} T, as shown in the diagram, so that angle θ = 50°.

What is the change in flux linkage when the coil is rotated anticlockwise until θ = 0°?

A The flux linkage decreases by 2.1×10^{-3} Wb turns.

B The flux linkage increases by 2.1×10^{-3} Wb turns.

C The flux linkage decreases by 3.8×10^{-3} Wb turns.

D The flux linkage increases by 3.8×10^{-3} Wb turns.

(Total 1 mark)

Q16. An electron moving with a constant speed enters a uniform magnetic field in a direction perpendicular to the magnetic field. What is the shape of the path that the electron would follow?

A parabolic

B circular

C elliptical

D a line parallel to the magnetic field

(Total 1 mark)

Q17. A negatively charged particle moves at right angles to a uniform magnetic field. The magnetic force on the particle acts

A in the direction of the field.

B in the opposite direction to that of the field.

C at an angle between 0° and 90° to the field.

D at right angles to the field.

(Total 1 mark)

Q18. A 10 mF capacitor is charged to 10 V and then discharged completely through a small motor. During the process, the motor lifts a weight of mass 0.10 kg. If 10% of the energy stored in the capacitor is used to lift the weight, through what approximate height will the weight be lifted?

A 0.05 m

B 0.10 m

C 0.50 m

D 1.00 m

(Total 1 mark)

Q19. Two protons are 1.0×10^{-14} m apart. Approximately how many times is the electrostatic force between them greater than the gravitational force between them? (Use the Data and Formulae booklet)

A 10^{23}

B 10^{30}

C 10^{36}

D 10^{42}

(Total 1 mark)

Q20. What is the acceleration of an electron at a point in an electric field where the field strength is 1.5×10^{5} V m^{-1}?

A 1.2×10^{6} m s^{-2}

B 1.4×10^{13} m s^{-2}

C 2.7×10^{15} m s^{-2}

D 2.6×10^{16} m s^{-2}

(Total 1 mark)

Q21. The repulsive force between two small negative charges separated by a distance *r* is *F*.

What is the force between the charges when the separation is reduced to $\frac{r}{3}$?

A $\frac{F}{9}$

B $\frac{F}{3}$

C $3F$

D $9F$

(Total 1 mark)

Q22. As a comet orbits the Sun the distance between the comet and the Sun continually changes. As the comet moves towards the Sun this distance reaches a minimum value. Which one of the following statements is **incorrect** as the comet approaches this minimum distance?

A The potential energy of the comet increases.

B The gravitational force acting on the comet increases.

C The direction of the gravitational force acting on the comet changes.

D The kinetic energy of the comet increases.

(Total 1 mark)

Q23. What would the period of rotation of the Earth need to be if objects at the equator were to appear weightless?

radius of Earth = 6.4×10^6 m

A 4.5×10^{-2} hours

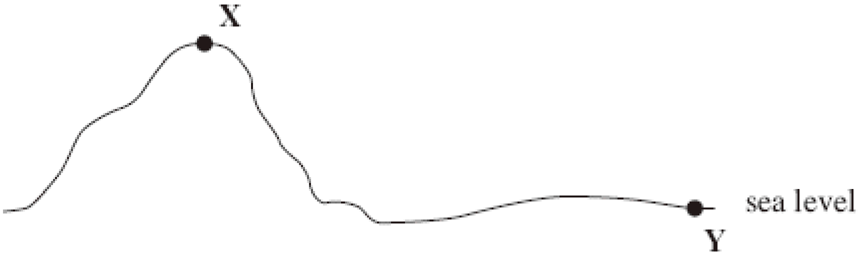
B 1.4 hours

C 24 hours

D 160 hours

(Total 1 mark)

Q24. The diagram shows two positions, **X** and **Y**, on the Earth's surface.

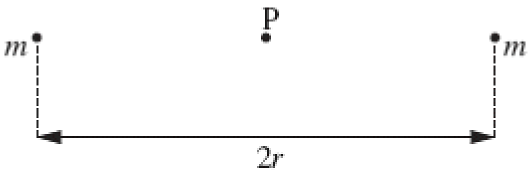


Which line, **A** to **D**, in the table gives correct comparisons at **X** and **Y** for gravitational potential and angular velocity?

	gravitational potential at X compared with Y	angular velocity at X compared with Y
A	greater	greater
B	greater	same
C	greater	smaller
D	same	same

(Total 1 mark)

Q25. The diagram shows two point masses each of mass *m* separated by a distance 2*r.*



What is the value of the gravitational field strength at the mid-point, P, between the two masses?

A $\frac{4Gm}{r^2}$

B $\frac{2Gm}{r^2}$

C $\frac{Gm}{2r^2}$

D zero

(Total 1 mark)

Q26. The gravitational force between two uniform spheres is 3.1 × 10^{-9} N when the distance between their centres is 150 mm. If the mass of one sphere is 2.5 kg, what is the mass of the other?

A 0.043 kg

B 0.42 kg

C 2.8 kg

D 4.1 kg

(Total 1 mark)

Q27. (a) The equation $F = BQv$ may be used to calculate magnetic forces.

(i) State the condition under which this equation applies.

....

....

(1)

(ii) Identify the physical quantities that are represented by the four symbols in the equation.

F ....

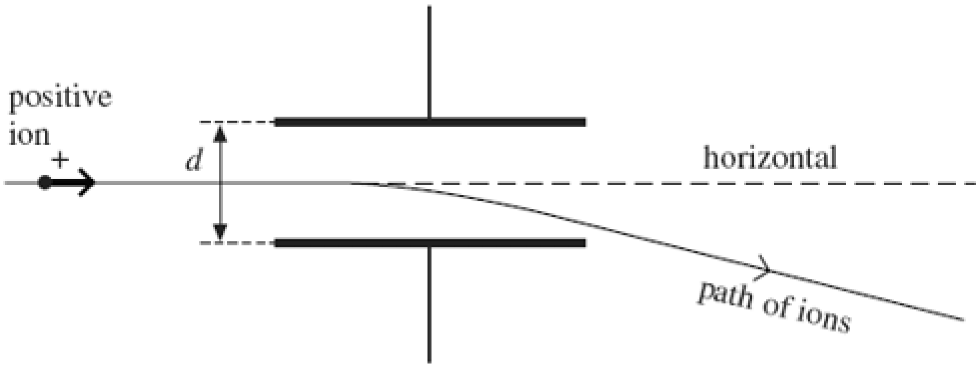
B ....

Q..

v...

(1)

(b) The figure below shows the path followed by a stream of identical positively charged ions, of the same kinetic energy, as they pass through the region between two charged plates. Initially the ions are travelling horizontally and they are then deflected downwards by the electric field between the plates.



While the electric field is still applied, the path of the ions may be restored to the horizontal, so that they have no overall deflection, by applying a magnetic field over the same region as the electric field. The magnetic field must be of suitable strength and has to be applied in a particular direction.

(i) State the direction in which the magnetic field should be applied.

....

(1)

(ii) Explain why the ions have no overall deflection when a magnetic field of the required strength has been applied.

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....

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....

(2)

(iii) A stream of ions passes between the plates at a velocity of $1.7 \times 10^5 ms^{-1}$. The separation *d* of the plates is 65 mm and the pd across them is 48 V. Calculate the value of *B* required so that there is no overall deflection of the ions, stating an appropriate unit.

answer = ...

(4)

(c) Explain what would happen to ions with a velocity higher than 1.7 x 10^5ms^{-1} when they pass between the plates at a time when the conditions in part (b)(iii) have been established.

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....

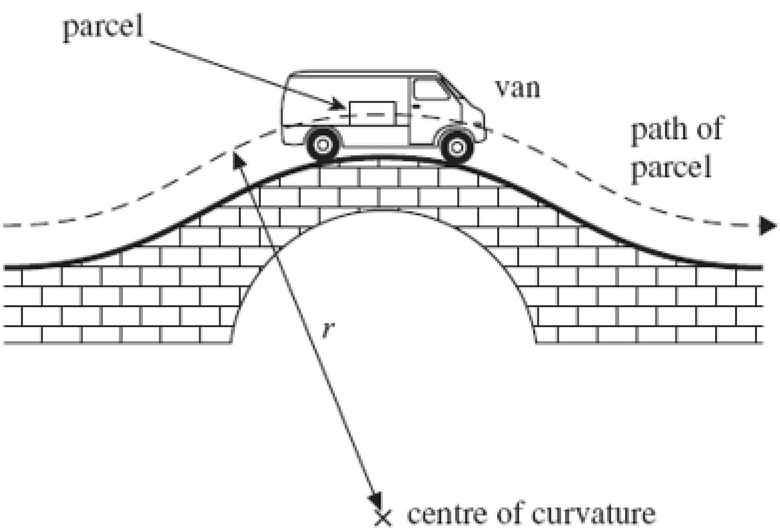
....

....

(2)
(Total 11 marks)

Q28. **Figure 1** shows a parcel on the floor of a delivery van that is passing over a hump-backed bridge on a straight section of road. The radius of curvature of the path of the parcel is *r* and the van is travelling at a constant speed *v*. The mass of the parcel is *m*.

Figure 1



(a) (i) Draw arrows on **Figure 2** below to show the forces that act on the parcel as it passes over the highest point of the bridge. Label these forces.

Figure 2

(1)

(ii) Write down an equation that relates the contact force, *R*, between the parcel and the floor of the van to *m*, *v*, *r* and the gravitational field strength, *g*.

....

....

(1)

(iii) Calculate *R* if $m = 12$ kg, $r = 23$ m, and $v = 11ms^{-1}$.

answer = ...N

(2)

(b) Explain what would happen to the magnitude of *R* if the van passed over the bridge at a higher speed. What would be the significance of any van speed greater than $15ms^{-1}$? Support your answer with a calculation.

....

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(3)
(Total 7 marks)

Q29. Which one of the following is **not** a cause of energy loss in a transformer?

A good insulation between the primary and secondary coil

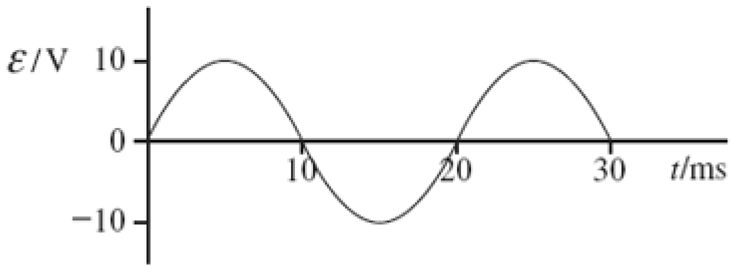
B induced currents in the soft iron core

C reversal of magnetism in the soft iron core

D resistances in the primary and secondary coil

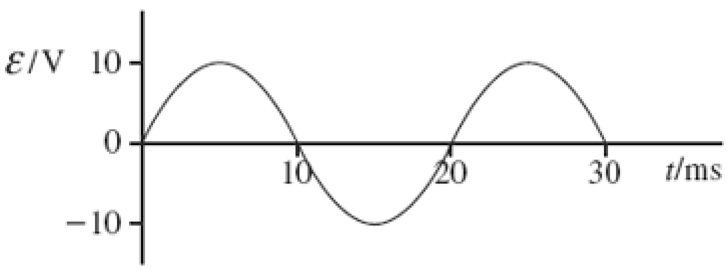
(Total 1 mark)

Q30.

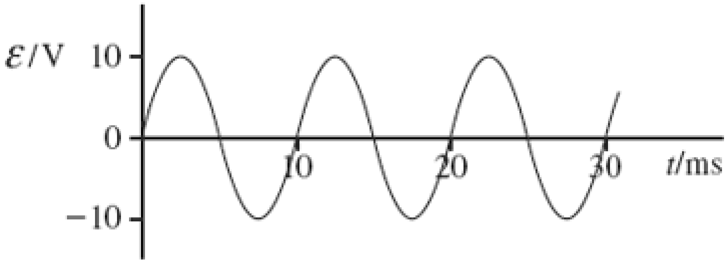


The above graph shows how the output emf, *ε*, varies with time, *t*, for a coil rotating at angular speed *ω* in a uniform magnetic field of flux density *B*. Which one of the following graphs shows how *ε* varies with *t* when the same coil is rotated at angular speed 2*ω* in a uniform magnetic field of flux density 0.5 *B*?

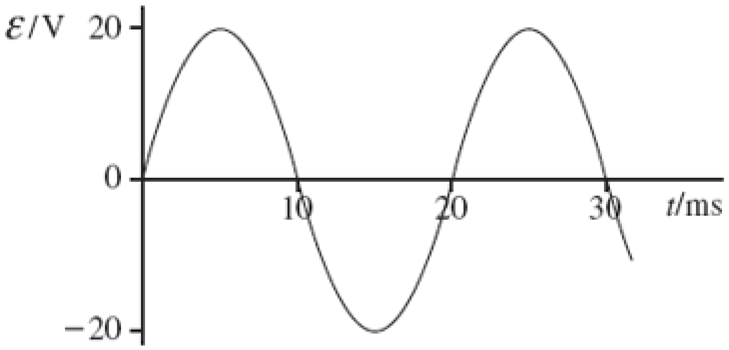
A



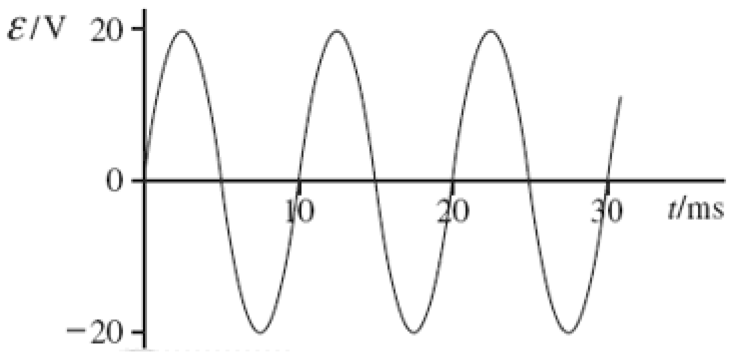
B



C

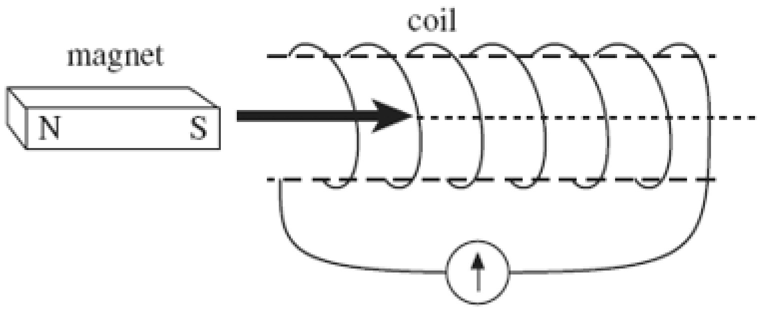


D



(Total 1 mark)

Q31. A bar magnet is pushed into a coil connected to a sensitive ammeter, as shown in the diagram, until it comes to rest inside the coil.



Why does the ammeter briefly show a non-zero reading?

A The magnetic flux linkage in the coil increases then decreases.

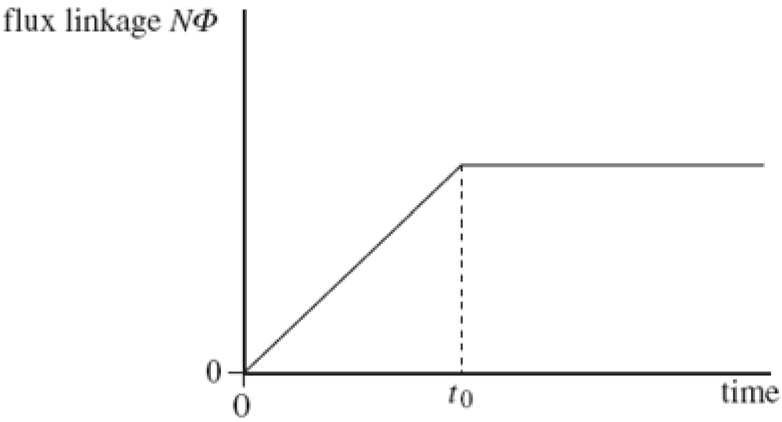
B The magnetic flux linkage in the coil increases then becomes constant.

C The magnetic flux linkage in the coil decreases then increases.

D The magnetic flux linkage in the coil decreases then becomes constant.

(Total 1 mark)

Q32. The graph shows how the flux linkage, $N\Phi$, through a coil changes when the coil is moved into a magnetic field.



The emf induced in the coil

A increases then becomes constant after time t_0.

B is constant then becomes zero after time t_0.

C is zero then increases after time t_0.

D decreases then becomes zero after time t_0.

(Total 1 mark)

Q33. Two charged particles, P and Q, move in circular orbits in a magnetic field of uniform flux density. The particles have the same charge but the mass of P is less than the mass of Q. T_P is the time taken for particle P to complete one orbit and T_Q the time for particle Q to complete one orbit. Which one of the following is correct?

A $T_P = T_Q$

B $T_P > T_Q$

C $T_P < T_Q$

D $T_P - T_Q = 1$

(Total 1 mark)

Q34. The electric potential at a distance *r* from a positive point charge is 45 V. The potential increases to 50 V when the distance from the charge decreases by 1.5 m. What is the value of *r*?

A 1.3 m

B 1.5 m

C 7.9 m

D 15 m

(Total 1 mark)

Q35. The electric potential at a distance r from a positive point charge is 45 V. The potential increases to 50 V when the distance from the charge decreases by 1.5 m. What is the value of r?

A 1.3 m

B 1.5 m

C 7.9 m

D 15 m

(Total 1 mark)

Magnetic Effects of Currents Questions

Q1. An α particle and a β^- particle both enter the same uniform magnetic field, which is perpendicular to their direction of motion. If the β^- particle has a speed 15 times that of the α particle, what is the value of the ratio

$$\frac{\text{magnitude of force on } \beta^- \text{particle}}{\text{magnitude of force on } \alpha \text{ particle}}\ ?$$

A 3.7

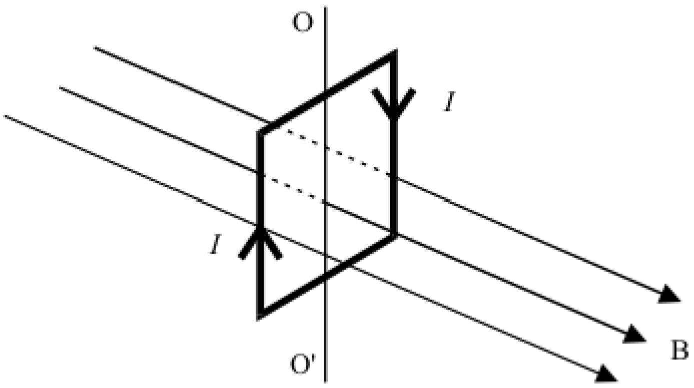
B 7.5

C 60

D 112.5

(Total 1 mark)

Q2. The diagram shows a vertical square coil whose plane is at right angles to a horizontal uniform magnetic field B. A current, *I*, flows in the coil, which can rotate about a vertical axis OO'.



Which one of the following statements is correct?

A The forces on the two vertical sides of the coil are equal and opposite.

B A couple acts on the coil.

C No forces act on the horizontal sides of the coil.

D If the coil is turned through a small angle about OO', it will remain in position.

(Total 1 mark)

Q3. (a) The equation $F = BIl$, where the symbols have their usual meanings, gives the magnetic force that acts on a conductor in a magnetic field.

Given the unit of each of the quantities in the equation.

F .... *B* ....

I .... l ....

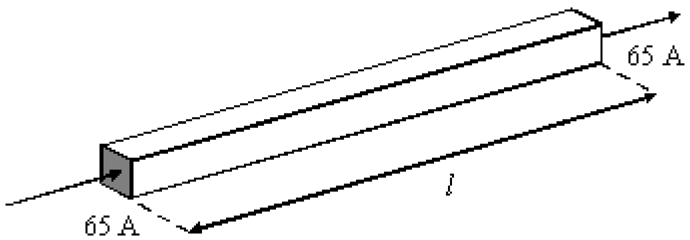
State the condition under which the equation applies.

....

....

(2)

(b) The diagram shows a horizontal copper bar of 25 mm × 25 mm square cross-section and length l carrying a current of 65 A.



(i) Calculate the minimum value of the flux density of the magnetic field in which it should be placed if its weight is to be supported by the magnetic force that acts upon it.

density of copper = 8.9×10^3 kg m^{-3}

....

....

....

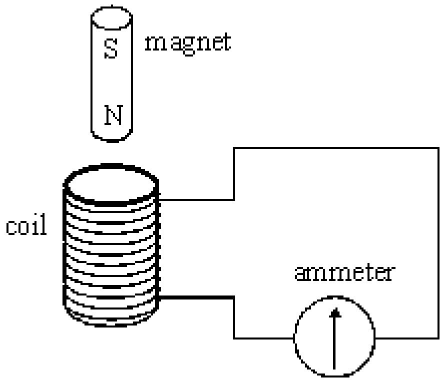
....

....

(ii) Draw an arrow on the diagram above to show the direction in which the magnetic field should be applied if your calculation in part (i) is to be valid. Label this arrow M.

(5)
(Total 7 marks)

Q4. A coil is connected to a centre zero ammeter, as shown. A student drops a magnet so that it falls vertically and completely through the coil.



(a) Describe what the student would observe on the ammeter as the magnet falls through the coil.

....

....

....

....

(2)

(b) If the coil were not present the magnet would accelerate downwards at the acceleration due to gravity. State and explain how its acceleration in the student's experiment would be affected, if at all,

(i) as it entered the coil,

....

....

....

(ii) as it left the coil.

....

....

....

(4)

(c) Suppose the student forgot to connect the ammeter to the coil, therefore leaving the circuit incomplete, before carrying out the experiment. Describe and explain what difference this would make to your conclusions in part (b).

You may be awarded marks for the quality of written communication provided in your answer.

....

....

....

....

....

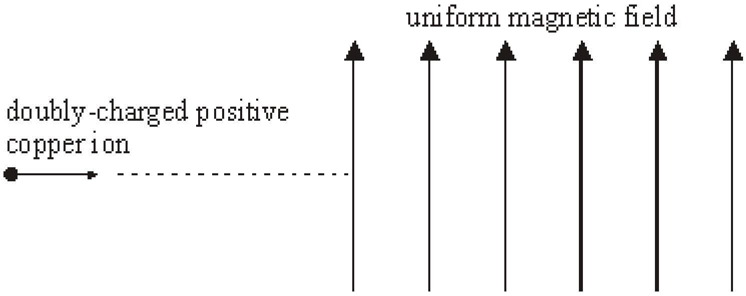
(3)
(Total 9 marks)

Q5. Which line, **A** to **D**, correctly describes the trajectory of charged particles which enter, at right angles, (a) a uniform electric field, and (b) a uniform magnetic field?

	(a) uniform electric field	(b) uniform magnetic field
A	circular	circular
B	circular	parabolic
C	parabolic	circular
D	parabolic	parabolic

(Total 1 mark)

Q6. (a)



The diagram above shows a doubly-charged positive ion of the copper isotope $^{63}_{29}Cu$ that is projected into a vertical magnetic field of flux density 0.28 T, with the field directed upwards. The ion enters the field at a speed of 7.8×10^{5} m s^{-1}.

(i) State the initial direction of the magnetic force that acts on the ion.

....

(ii) Describe the subsequent path of the ion as fully as you can.
Your answer should include both a qualitative description and a calculation.

mass of $^{63}_{29}Cu$ ion = 1.05×10^{-25} kg

....

....

....

....

....

....

....

....

(5)

(b) State the effect on the path in part (a) if the following changes are made separately.

(i) The strength of the magnetic field is doubled.

....

....

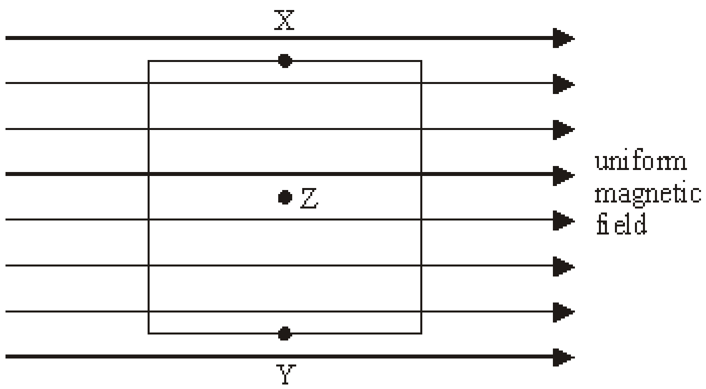
(ii) A singly-charged positive $^{63}_{29}Cu$ ion replaces the original one.

....

....

(3)
(Total 8 marks)

Q7.



The diagram shows a square coil with its plane parallel to a uniform magnetic field. Which one of the following would induce an emf in the coil?

A movement of the coil slightly to the left

B movement of the coil slightly downwards

C rotation of the coil about an axis through XY

D rotation of the coil about an axis perpendicular to the plane of the coil through Z

(Total 1 mark)

Q8.

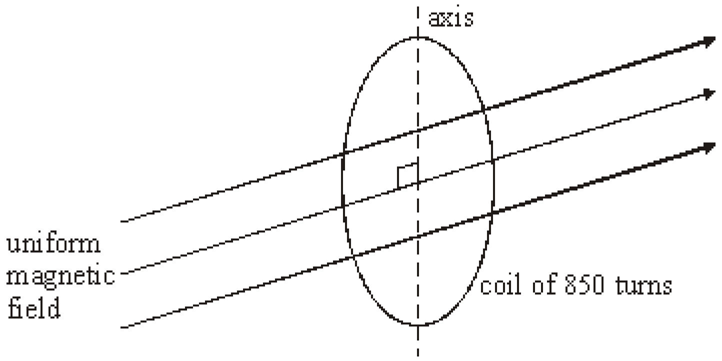


Figure 1

A circular coil of diameter 140 mm has 850 turns. It is placed so that its plane is perpendicular to a horizontal magnetic field of uniform flux density 45 mT, as shown in **Figure 1**.

(a) Calculate the magnetic flux passing through the coil when in this position.

....

....

(2)

(b) The coil is rotated through 90° about a vertical axis in a time of 120 ms.

Calculate

(i) the change of magnetic flux linkage produced by this rotation,

....

....

(ii) the average emf induced in the coil when it is rotated.

....

....

....

(4)
(Total 6 marks)

Q9. Protons, each of mass *m* and charge *e*, follow a circular path when travelling perpendicular to a magnetic field of uniform flux density *B*. What is the time taken for one complete orbit?

A $\dfrac{2\pi eB}{m}$

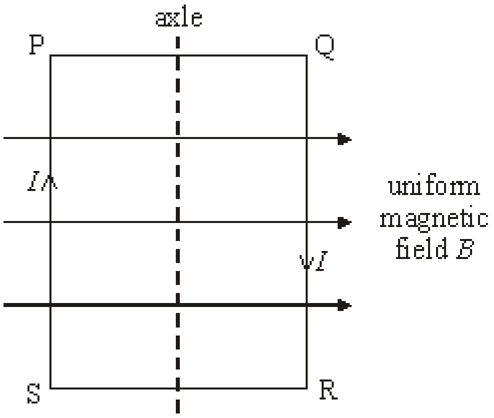
B $\dfrac{m}{2\pi eB}$

C $\dfrac{eB}{2\pi m}$

D $\dfrac{2\pi m}{eB}$

(Total 1 mark)

Q10.



A coil, mounted on an axle, has its plane parallel to the flux lines of a uniform magnetic field *B*, as shown. When a current *I* is switched on, and before the coil is allowed to move,

A there are no forces due to *B* on the sides PQ and RS.

B there are no forces due to *B* on the sides SP and QR.

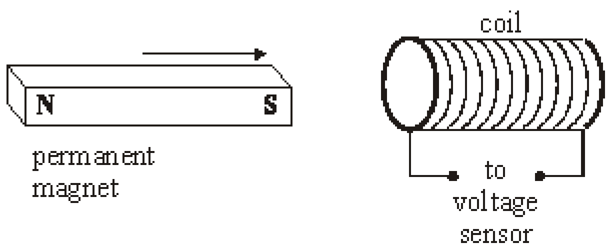
C sides SP and QR attract each other.

D sides PQ and RS attract each other.

(Total 1 mark)

Q11. (a) In an experiment to illustrate electromagnetic induction, a permanent magnet is moved towards a coil, as shown in **Figure 1**, causing an emf to be induced across the coil.

Figure 1



Using Faraday's law, explain why a larger emf would be induced in this experiment if a stronger magnet were moved at the same speed.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

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....

....

....

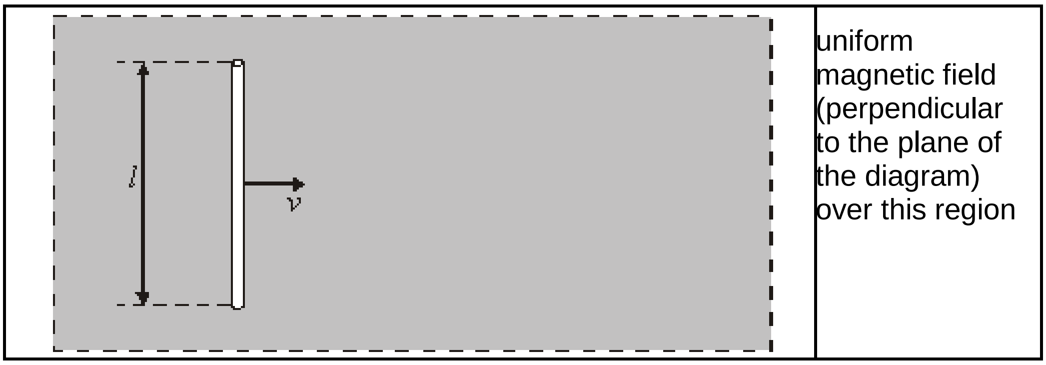
....

....

(3)

(b) A conductor of length *l* is moved at a constant speed *v* so that it passes perpendicularly through a uniform magnetic field of flux density *B*, as shown in **Figure 2**.

Figure 2



(i) Give an expression for the area of the magnetic field swept out by the conductor in time Δt.

....

....

(ii) Show that the induced emf, $\in$, across the ends of the conductor is given by $\in = Blv$.

....

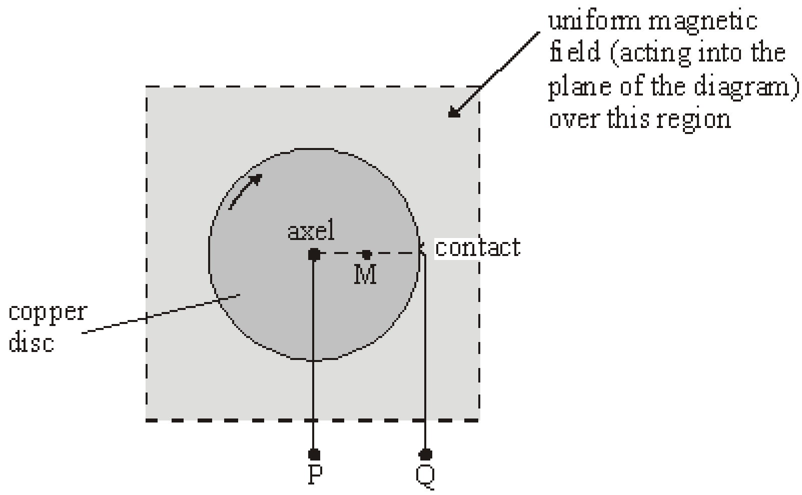
....

....

(3)

(c) A simple electrical generator can be made from a copper disc, which is rotated at right angles to a uniform magnetic field, directed into the plane of the diagram (**Figure 3**). An emf is developed across terminals P (connected to the axle) and Q (connected to a contact on the edge of the disc).

Figure 3



The radius of the disc is 64 mm and it is rotated at 16 revolutions per second in a uniform magnetic field of flux density 28 mT.

(i) Calculate the angular speed of the disc.

....

....

....

(ii) Calculate the linear speed of the mid-point M of a radius of the disc.

....

....

....

(iii) Hence, or otherwise, calculate the emf induced across terminals P and Q.

....

....

....

(5)
(Total 11 marks)

Q12. Particles of mass *m* carrying a charge *Q* travel in a circular path of radius *r* in a magnetic field of flux density *B* with a speed *v*. How many of the following quantities, if changed one at a time, would change the radius of the path?

- *m*
- *Q*
- *B*
- *v*

A one

B two

C three

D four

(Total 1 mark)

Q13. Why, when transporting electricity on the National Grid, are high voltages and low currents used?

A The energy lost by radiation from electromagnetic waves is reduced.

B The electrons move more rapidly.

C The heat losses are reduced.

D The resistance of the power lines is reduced.

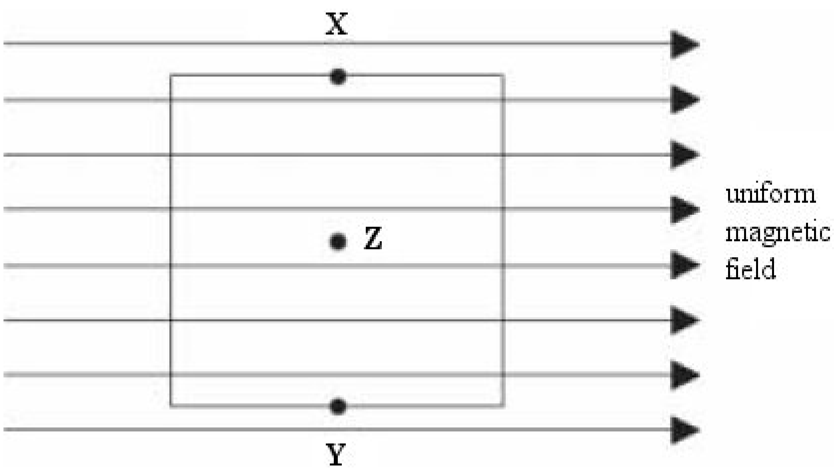
(Total 1 mark)

Q14. The primary winding of a perfectly efficient transformer has 200 turns and the secondary has 1000 turns. When a sinusoidal pd of rms value 10 V is applied to the input, there is a primary current of rms value 0.10 A rms. Which line in the following table, **A** to **D**, gives correct rms output values obtainable from the secondary when the primary is supplied in this way?

	rms output emf/V	rms output current/A
A	50	0.10
B	50	0.02
C	10	0.10
D	10	0.02

(Total 1 mark)

Q15.



The diagram shows a square coil with its plane parallel to a uniform magnetic field. Which one of the following would induce an emf in the coil?

A movement of the coil slightly to the left

B movement of the coil slightly downwards

C rotation of the coil about an axis through XY

D rotation of the coil about an axis perpendicular to the plane of the coil through Z

(Total 1 mark)

Q16. Protons, each of mass *m* and charge *e*, follow a circular path when travelling perpendicular to a magnetic field of uniform flux density *B*. What is the time taken for one complete orbit?

A $\frac{2\pi eB}{m}$

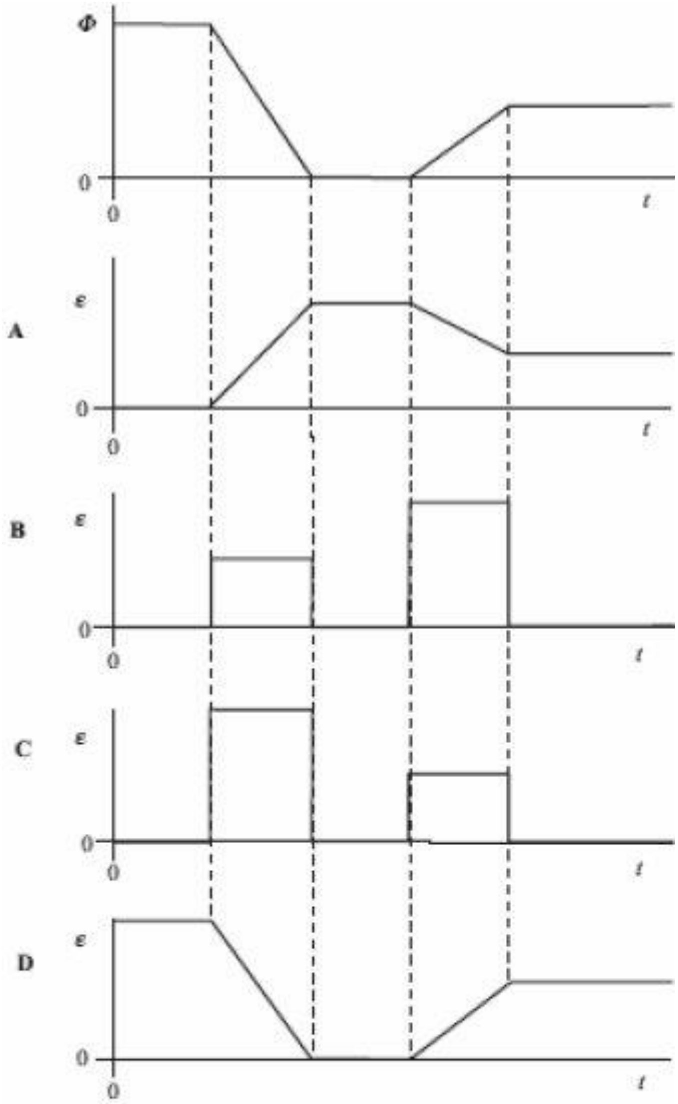
B $\frac{m}{2\pi eB}$

C $\frac{eB}{2\pi m}$

D $\frac{2\pi m}{eB}$

(Total 1 mark)

Q17. The magnetic flux, Φ, through a coil varies with time, *t*, as shown by the first graph. Which one of the following graphs, A to D, best represents how the magnitude, ϵ, of the induced emf varies in this same period of time?



(Total 1 mark)

Q18. The magnetic flux through a coil of *N* turns is increased uniformly from zero to a maximum value in a time *t*. An emf, *E*, is induced across the coil.
What is the maximum value of the magnetic flux through the coil?

A $\frac{Et}{N}$

B $\frac{N}{Et}$

C $E\,t\,N$

D $\frac{E}{Nt}$

(Total 1 mark)

Q19. A section of current-carrying wire is placed at right angles to a uniform magnetic field of flux density *B*. When the current in the wire is I, the magnetic force that acts on this section is *F*.

What force acts when the same section of wire is placed at right angles to a uniform magnetic field of flux density 2*B* when the current is 0.25 I?

A $\frac{F}{4}$

B $\frac{F}{2}$

C *F*

D *2F*

(Total 1 mark)