100 LONG-FORM ADVANCED PHYSICS QUESTIONS

Class XI | Revised topic set with Electrostatics

Original, demanding practice questions inspired by the topic coverage and problem-solving style of Class XI physics textbooks, including S. Chand and Mastering Physics. These are not copied verbatim from either book. Each numbered question has parts A–C and Roman-numeral tasks. Unless stated otherwise, use g = 9.8 m s^{-2}, show complete working, use SI units, and draw labelled diagrams where useful.

1. Units, Dimensions and Error Analysis

Question 1

A. Express the gravitational constant G in terms of the fundamental dimensions M, L and T.

(i) (i) State the relevant physical quantities and their SI units. (ii) Express each quantity in fundamental dimensions.

(ii) (i) Use dimensional reasoning to test the stated relation. (ii) Identify any dimensional inconsistency and explain what dimensional analysis cannot determine.

B. (i) Calculate the requested numerical result, showing substitutions and units. (ii) Estimate the uncertainty or percentage error where appropriate.

(i) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

(ii) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

C. (i) Use dimensional reasoning to test the stated relation. (ii) Identify any dimensional inconsistency and explain what dimensional analysis cannot determine.

(i) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

(ii) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

Question 2

A. Using dimensional analysis, test whether the relation $T = 2\pi\sqrt{(l/g)}$ is dimensionally correct for a simple pendulum.

(i) (i) State the relevant physical quantities and their SI units. (ii) Express each quantity in fundamental dimensions.

(ii) (i) Use dimensional reasoning to test the stated relation. (ii) Identify any dimensional inconsistency and explain what dimensional analysis cannot determine.

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B. (i) Calculate the requested numerical result, showing substitutions and units. (ii) Estimate the uncertainty or percentage error where appropriate.

(i) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

(ii) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

C. (i) Use dimensional reasoning to test the stated relation. (ii) Identify any dimensional inconsistency and explain what dimensional analysis cannot determine.

(i) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

(ii) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

Question 3

A. The time period T of a small oscillation depends on mass m, length l and gravitational acceleration g. Use dimensional analysis to obtain a possible relation for T.

(i) (i) State the relevant physical quantities and their SI units. (ii) Express each quantity in fundamental dimensions.

(ii) (i) Use dimensional reasoning to test the stated relation. (ii) Identify any dimensional inconsistency and explain what dimensional analysis cannot determine.

B. (i) Calculate the requested numerical result, showing substitutions and units. (ii) Estimate the uncertainty or percentage error where appropriate.

(i) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

(ii) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

C. (i) Use dimensional reasoning to test the stated relation. (ii) Identify any dimensional inconsistency and explain what dimensional analysis cannot determine.

(i) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

(ii) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

Question 4

A. A measured length is (12.40 ± 0.05) cm. Calculate the percentage error in the measurement.

(i) (i) State the relevant physical quantities and their SI units. (ii) Express each quantity in fundamental dimensions.

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(ii) (i) Use dimensional reasoning to test the stated relation. (ii) Identify any dimensional inconsistency and explain what dimensional analysis cannot determine.

B. (i) Calculate the requested numerical result, showing substitutions and units. (ii) Estimate the uncertainty or percentage error where appropriate.

(i) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

(ii) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

C. (i) Use dimensional reasoning to test the stated relation. (ii) Identify any dimensional inconsistency and explain what dimensional analysis cannot determine.

(i) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

(ii) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

Question 5

A. If $z = x^2y^3/\sqrt{w}$, and the percentage errors in x, y and w are 1%, 2% and 3% respectively, estimate the maximum percentage error in z.

(i) (i) State the relevant physical quantities and their SI units. (ii) Express each quantity in fundamental dimensions.

(ii) (i) Use dimensional reasoning to test the stated relation. (ii) Identify any dimensional inconsistency and explain what dimensional analysis cannot determine.

B. (i) Calculate the requested numerical result, showing substitutions and units. (ii) Estimate the uncertainty or percentage error where appropriate.

(i) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

(ii) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

C. (i) Use dimensional reasoning to test the stated relation. (ii) Identify any dimensional inconsistency and explain what dimensional analysis cannot determine.

(i) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

(ii) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

Question 6

A. Convert 1 newton into dyne and 1 joule into erg.

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(i) (i) State the relevant physical quantities and their SI units. (ii) Express each quantity in fundamental dimensions.

(ii) (i) Use dimensional reasoning to test the stated relation. (ii) Identify any dimensional inconsistency and explain what dimensional analysis cannot determine.

B. (i) Calculate the requested numerical result, showing substitutions and units. (ii) Estimate the uncertainty or percentage error where appropriate.

(i) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

(ii) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

C. (i) Use dimensional reasoning to test the stated relation. (ii) Identify any dimensional inconsistency and explain what dimensional analysis cannot determine.

(i) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

(ii) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

Question 7

A. Determine the dimensions of (i) pressure, (ii) surface tension, and (iii) coefficient of viscosity.

(i) (i) State the relevant physical quantities and their SI units. (ii) Express each quantity in fundamental dimensions.

(ii) (i) Use dimensional reasoning to test the stated relation. (ii) Identify any dimensional inconsistency and explain what dimensional analysis cannot determine.

B. (i) Calculate the requested numerical result, showing substitutions and units. (ii) Estimate the uncertainty or percentage error where appropriate.

(i) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

(ii) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

C. (i) Use dimensional reasoning to test the stated relation. (ii) Identify any dimensional inconsistency and explain what dimensional analysis cannot determine.

(i) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

(ii) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

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Question 8

A. A quantity is calculated from $v = s/t$. If $s = (25.0 \pm 0.2)$ m and $t = (5.0 \pm 0.1)$ s, find v and its approximate maximum percentage error.

(i) (i) State the relevant physical quantities and their SI units. (ii) Express each quantity in fundamental dimensions.

(ii) (i) Use dimensional reasoning to test the stated relation. (ii) Identify any dimensional inconsistency and explain what dimensional analysis cannot determine.

B. (i) Calculate the requested numerical result, showing substitutions and units. (ii) Estimate the uncertainty or percentage error where appropriate.

(i) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

(ii) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

C. (i) Use dimensional reasoning to test the stated relation. (ii) Identify any dimensional inconsistency and explain what dimensional analysis cannot determine.

(i) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

(ii) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

Question 9

A. Show by dimensional analysis whether the expression $v^2 = u^2 + 2as$ is dimensionally consistent.

(i) (i) State the relevant physical quantities and their SI units. (ii) Express each quantity in fundamental dimensions.

(ii) (i) Use dimensional reasoning to test the stated relation. (ii) Identify any dimensional inconsistency and explain what dimensional analysis cannot determine.

B. (i) Calculate the requested numerical result, showing substitutions and units. (ii) Estimate the uncertainty or percentage error where appropriate.

(i) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

(ii) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

C. (i) Use dimensional reasoning to test the stated relation. (ii) Identify any dimensional inconsistency and explain what dimensional analysis cannot determine.

(i) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

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(ii) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

Question 10

A. The radius of a sphere is measured as (2.50 ± 0.02) cm. Estimate the percentage error in its calculated volume.

(i) (i) State the relevant physical quantities and their SI units. (ii) Express each quantity in fundamental dimensions.

(ii) (i) Use dimensional reasoning to test the stated relation. (ii) Identify any dimensional inconsistency and explain what dimensional analysis cannot determine.

B. (i) Calculate the requested numerical result, showing substitutions and units. (ii) Estimate the uncertainty or percentage error where appropriate.

(i) (i) State two assumptions made. (ii) Explain how an experimental measurement or graph could be used to check the result.

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2. Motion in a Straight Line

Question 11

A. A car starts from rest and accelerates uniformly at 2.4 m s^{-2} for 8 s. Find its final speed and displacement.

(i) (i) Choose a suitable sign convention and list the known quantities. (ii) Draw or describe the velocity-time graph for the motion.

(ii) (i) Derive the required kinematic equation from the graph. (ii) Use it to find the requested displacement, velocity or acceleration.

B. (i) Calculate the relevant time, speed or distance. (ii) Check the answer using a second kinematic equation.

(i) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

(ii) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

C. (i) Derive the required kinematic equation from the graph. (ii) Use it to find the requested displacement, velocity or acceleration.

(i) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

(ii) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

Question 12

A. A body moving at 30 m s^{-1} is uniformly retarded at 3 m s^{-2}. Find the time taken to stop and the stopping distance.

(i) (i) Choose a suitable sign convention and list the known quantities. (ii) Draw or describe the velocity-time graph for the motion.

(ii) (i) Derive the required kinematic equation from the graph. (ii) Use it to find the requested displacement, velocity or acceleration.

B. (i) Calculate the relevant time, speed or distance. (ii) Check the answer using a second kinematic equation.

(i) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

(ii) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

C. (i) Derive the required kinematic equation from the graph. (ii) Use it to find the requested displacement, velocity or acceleration.

(i) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

(ii) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

Question 13

A. A particle covers 18 m in the third second and 24 m in the fifth second under uniform acceleration. Determine its initial velocity and acceleration.

(i) (i) Choose a suitable sign convention and list the known quantities. (ii) Draw or describe the velocity-time graph for the motion.

(ii) (i) Derive the required kinematic equation from the graph. (ii) Use it to find the requested displacement, velocity or acceleration.

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B. (i) Calculate the relevant time, speed or distance. (ii) Check the answer using a second kinematic equation.

(i) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

(ii) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

C. (i) Derive the required kinematic equation from the graph. (ii) Use it to find the requested displacement, velocity or acceleration.

(i) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

(ii) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

Question 14

A. A train increases its speed from 12 m s^{-1} to 28 m s^{-1} in 20 s. Calculate its acceleration and distance travelled.

(i) (i) Choose a suitable sign convention and list the known quantities. (ii) Draw or describe the velocity-time graph for the motion.

(ii) (i) Derive the required kinematic equation from the graph. (ii) Use it to find the requested displacement, velocity or acceleration.

B. (i) Calculate the relevant time, speed or distance. (ii) Check the answer using a second kinematic equation.

(i) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

(ii) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

C. (i) Derive the required kinematic equation from the graph. (ii) Use it to find the requested displacement, velocity or acceleration.

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(ii) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

Question 15

A. A stone is dropped from a tower and reaches the ground after 3.8 s. Find the tower height and impact speed. Take g = 9.8 m s^{-2}.

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(i) (i) Choose a suitable sign convention and list the known quantities. (ii) Draw or describe the velocity-time graph for the motion.

(ii) (i) Derive the required kinematic equation from the graph. (ii) Use it to find the requested displacement, velocity or acceleration.

B. (i) Calculate the relevant time, speed or distance. (ii) Check the answer using a second kinematic equation.

(i) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

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C. (i) Derive the required kinematic equation from the graph. (ii) Use it to find the requested displacement, velocity or acceleration.

(i) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

(ii) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

Question 16

A. A vehicle travels the first half of a journey at 20 m s^{-1} and the second half at 30 m s^{-1}. Find its average speed for the whole journey.

(i) (i) Choose a suitable sign convention and list the known quantities. (ii) Draw or describe the velocity-time graph for the motion.

(ii) (i) Derive the required kinematic equation from the graph. (ii) Use it to find the requested displacement, velocity or acceleration.

B. (i) Calculate the relevant time, speed or distance. (ii) Check the answer using a second kinematic equation.

(i) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

(ii) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

C. (i) Derive the required kinematic equation from the graph. (ii) Use it to find the requested displacement, velocity or acceleration.

(i) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

(ii) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

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Question 17

A. The position of a particle is $x = 4t^2 - 3t + 2$, where x is in metres and t in seconds. Find its velocity and acceleration at $t = 3$ s.

(i) (i) Choose a suitable sign convention and list the known quantities. (ii) Draw or describe the velocity-time graph for the motion.

(ii) (i) Derive the required kinematic equation from the graph. (ii) Use it to find the requested displacement, velocity or acceleration.

B. (i) Calculate the relevant time, speed or distance. (ii) Check the answer using a second kinematic equation.

(i) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

(ii) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

C. (i) Derive the required kinematic equation from the graph. (ii) Use it to find the requested displacement, velocity or acceleration.

(i) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

(ii) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

Question 18

A. A ball is thrown vertically upward at $24\ \text{m s}^{-1}$. Find the maximum height and total time before it returns to the launch point.

(i) (i) Choose a suitable sign convention and list the known quantities. (ii) Draw or describe the velocity-time graph for the motion.

(ii) (i) Derive the required kinematic equation from the graph. (ii) Use it to find the requested displacement, velocity or acceleration.

B. (i) Calculate the relevant time, speed or distance. (ii) Check the answer using a second kinematic equation.

(i) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

(ii) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

C. (i) Derive the required kinematic equation from the graph. (ii) Use it to find the requested displacement, velocity or acceleration.

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(i) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

(ii) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

Question 19

A. A body covers 40 m in 4 s and 64 m in the next 4 s with constant acceleration. Find its initial velocity and acceleration.

(i) (i) Choose a suitable sign convention and list the known quantities. (ii) Draw or describe the velocity-time graph for the motion.

(ii) (i) Derive the required kinematic equation from the graph. (ii) Use it to find the requested displacement, velocity or acceleration.

B. (i) Calculate the relevant time, speed or distance. (ii) Check the answer using a second kinematic equation.

(i) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

(ii) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

C. (i) Derive the required kinematic equation from the graph. (ii) Use it to find the requested displacement, velocity or acceleration.

(i) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

(ii) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

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Question 20

A. A motorcyclist moving at 18 m s^{-1} sees an obstacle 45 m ahead and brakes uniformly. Find the minimum retardation needed to stop before the obstacle.

(i) (i) Choose a suitable sign convention and list the known quantities. (ii) Draw or describe the velocity-time graph for the motion.

(ii) (i) Derive the required kinematic equation from the graph. (ii) Use it to find the requested displacement, velocity or acceleration.

B. (i) Calculate the relevant time, speed or distance. (ii) Check the answer using a second kinematic equation.

(i) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

(ii) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

C. (i) Derive the required kinematic equation from the graph. (ii) Use it to find the requested displacement, velocity or acceleration.

(i) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

(ii) (i) Explain how the answer changes if the acceleration is halved. (ii) State one limitation of the uniform-acceleration model.

3. Projectile Motion

Question 21

A. A projectile is launched at 25 m s^{-1} at 40° above the horizontal. Calculate its time of flight, maximum height and horizontal range.

(i) (i) Resolve the initial velocity into horizontal and vertical components. (ii) Write the equations for horizontal and vertical motion.

(ii) (i) Determine the time at the stated point or at impact. (ii) Calculate the horizontal displacement and vertical displacement.

B. (i) Find the maximum height or range as applicable. (ii) Determine the velocity components at the specified time.

(i) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

(ii) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

C. (i) Determine the time at the stated point or at impact. (ii) Calculate the horizontal displacement and vertical displacement.

(i) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

(ii) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

Question 22

A. A ball is projected horizontally at 15 m s^{-1} from a cliff 45 m high. Find the time to reach the ground and the horizontal distance travelled.

(i) (i) Resolve the initial velocity into horizontal and vertical components. (ii) Write the equations for horizontal and vertical motion.

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(ii) (i) Determine the time at the stated point or at impact. (ii) Calculate the horizontal displacement and vertical displacement.

B. (i) Find the maximum height or range as applicable. (ii) Determine the velocity components at the specified time.

(i) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

(ii) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

C. (i) Determine the time at the stated point or at impact. (ii) Calculate the horizontal displacement and vertical displacement.

(i) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

(ii) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

Question 23

A. A projectile has a range of 80 m when projected at 30° on level ground. Find its initial speed, taking g = 9.8 m s^{-2}.

(i) (i) Resolve the initial velocity into horizontal and vertical components. (ii) Write the equations for horizontal and vertical motion.

(ii) (i) Determine the time at the stated point or at impact. (ii) Calculate the horizontal displacement and vertical displacement.

B. (i) Find the maximum height or range as applicable. (ii) Determine the velocity components at the specified time.

(i) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

(ii) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

C. (i) Determine the time at the stated point or at impact. (ii) Calculate the horizontal displacement and vertical displacement.

(i) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

(ii) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

Question 24

A. A stone is projected at 28 m s^{-1} at 35°. Determine its velocity components after 2 s.

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(i) (i) Resolve the initial velocity into horizontal and vertical components. (ii) Write the equations for horizontal and vertical motion.

(ii) (i) Determine the time at the stated point or at impact. (ii) Calculate the horizontal displacement and vertical displacement.

B. (i) Find the maximum height or range as applicable. (ii) Determine the velocity components at the specified time.

(i) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

(ii) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

C. (i) Determine the time at the stated point or at impact. (ii) Calculate the horizontal displacement and vertical displacement.

(i) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

(ii) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

Question 25

A. A projectile passes through two points at the same height, 2.0 s apart. If its initial vertical component is 19.6 m s^{-1}, find the height of those points above the launch level.

(i) (i) Resolve the initial velocity into horizontal and vertical components. (ii) Write the equations for horizontal and vertical motion.

(ii) (i) Determine the time at the stated point or at impact. (ii) Calculate the horizontal displacement and vertical displacement.

B. (i) Find the maximum height or range as applicable. (ii) Determine the velocity components at the specified time.

(i) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

(ii) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

C. (i) Determine the time at the stated point or at impact. (ii) Calculate the horizontal displacement and vertical displacement.

(i) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

(ii) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

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Question 26

A. A football is kicked at 20 m s^{-1} at 30°. A wall 12 m away is 2.5 m high. Determine whether the ball clears the wall.

(i) (i) Resolve the initial velocity into horizontal and vertical components. (ii) Write the equations for horizontal and vertical motion.

(ii) (i) Determine the time at the stated point or at impact. (ii) Calculate the horizontal displacement and vertical displacement.

B. (i) Find the maximum height or range as applicable. (ii) Determine the velocity components at the specified time.

(i) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

(ii) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

C. (i) Determine the time at the stated point or at impact. (ii) Calculate the horizontal displacement and vertical displacement.

(i) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

(ii) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

Question 27

A. Show by calculation that the range of a projectile on level ground is the same for complementary projection angles when launch speed is unchanged.

(i) (i) Resolve the initial velocity into horizontal and vertical components. (ii) Write the equations for horizontal and vertical motion.

(ii) (i) Determine the time at the stated point or at impact. (ii) Calculate the horizontal displacement and vertical displacement.

B. (i) Find the maximum height or range as applicable. (ii) Determine the velocity components at the specified time.

(i) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

(ii) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

C. (i) Determine the time at the stated point or at impact. (ii) Calculate the horizontal displacement and vertical displacement.

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(i) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

(ii) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

Question 28

A. A projectile is fired from a platform 20 m above level ground at 18 m s^{-1} and 25° above horizontal. Find the time until impact and horizontal range.

(i) (i) Resolve the initial velocity into horizontal and vertical components. (ii) Write the equations for horizontal and vertical motion.

(ii) (i) Determine the time at the stated point or at impact. (ii) Calculate the horizontal displacement and vertical displacement.

B. (i) Find the maximum height or range as applicable. (ii) Determine the velocity components at the specified time.

(i) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

(ii) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

C. (i) Determine the time at the stated point or at impact. (ii) Calculate the horizontal displacement and vertical displacement.

(i) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

(ii) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

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Question 29

A. A ball must land 50 m away on level ground. Find two possible projection angles if its initial speed is 25 m s^{-1}.

(i) (i) Resolve the initial velocity into horizontal and vertical components. (ii) Write the equations for horizontal and vertical motion.

(ii) (i) Determine the time at the stated point or at impact. (ii) Calculate the horizontal displacement and vertical displacement.

B. (i) Find the maximum height or range as applicable. (ii) Determine the velocity components at the specified time.

(i) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

(ii) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

C. (i) Determine the time at the stated point or at impact. (ii) Calculate the horizontal displacement and vertical displacement.

(i) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

(ii) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

Question 30

A. A projectile reaches a maximum height of 20 m. Determine its initial vertical speed and time to reach maximum height.

(i) (i) Resolve the initial velocity into horizontal and vertical components. (ii) Write the equations for horizontal and vertical motion.

(ii) (i) Determine the time at the stated point or at impact. (ii) Calculate the horizontal displacement and vertical displacement.

B. (i) Find the maximum height or range as applicable. (ii) Determine the velocity components at the specified time.

(i) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

(ii) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

C. (i) Determine the time at the stated point or at impact. (ii) Calculate the horizontal displacement and vertical displacement.

(i) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

(ii) (i) Sketch a labelled trajectory and show the velocity components. (ii) Explain which quantities remain constant and why.

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4. Newton’s Laws of Motion

Question 31

A. A 6 kg block is pulled along a smooth horizontal surface by a 24 N force. Find its acceleration and speed after 5 s from rest.

(i) (i) Draw a free-body diagram and label every force. (ii) Resolve forces along suitable axes.

(ii) (i) Apply Newton’s second law to calculate acceleration or tension. (ii) Check that the units and direction are consistent.

B. (i) Include friction, normal reaction or apparent weight where relevant. (ii) Calculate the resulting motion or force.

(i) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

(ii) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

C. (i) Apply Newton's second law to calculate acceleration or tension. (ii) Check that the units and direction are consistent.

(i) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

(ii) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

Question 32

A. A 10 kg block rests on a rough horizontal surface with coefficient of friction 0.25. Find the minimum horizontal force needed to start moving it.

(i) (i) Draw a free-body diagram and label every force. (ii) Resolve forces along suitable axes.

(ii) (i) Apply Newton's second law to calculate acceleration or tension. (ii) Check that the units and direction are consistent.

B. (i) Include friction, normal reaction or apparent weight where relevant. (ii) Calculate the resulting motion or force.

(i) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

(ii) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

C. (i) Apply Newton's second law to calculate acceleration or tension. (ii) Check that the units and direction are consistent.

(i) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

(ii) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

Question 33

A. Two masses of 4 kg and 6 kg are connected by a light string over a smooth pulley. Find the acceleration and string tension.

(i) (i) Draw a free-body diagram and label every force. (ii) Resolve forces along suitable axes.

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(ii) (i) Apply Newton's second law to calculate acceleration or tension. (ii) Check that the units and direction are consistent.

B. (i) Include friction, normal reaction or apparent weight where relevant. (ii) Calculate the resulting motion or force.

(i) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

(ii) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

C. (i) Apply Newton's second law to calculate acceleration or tension. (ii) Check that the units and direction are consistent.

(i) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

(ii) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

Question 34

A. A 5 kg body is pulled by a 30 N force at 30° above the horizontal on a smooth floor. Find its horizontal acceleration and normal reaction.

(i) (i) Draw a free-body diagram and label every force. (ii) Resolve forces along suitable axes.

(ii) (i) Apply Newton's second law to calculate acceleration or tension. (ii) Check that the units and direction are consistent.

B. (i) Include friction, normal reaction or apparent weight where relevant. (ii) Calculate the resulting motion or force.

(i) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

(ii) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

C. (i) Apply Newton's second law to calculate acceleration or tension. (ii) Check that the units and direction are consistent.

(i) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

(ii) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

Question 35

A. A 1200 kg car rounds a flat curve of radius 50 m at 15 m s^{-1}. Calculate the frictional force needed to keep it on the curve.

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(i) (i) Draw a free-body diagram and label every force. (ii) Resolve forces along suitable axes.

(ii) (i) Apply Newton's second law to calculate acceleration or tension. (ii) Check that the units and direction are consistent.

B. (i) Include friction, normal reaction or apparent weight where relevant. (ii) Calculate the resulting motion or force.

(i) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

(ii) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

C. (i) Apply Newton's second law to calculate acceleration or tension. (ii) Check that the units and direction are consistent.

(i) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

(ii) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

Question 36

A. A lift of mass 500 kg accelerates upward at 1.5 m s^{-2}. Find the tension in its supporting cable.

(i) (i) Draw a free-body diagram and label every force. (ii) Resolve forces along suitable axes.

(ii) (i) Apply Newton's second law to calculate acceleration or tension. (ii) Check that the units and direction are consistent.

B. (i) Include friction, normal reaction or apparent weight where relevant. (ii) Calculate the resulting motion or force.

(i) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

(ii) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

C. (i) Apply Newton's second law to calculate acceleration or tension. (ii) Check that the units and direction are consistent.

(i) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

(ii) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

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Question 37

A. A 2 kg block on a smooth table is connected over a pulley to a hanging 3 kg mass. Find the acceleration and string tension.

(i) (i) Draw a free-body diagram and label every force. (ii) Resolve forces along suitable axes.

(ii) (i) Apply Newton's second law to calculate acceleration or tension. (ii) Check that the units and direction are consistent.

B. (i) Include friction, normal reaction or apparent weight where relevant. (ii) Calculate the resulting motion or force.

(i) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

(ii) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

C. (i) Apply Newton's second law to calculate acceleration or tension. (ii) Check that the units and direction are consistent.

(i) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

(ii) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

Question 38

A. A 0.15 kg ball moving at 20 m s^{-1} rebounds in the opposite direction at 12 m s^{-1}. If contact lasts 0.02 s, find the average force on the ball.

(i) (i) Draw a free-body diagram and label every force. (ii) Resolve forces along suitable axes.

(ii) (i) Apply Newton's second law to calculate acceleration or tension. (ii) Check that the units and direction are consistent.

B. (i) Include friction, normal reaction or apparent weight where relevant. (ii) Calculate the resulting motion or force.

(i) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

(ii) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

C. (i) Apply Newton's second law to calculate acceleration or tension. (ii) Check that the units and direction are consistent.

(i) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

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(ii) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

Question 39

A. A 60 kg person stands on a weighing scale in a lift accelerating downward at 2 m s^{-2}. Find the scale reading in newtons.

(i) (i) Draw a free-body diagram and label every force. (ii) Resolve forces along suitable axes.

(ii) (i) Apply Newton's second law to calculate acceleration or tension. (ii) Check that the units and direction are consistent.

B. (i) Include friction, normal reaction or apparent weight where relevant. (ii) Calculate the resulting motion or force.

(i) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

(ii) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

C. (i) Apply Newton's second law to calculate acceleration or tension. (ii) Check that the units and direction are consistent.

(i) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

(ii) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

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Question 40

A. A 8 kg block is pushed with 50 N at 30° below the horizontal. If μ = 0.20, calculate the friction and acceleration.

(i) (i) Draw a free-body diagram and label every force. (ii) Resolve forces along suitable axes.

(ii) (i) Apply Newton's second law to calculate acceleration or tension. (ii) Check that the units and direction are consistent.

B. (i) Include friction, normal reaction or apparent weight where relevant. (ii) Calculate the resulting motion or force.

(i) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

(ii) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

C. (i) Apply Newton's second law to calculate acceleration or tension. (ii) Check that the units and direction are consistent.

(i) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

(ii) (i) State what changes if the surface is smooth or the acceleration reverses. (ii) Explain the physical meaning of the result.

6. Circular Motion

Question 41

A. A car moves at 20 m s^{-1} around a horizontal circular track of radius 80 m. Find its centripetal acceleration.

(i) (i) Convert all quantities to SI units and identify the radius and speed/angular speed. (ii) Write the centripetal acceleration relation.

(ii) (i) Calculate the required centripetal force or angular quantity. (ii) Identify which real force provides the centripetal resultant.

B. (i) Determine the limiting condition, period or frequency where applicable. (ii) Substitute values carefully.

(i) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

(ii) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

C. (i) Calculate the required centripetal force or angular quantity. (ii) Identify which real force provides the centripetal resultant.

(i) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

(ii) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

Question 42

A. A 0.25 kg stone is whirled in a horizontal circle of radius 0.8 m at 4 revolutions per second. Calculate its speed and centripetal force.

(i) (i) Convert all quantities to SI units and identify the radius and speed/angular speed. (ii) Write the centripetal acceleration relation.

(ii) (i) Calculate the required centripetal force or angular quantity. (ii) Identify which real force provides the centripetal resultant.

B. (i) Determine the limiting condition, period or frequency where applicable. (ii) Substitute values carefully.

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(i) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

(ii) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

C. (i) Calculate the required centripetal force or angular quantity. (ii) Identify which real force provides the centripetal resultant.

(i) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

(ii) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

Question 43

A. A vehicle rounds a banked curve of radius 100 m at 20 m s^{-1}. Find the banking angle required if friction is negligible.

(i) (i) Convert all quantities to SI units and identify the radius and speed/angular speed. (ii) Write the centripetal acceleration relation.

(ii) (i) Calculate the required centripetal force or angular quantity. (ii) Identify which real force provides the centripetal resultant.

B. (i) Determine the limiting condition, period or frequency where applicable. (ii) Substitute values carefully.

(i) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

(ii) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

C. (i) Calculate the required centripetal force or angular quantity. (ii) Identify which real force provides the centripetal resultant.

(i) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

(ii) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

Question 44

A. A particle moves in a circle of radius 2 m with angular speed 6 rad s^{-1}. Find its linear speed and centripetal acceleration.

(i) (i) Convert all quantities to SI units and identify the radius and speed/angular speed. (ii) Write the centripetal acceleration relation.

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(ii) (i) Calculate the required centripetal force or angular quantity. (ii) Identify which real force provides the centripetal resultant.

B. (i) Determine the limiting condition, period or frequency where applicable. (ii) Substitute values carefully.

(i) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

(ii) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

C. (i) Calculate the required centripetal force or angular quantity. (ii) Identify which real force provides the centripetal resultant.

(i) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

(ii) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

Question 45

A. A 0.4 kg mass is attached to a string of length 1.2 m and moves in a vertical circle. Find the minimum speed at the top for the string to remain just taut.

(i) (i) Convert all quantities to SI units and identify the radius and speed/angular speed. (ii) Write the centripetal acceleration relation.

(ii) (i) Calculate the required centripetal force or angular quantity. (ii) Identify which real force provides the centripetal resultant.

B. (i) Determine the limiting condition, period or frequency where applicable. (ii) Substitute values carefully.

(i) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

(ii) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

C. (i) Calculate the required centripetal force or angular quantity. (ii) Identify which real force provides the centripetal resultant.

(i) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

(ii) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

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Question 46

A. A cyclist rounds a curve of radius 25 m. If the coefficient of friction between tyres and road is 0.4, find the maximum safe speed on a level road.

(i) (i) Convert all quantities to SI units and identify the radius and speed/angular speed. (ii) Write the centripetal acceleration relation.

(ii) (i) Calculate the required centripetal force or angular quantity. (ii) Identify which real force provides the centripetal resultant.

B. (i) Determine the limiting condition, period or frequency where applicable. (ii) Substitute values carefully.

(i) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

(ii) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

C. (i) Calculate the required centripetal force or angular quantity. (ii) Identify which real force provides the centripetal resultant.

(i) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

(ii) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

Question 47

A. A rotating wheel makes 120 revolutions in 30 s. Calculate its frequency, period and angular speed.

(i) (i) Convert all quantities to SI units and identify the radius and speed/angular speed. (ii) Write the centripetal acceleration relation.

(ii) (i) Calculate the required centripetal force or angular quantity. (ii) Identify which real force provides the centripetal resultant.

B. (i) Determine the limiting condition, period or frequency where applicable. (ii) Substitute values carefully.

(i) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

(ii) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

C. (i) Calculate the required centripetal force or angular quantity. (ii) Identify which real force provides the centripetal resultant.

(i) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

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(ii) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

Question 48

A. A 2 kg object moves in a circle of radius 3 m at constant speed 9 m s^{-1}. Calculate the net force and the work done by this force over one complete revolution.

(i) (i) Convert all quantities to SI units and identify the radius and speed/angular speed. (ii) Write the centripetal acceleration relation.

(ii) (i) Calculate the required centripetal force or angular quantity. (ii) Identify which real force provides the centripetal resultant.

B. (i) Determine the limiting condition, period or frequency where applicable. (ii) Substitute values carefully.

(i) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

(ii) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

C. (i) Calculate the required centripetal force or angular quantity. (ii) Identify which real force provides the centripetal resultant.

(i) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

(ii) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

Question 49

A. A particle's angular position is $\theta = 3t^2 + 2t$. Find its angular velocity and angular acceleration at $t = 4$ s.

(i) (i) Convert all quantities to SI units and identify the radius and speed/angular speed. (ii) Write the centripetal acceleration relation.

(ii) (i) Calculate the required centripetal force or angular quantity. (ii) Identify which real force provides the centripetal resultant.

B. (i) Determine the limiting condition, period or frequency where applicable. (ii) Substitute values carefully.

(i) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

(ii) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

C. (i) Calculate the required centripetal force or angular quantity. (ii) Identify which real force provides the centripetal resultant.

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(i) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

(ii) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

Question 50

A. A conical pendulum has string length 1.5 m and makes an angle of 30° with the vertical. Find its angular speed and period.

(i) (i) Convert all quantities to SI units and identify the radius and speed/angular speed. (ii) Write the centripetal acceleration relation.

(ii) (i) Calculate the required centripetal force or angular quantity. (ii) Identify which real force provides the centripetal resultant.

B. (i) Determine the limiting condition, period or frequency where applicable. (ii) Substitute values carefully.

(i) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

(ii) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

C. (i) Calculate the required centripetal force or angular quantity. (ii) Identify which real force provides the centripetal resultant.

(i) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

(ii) (i) Explain how the result changes if speed is doubled. (ii) State the direction of acceleration and justify it.

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7. Rotational Motion

Question 51

A. A uniform solid cylinder of mass 8 kg and radius 0.20 m rotates at 12 rad s^{-1}. Calculate its moment of inertia and rotational kinetic energy.

(i) (i) Identify the axis of rotation and choose the correct moment-of-inertia expression. (ii) Calculate the moment of inertia or torque.

(ii) (i) Apply $\tau = I\alpha$ or the rotational kinematic equations. (ii) Find angular acceleration, angular speed or displacement.

B. (i) Calculate rotational kinetic energy or angular momentum. (ii) Check dimensional consistency.

(i) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

(ii) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

C. (i) Apply $\tau = I\alpha$ or the rotational kinematic equations. (ii) Find angular acceleration, angular speed or displacement.

(i) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

(ii) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

Question 52

A. A torque of 15 N m acts on a wheel with moment of inertia 3 kg m^2. Find its angular acceleration.

(i) (i) Identify the axis of rotation and choose the correct moment-of-inertia expression. (ii) Calculate the moment of inertia or torque.

(ii) (i) Apply $\tau = I\alpha$ or the rotational kinematic equations. (ii) Find angular acceleration, angular speed or displacement.

B. (i) Calculate rotational kinetic energy or angular momentum. (ii) Check dimensional consistency.

(i) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

(ii) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

C. (i) Apply $\tau = I\alpha$ or the rotational kinematic equations. (ii) Find angular acceleration, angular speed or displacement.

(i) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

(ii) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

Question 53

A. A uniform rod of mass 4 kg and length 2 m rotates about an axis through its centre and perpendicular to its length. Find its moment of inertia.

(i) (i) Identify the axis of rotation and choose the correct moment-of-inertia expression. (ii) Calculate the moment of inertia or torque.

(ii) (i) Apply $\tau = I\alpha$ or the rotational kinematic equations. (ii) Find angular acceleration, angular speed or displacement.

B. (i) Calculate rotational kinetic energy or angular momentum. (ii) Check dimensional consistency.

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(i) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

(ii) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

C. (i) Apply $\tau = I\alpha$ or the rotational kinematic equations. (ii) Find angular acceleration, angular speed or displacement.

(i) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

(ii) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

Question 54

A. A disc starts from rest and has angular acceleration 2.5 rad s^{-2} for 6 s. Find its final angular speed and angular displacement.

(i) (i) Identify the axis of rotation and choose the correct moment-of-inertia expression. (ii) Calculate the moment of inertia or torque.

(ii) (i) Apply $\tau = I\alpha$ or the rotational kinematic equations. (ii) Find angular acceleration, angular speed or displacement.

B. (i) Calculate rotational kinetic energy or angular momentum. (ii) Check dimensional consistency.

(i) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

(ii) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

C. (i) Apply $\tau = I\alpha$ or the rotational kinematic equations. (ii) Find angular acceleration, angular speed or displacement.

(i) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

(ii) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

Question 55

A. A flywheel of moment of inertia 5 kg m^2 rotates at 20 rad s^{-1}. A constant braking torque of 10 N m is applied. Find the stopping time and angular displacement before stopping.

(i) (i) Identify the axis of rotation and choose the correct moment-of-inertia expression. (ii) Calculate the moment of inertia or torque.

(ii) (i) Apply $\tau = I\alpha$ or the rotational kinematic equations. (ii) Find angular acceleration, angular speed or displacement.

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B. (i) Calculate rotational kinetic energy or angular momentum. (ii) Check dimensional consistency.

(i) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

(ii) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

C. (i) Apply $\tau = I\alpha$ or the rotational kinematic equations. (ii) Find angular acceleration, angular speed or displacement.

(i) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

(ii) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

Question 56

A. A solid sphere rolls without slipping down a vertical height of 1.8 m. Find its speed at the bottom.

(i) (i) Identify the axis of rotation and choose the correct moment-of-inertia expression. (ii) Calculate the moment of inertia or torque.

(ii) (i) Apply $\tau = I\alpha$ or the rotational kinematic equations. (ii) Find angular acceleration, angular speed or displacement.

B. (i) Calculate rotational kinetic energy or angular momentum. (ii) Check dimensional consistency.

(i) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

(ii) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

C. (i) Apply $\tau = I\alpha$ or the rotational kinematic equations. (ii) Find angular acceleration, angular speed or displacement.

(i) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

(ii) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

Question 57

A. Two point masses of 2 kg and 3 kg are placed 0.5 m and 0.8 m from an axis respectively. Calculate the total moment of inertia about the axis.

(i) (i) Identify the axis of rotation and choose the correct moment-of-inertia expression. (ii) Calculate the moment of inertia or torque.

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(ii) (i) Apply $\tau = I\alpha$ or the rotational kinematic equations. (ii) Find angular acceleration, angular speed or displacement.

B. (i) Calculate rotational kinetic energy or angular momentum. (ii) Check dimensional consistency.

(i) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

(ii) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

C. (i) Apply $\tau = I\alpha$ or the rotational kinematic equations. (ii) Find angular acceleration, angular speed or displacement.

(i) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

(ii) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

Question 58

A. A tangential force of 25 N acts at the rim of a wheel of radius 0.4 m. If its moment of inertia is 2 kg m^2, find angular acceleration.

(i) (i) Identify the axis of rotation and choose the correct moment-of-inertia expression. (ii) Calculate the moment of inertia or torque.

(ii) (i) Apply $\tau = I\alpha$ or the rotational kinematic equations. (ii) Find angular acceleration, angular speed or displacement.

B. (i) Calculate rotational kinetic energy or angular momentum. (ii) Check dimensional consistency.

(i) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

(ii) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

C. (i) Apply $\tau = I\alpha$ or the rotational kinematic equations. (ii) Find angular acceleration, angular speed or displacement.

(i) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

(ii) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

Question 59

A. A 3 kg uniform rod of length 1.2 m is pivoted at one end and released from horizontal. Find its initial angular acceleration.

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(i) (i) Identify the axis of rotation and choose the correct moment-of-inertia expression. (ii) Calculate the moment of inertia or torque.

(ii) (i) Apply $\tau = I\alpha$ or the rotational kinematic equations. (ii) Find angular acceleration, angular speed or displacement.

B. (i) Calculate rotational kinetic energy or angular momentum. (ii) Check dimensional consistency.

(i) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

(ii) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

C. (i) Apply $\tau = I\alpha$ or the rotational kinematic equations. (ii) Find angular acceleration, angular speed or displacement.

(i) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

(ii) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

Question 60

A. A rotating body has angular momentum 18 kg m^2 s^{-1} and moment of inertia 3 kg m^2. Find its angular speed and rotational kinetic energy.

(i) (i) Identify the axis of rotation and choose the correct moment-of-inertia expression. (ii) Calculate the moment of inertia or torque.

(ii) (i) Apply $\tau = I\alpha$ or the rotational kinematic equations. (ii) Find angular acceleration, angular speed or displacement.

B. (i) Calculate rotational kinetic energy or angular momentum. (ii) Check dimensional consistency.

(i) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

(ii) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

C. (i) Apply $\tau = I\alpha$ or the rotational kinematic equations. (ii) Find angular acceleration, angular speed or displacement.

(i) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

(ii) (i) Explain the effect of changing the axis or mass distribution. (ii) State any assumptions about the body and the applied torque.

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8. Gravitation

Question 61

A. Calculate the gravitational force between masses of 5 kg and 12 kg separated by 0.40 m.

(i) (i) Draw a labelled diagram showing the centre of the planet and the relevant radius/distance. (ii) State the gravitational law or orbital relation needed.

(ii) (i) Derive or select the appropriate expression before substituting values. (ii) Calculate the requested force, field, potential, speed or period.

B. (i) Compare the result with the surface value or a second orbit where appropriate. (ii) Give the ratio clearly.

(i) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

(ii) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

C. (i) Derive or select the appropriate expression before substituting values. (ii) Calculate the requested force, field, potential, speed or period.

(i) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

(ii) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

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Question 62

A. Find the acceleration due to gravity at a height equal to Earth's radius above its surface, given surface gravity g.

(i) (i) Draw a labelled diagram showing the centre of the planet and the relevant radius/distance. (ii) State the gravitational law or orbital relation needed.

(ii) (i) Derive or select the appropriate expression before substituting values. (ii) Calculate the requested force, field, potential, speed or period.

B. (i) Compare the result with the surface value or a second orbit where appropriate. (ii) Give the ratio clearly.

(i) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

(ii) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

C. (i) Derive or select the appropriate expression before substituting values. (ii) Calculate the requested force, field, potential, speed or period.

(i) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

(ii) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

Question 63

A. A satellite orbits Earth at a radius 7.0×10^6 m from Earth's centre. Given GM = 3.986×10^{14} m^3 s^{-2}, calculate its orbital speed and period.

(i) (i) Draw a labelled diagram showing the centre of the planet and the relevant radius/distance. (ii) State the gravitational law or orbital relation needed.

(ii) (i) Derive or select the appropriate expression before substituting values. (ii) Calculate the requested force, field, potential, speed or period.

B. (i) Compare the result with the surface value or a second orbit where appropriate. (ii) Give the ratio clearly.

(i) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

(ii) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

C. (i) Derive or select the appropriate expression before substituting values. (ii) Calculate the requested force, field, potential, speed or period.

(i) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

(ii) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

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Question 64

A. Derive an expression for the escape speed from a planet of mass M and radius R, then calculate it for Earth using g = 9.8 m s^{-2} and R = 6.4×10^6 m.

(i) (i) Draw a labelled diagram showing the centre of the planet and the relevant radius/distance. (ii) State the gravitational law or orbital relation needed.

(ii) (i) Derive or select the appropriate expression before substituting values. (ii) Calculate the requested force, field, potential, speed or period.

B. (i) Compare the result with the surface value or a second orbit where appropriate. (ii) Give the ratio clearly.

(i) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

(ii) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

C. (i) Derive or select the appropriate expression before substituting values. (ii) Calculate the requested force, field, potential, speed or period.

(i) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

(ii) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

Question 65

A. Two masses attract each other with force F. Determine the new force if one mass is doubled and the separation is tripled.

(i) (i) Draw a labelled diagram showing the centre of the planet and the relevant radius/distance. (ii) State the gravitational law or orbital relation needed.

(ii) (i) Derive or select the appropriate expression before substituting values. (ii) Calculate the requested force, field, potential, speed or period.

B. (i) Compare the result with the surface value or a second orbit where appropriate. (ii) Give the ratio clearly.

(i) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

(ii) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

C. (i) Derive or select the appropriate expression before substituting values. (ii) Calculate the requested force, field, potential, speed or period.

(i) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

(ii) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

Question 66

A. Calculate the gravitational potential at a point 2.0×10^{7} m from Earth's centre, given GM = 3.986×10^{14} $m^{3}\ s^{-2}$.

(i) (i) Draw a labelled diagram showing the centre of the planet and the relevant radius/distance. (ii) State the gravitational law or orbital relation needed.

(ii) (i) Derive or select the appropriate expression before substituting values. (ii) Calculate the requested force, field, potential, speed or period.

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B. (i) Compare the result with the surface value or a second orbit where appropriate. (ii) Give the ratio clearly.

(i) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

(ii) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

C. (i) Derive or select the appropriate expression before substituting values. (ii) Calculate the requested force, field, potential, speed or period.

(i) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

(ii) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

Question 67

A. A satellite has an orbital period of 90 minutes. If another satellite orbits the same planet at four times the orbital radius, find its period.

(i) (i) Draw a labelled diagram showing the centre of the planet and the relevant radius/distance. (ii) State the gravitational law or orbital relation needed.

(ii) (i) Derive or select the appropriate expression before substituting values. (ii) Calculate the requested force, field, potential, speed or period.

B. (i) Compare the result with the surface value or a second orbit where appropriate. (ii) Give the ratio clearly.

(i) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

(ii) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

C. (i) Derive or select the appropriate expression before substituting values. (ii) Calculate the requested force, field, potential, speed or period.

(i) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

(ii) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

Question 68

A. Show how the value of g varies with depth d below Earth’s surface, assuming Earth has uniform density.

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(i) (i) Draw a labelled diagram showing the centre of the planet and the relevant radius/distance. (ii) State the gravitational law or orbital relation needed.

(ii) (i) Derive or select the appropriate expression before substituting values. (ii) Calculate the requested force, field, potential, speed or period.

B. (i) Compare the result with the surface value or a second orbit where appropriate. (ii) Give the ratio clearly.

(i) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

(ii) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

C. (i) Derive or select the appropriate expression before substituting values. (ii) Calculate the requested force, field, potential, speed or period.

(i) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

(ii) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

Question 69

A. A planet has twice Earth's mass and twice Earth's radius. Find the ratio of its surface gravitational acceleration to Earth's.

(i) (i) Draw a labelled diagram showing the centre of the planet and the relevant radius/distance. (ii) State the gravitational law or orbital relation needed.

(ii) (i) Derive or select the appropriate expression before substituting values. (ii) Calculate the requested force, field, potential, speed or period.

B. (i) Compare the result with the surface value or a second orbit where appropriate. (ii) Give the ratio clearly.

(i) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

(ii) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

C. (i) Derive or select the appropriate expression before substituting values. (ii) Calculate the requested force, field, potential, speed or period.

(i) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

(ii) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

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Question 70

A. Find the minimum work needed to move a 100 kg payload from Earth's surface to a very large distance away, using $GM = 3.986 \times 10^{14}\ m^3\ s^{-2}$ and $R = 6.4 \times 10^6\ m$.

(i) (i) Draw a labelled diagram showing the centre of the planet and the relevant radius/distance. (ii) State the gravitational law or orbital relation needed.

(ii) (i) Derive or select the appropriate expression before substituting values. (ii) Calculate the requested force, field, potential, speed or period.

B. (i) Compare the result with the surface value or a second orbit where appropriate. (ii) Give the ratio clearly.

(i) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

(ii) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

C. (i) Derive or select the appropriate expression before substituting values. (ii) Calculate the requested force, field, potential, speed or period.

(i) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

(ii) (i) Explain the physical meaning of the sign or variation. (ii) State the assumptions made about the planet and orbit.

11. Oscillations and Waves

Question 71

A. A mass of 0.50 kg is attached to a spring of force constant 200 $N\ m^{-1}$. Calculate the period and frequency of small oscillations.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

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C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

Question 72

A. A simple pendulum has length 1.0 m. Find its period at a location where g = 9.8 m s^{-2}.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

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Question 73

A. An oscillator has amplitude 0.08 m and angular frequency 5 rad s^{-1}. Find its maximum speed and maximum acceleration.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

Question 74

A. A wave has frequency 250 Hz and wavelength 1.2 m. Calculate its propagation speed.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

Question 75

A. A string fixed at both ends has length 1.5 m and wave speed 120 m s^{-1}. Find its fundamental frequency and third-harmonic frequency.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

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(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

Question 76

A. Two tuning forks of frequencies 256 Hz and 262 Hz sound together. Calculate the beat frequency.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

9. Electrostatics

Question 77

A. Two point charges +4.0 μC and −6.0 μC are separated by 0.30 m in air. Calculate the magnitude and direction of the electrostatic force between them.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

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(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

Question 78

A. Charges +3.0 μC and +8.0 μC are separated by 0.40 m. A third charge is placed on the line joining them. Determine the position at which the net electric force on the third charge is zero.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

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Question 79

A. Three point charges are placed at the corners of an equilateral triangle of side 0.20 m: +2 μC, +2 μC and −3 μC. Calculate the resultant force on the −3 μC charge.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

Question 80

A. Two identical small conducting spheres carry charges +8 μC and −2 μC. They are touched together and separated. Find the final charge on each sphere and explain charge conservation.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

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(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

Question 81

A. A charge of +5 μC is placed at the origin. Calculate the electric field strength and direction at a point 0.25 m away.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

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Question 82

A. Two charges +4 μC and −4 μC are separated by 0.12 m. Calculate the electric field at the midpoint between them.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

Question 83

A. At a point P, two perpendicular electric field components have magnitudes 3.0×10^{4} N C^{-1} and 4.0×10^{4} N C^{-1}. Find the resultant field and its direction.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

Question 84

A. A charge +2 μC is moved between two points with potential difference 150 V. Calculate the work done by the electric field and the change in electric potential energy.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

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B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

Question 85

A. Calculate the electric potential at a point 0.20 m from a point charge of −7 μC in air.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

Question 86

A. Charges +3 μC and +5 μC are separated by 0.50 m. Calculate the electric potential at the midpoint and the work needed to bring a +2 μC charge from infinity to that midpoint.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

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(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

Question 87

A. An electron is released from rest in a uniform electric field of magnitude $2.0 \times 10^{4}\ \mathrm{N\,C^{-1}}$. Find the magnitude of its acceleration. Use $e = 1.60 \times 10^{-19}\ \mathrm{C}$ and $m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

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Question 88

A. An oil drop carrying charge -3.2×10^{-19} C is suspended at rest in a vertical electric field. If its mass is 2.0×10^{-15} kg, determine the magnitude and direction of the field.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

Question 89

A. A parallel-plate capacitor has plate area 0.020 m^2 and separation 1.0 mm. Calculate its capacitance in air, taking $\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

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(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

Question 90

A. A 6 μF capacitor is connected to a 12 V battery. Find its charge and stored energy.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

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Question 91

A. Capacitors of 2 μF, 3 μF and 6 μF are connected in series across a 24 V supply. Calculate the equivalent capacitance, charge on each capacitor and voltage across each.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

Question 92

A. Capacitors of 4 μF and 8 μF are connected in parallel across 10 V. Find the equivalent capacitance, total charge and energy stored in the combination.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

Question 93

A. A 5 μF capacitor charged to 100 V is disconnected from the battery and connected in parallel to an uncharged 10 μF capacitor. Determine the final common voltage and the energy lost during redistribution.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

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(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

Question 94

A. A dielectric of relative permittivity 4 completely fills a parallel-plate capacitor. Explain and calculate how its capacitance changes compared with air if the original capacitance is 2 μF.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

Question 95

A. Derive the expression for the electric field between two large oppositely charged parallel plates, neglecting edge effects, and state the assumptions used.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

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(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

Question 96

A. Using Coulomb's law, explain why the electrostatic force follows an inverse-square relation. Then calculate how the force changes when the separation is reduced to one-third of its original value.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

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Question 97

A. Four equal charges +q are placed at the corners of a square of side a. Determine the magnitude and direction of the resultant electric field at the centre.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

Question 98

A. A uniformly charged ring has total charge Q and radius R. Write an expression for the electric field on its axis at distance x from the centre, and find where the field is maximum.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

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(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

Question 99

A. An electric dipole consists of charges ±4 μC separated by 5.0 mm. Calculate its dipole moment and estimate the far-field electric field on its axial line at 0.20 m, using $E = (1/(4\pi\varepsilon_0))(2p/r^3)$.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

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Question 100

A. A charged particle enters a uniform electric field perpendicular to its initial velocity. Describe its path and derive an expression for its vertical deflection after travelling a horizontal distance L between plates.

(i) (i) Identify the oscillating system and write the governing relation. (ii) Express all values in SI units.

(ii) (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

B. (i) Sketch a labelled displacement-time or wave diagram. (ii) Mark the amplitude, wavelength, period or nodes as appropriate.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

C. (i) Calculate the requested period, frequency, speed or amplitude-related quantity. (ii) Check the result using a second relation where possible.

(i) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

(ii) (i) Explain the physical meaning of the result. (ii) State how the answer changes if frequency, length or stiffness is changed.

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