For a ball bearing falling through a liquid, it has thee forces acting on it namely the up thrust, the weight of the bearing, w and the viscous force F acting as indicated above. As the ball accelerates downwards the velocity V increases consequently the viscous force F increases.

So the sum of the upward forces ie $F+u$ also increases. But since u and w are constant, it implies that the ball retards. As F increases due to increased velocity an instant is reached when F+u= w_1 and therefore the acceleration will be zero.

Revision Exercise (Mechanics)

The velocity of propagation, c, of ripple on the surface of a liquid is given by one of the following equations.

i) $c^2 = A\rho\lambda/_\gamma$ iii) $c = A_\gamma/_{\rho\lambda}$

ii) $c = A\rho\lambda y^2$ iv) $c = A\rho_\gamma/_\lambda$

Where A is a dimensionless consistent, $_\gamma$ is the surface tension of the liquid, ρ is its density and λ is the wavelength of the ripples.

a) Use the method of dimensions to determine which equation is correct.

b) By a graphical method, use the following figures for water to confirm your choice , and to determine the value of A.

C(ms^{-1})	0.67	0.45	0.36	0.27
$\lambda x10^{-3}$ (m)	1.0	2.2	3.5	6.1

(coefficient of surface tension of water = 7.2 x 10^{-2} Nm-1 and density of water =10^3 kg/m^3)

2 (a)(i) Explain the meaning of dimensions of a physical quantity

ii)The velocity v of waves of wavelength λ, on the surface on the pool of liquid, of surface tension γ and density ρ respectively is given by $v^2 = \frac{\lambda g}{2\pi} + \frac{2\pi\gamma}{\lambda\rho}$ where g is the acceleration due to gravity. Show that the above equation is dimensionally correct.

iii)A sphere of radius, a, moving through a liquid of density ρ with a high velocity v experiences a retarding force F given by

$F = ka^x\rho^y v^z$ where k is anon dimensional coefficient. Use the method of dimensions to find the values of x, y and z.

(b)(i) Define coefficient of viscosity η and obtain its dimensions.

ii) The viscous drag F on a solid sphere moving through a viscous medium may be considered to depend on the velocity v of the sphere, its radius r and the coefficient of viscosity η of the medium $F = kv^a r^b \eta^c$ where a, b and c are numbers and k is a numerical constant. Use dimensional analysis to solve for a, b and c.

3(a) Assuming conditions of streamline flow, the volume rate of flow ($^V/_t$) of a liquid issuing from the tube will depend on the pressure gradient ($^p/_L$) along the tube, the radius r of the tube and the coefficient of viscosity η of the liquid. Show that $\left(\frac{v}{t}\right) = \frac{kPr^4}{\eta L}$ is dimensionally consistent where k is some numerical constant.

(b) the characteristic of wave motion in deep water is such that $v = \left[\frac{\lambda}{2\pi}\left(A + \frac{4\pi^2}{\lambda^2\rho}\right)\right]^x$ where A is a constant which has dimensions, v is the velocity of the wave, λ is its wavelength γ is the surface tension, ρ is the density. Using a method of dimensions, obtain the value of x and the dimensions of A.

(c) Use the dimensional analysis to show the velocity of transverse vibrations of a stretched string depends on its length (L), mass (m) and the tensional force (F) in the string.

4(a) A body of mass 30kg lies on a smooth table at a distance of 10m from the edge of the table. The mass is connected to another mass of 10 kg by a light inelastic string passing over a small smooth pulley at the edge of the table. Find

i) The acceleration of the system

ii) The tension in the string

iii) The time taken by the 30 kg mass to reach the edge of the table.

b)P is a smooth fixed pulley, over which passes a light inelastic string. Each end of the string supports a scale pan of mass m kg. One scale pan contains a particle of mass m_1 kg, the other contains a particle of mass m_2 kg.

Given that $m_1 > m_2$.

(i)Determine an expression for the magnitude of the acceleration of the scale pan and its contents.

(ii) Show that the reaction R_1 of the scale pan on the particle of mass m_1 kg is given by

$$R_1 = \frac{2m_{1(m+m_2)g}}{(2m + m_1 + m_2)}$$

c)Sand is deposited at a uniform rate of 20kgs^{-1} and with negligible kinetic energy onto an empty conveyor belt moving horizontally at a constant speed of 10m per minute. Find

(i) the force required to maintain the constant velocity.

(ii) the power required to maintain the constant velocity.

(iii) the rate of change of kinetic energy of the moving sand. Why are the latter two quantities unequal.

5(a)(i) State Newton's laws of motion.

(ii) A man of mass 80 kg stands on a platform of mass 40 kg. The pulls a rope that is fastened to the platform and runs over a pulley on the ceiling. With what force does he have to pull, in order to give himself and the platform an upward acceleration of 1ms^{-2}?

(b)(i) Water leaves a hose at a rate of 5.0kgs^{-1} with a speed of 20m/s and is directed horizontally on a vertical wall which supports it. Calculate the force exerted by the water on the wall.

(ii) Rain is falling vertically at 8.0ms^{-1} relative to the ground. The raindrops make tracks on the side window of a car at an angle of 30° below the horizontal. Calculate the speed of the car.

6)(a) Briefly distinguish between conservative and non-conservative forces. Give an example of each.

(b) An ideal massless spring S can be compressed 2.0cm by a force of 200N. The same spring is placed at the bottom of a frictionless inclined plane which makes an angle of 45° with the horizontal as shown below.

A 2.0 kg mass m is released from rest at the top of the incline and is brought to rest momentarily after the compressing the string by 3.0 cm. find:

(i) The elastic potential energy stored in the spring.
(ii) The distance through which the mass slides before it reaches the spring.
(iii) The speed of the mass just before it reaches the spring.
(iv) The time taken by the mass to reach the spring.

(c) A particle of mass m kg is suspended from a fixed point by a light elastic cord of natural length **a** metres. The particle gives an extended length of **b** metres of the cord when hanging freely under gravity. The particle is then held at the point of suspension and left to fall.

(i) Determine an expression for the elastic constant of the cord in terms of **a, b** and **m.**
(ii) Use the principle of conservation of mechanical energy to determine an expression for the speed of the particle at a point **2a** metres below the point of suspension.

7. (a) A loaded box is being pulled uniformly up a rough inclined plane by means of a light inextensible rope. The inclined plane makes an angle θ with the horizontal.

(i) Draw a force diagram to indicate the forces on the box.
(ii) If the mass of the box is 200 kg and the coefficient of sliding friction between the box and the plane is 0.4 and θ=25°, What work must be done to pull the box a distance 10m up the plane?
(iii) If the rope breaks, what will be its velocity after travelling down the plane?
(iv)Describe qualitatively, the energy transformations that occur in a(iii) above.

(b) A car of mass 1000kg increases its speed from $10ms^{-1}$ to $20ms^{-1}$ whilst moving 500m up a road inclined at an angle α to the horizontal where $\sin\alpha=\frac{1}{20}$. There is a constant resistance to motion of 300N. Calculate the driving force exerted by the engine assuming that it is constant.

(c) A cyclist coasts down a 4° hill at $6kmh^{-1}$. If the force of friction is proportional to the speed, so that frictional force $F=Cv$ where C is a constant. Calculate

(i) The value of C
(ii) The average force that must be applied in order to descend the hill at 20 kmh^{-1}. Assume the mass of the cyclist plus the bicycle is 80 kg.

8.(a)(i) Define the term power as applied to a machine.

(ii) A truck of mass 1500 kg moves with uniform velocity of 5.0 ms^{-1} up a straight track inclined at an angle of 30o to the horizontal. The total frictional resistance to the motion of the truck is 580N. Calculate the power developed by the engine.
(iii) If the engine of the truck in (a)(ii) cannot develop a power greater than 75kW, calculate the maximum speed attainable by the truck.

(c) Two cartons of masses 80 kg and 120 kg respectively are in contact and at rest on a horizontal surface, a 700N horizontal force is exerted on the 80 kg carton. If the coefficient of kinetic friction is 0.25. calculate

(i) The acceleration of the system.
(ii) The force that each carton exerts on the other.

(9)(a)(i) State the laws of static friction.

(ii) Describe a simple experiment to measure the coefficient of static friction between two solid surfaces.
(iii) Give two instances in which increasing friction is beneficial.

(b)(i) A car of mass of 2000kg, moving a long a straight road at a speed of $96kmh^{-1}$, is brought to rest by a steady application of brakes in a distance of 80m. Find the coefficient of kinetic friction between the tyres and the road.

(ii) Discuss the energy transformations which occur from the time the brakes of a moving car are applied to the time the car comes to a stop.

(c) A car of mass 3000 kg climbs a track inclined at an angle of 20° to the horizontal. The speed of the car at the bottom of the incline is 15 m/s. If the coefficient of the kinetic friction is 0.3 and the engine exerts a force of 600N, how far up the incline does the car move in 10s?

10.(a)(i) Distinguish between vectors and scalar quantities.

(ii) State the class to which you assign each of the following: **momentum, kinetic energy, velocity, charge, mass, pressure and force.**

(b) A motorist travelling at a constant speed of 50 kmh^{-1} passes a motorcyclist just starting off in the same direction. If the motorcyclist maintains a constant acceleration of 2.8 m/s^2, calculate;

(i) the time taken by the motorcyclist to catch up with the motorist.
(ii) the speed with which the motorcyclist overtakes the motorist.
(iii) The distance travelled by the motorcyclist before overtaking.

11(a)(i) Giving two examples, explain the term conservative force.

(ii) A mass of 800 kg is released from rest so that it falls vertically through a distance of 30 cm onto a scale pan, of negligible mass, hung from a spring of force constant 200 N^1. Find the position of the scale pan when it first comes to rest.

(b) A ball is thrown straight upward with a speed **u** ms^{-1} from a point **h** metres above the ground. Show that the time taken to strike the ground is

$$t = \frac{u}{g}\left[1 + \left(1 + \frac{2hg}{u^2}\right)^{1/2}\right]$$

(c) A car of mass 500 kg moves from rest, with the engine switched off, down a road which is inclined at an angle of 49° to the horizontal.

(i) Find the normal reaction.

(ii) Find the acceleration if the coefficient of sliding friction between the tyres and the surface of the road is 0.25.

12(a) A shot is fired from the top of a cliff 250m high with a velocity of 650m/s at elevation of 30°. Find the distance from the point where the shot strikes the water to the bottom of the cliff.

(b) A shell is fired at 400 m/s at an angle of 25° to the horizontal.

(i) Calculate the range of the shell.

(ii) find the minimum initial velocity of the shell required to achieve the range calculated in b(i) above.

(c) A plane moving at 1500 m/s drops a bomb when it is at a height of ½ km from the ground. How far from the point at which the bomb is dropped does the bomb land?

13 (a) A body is projected at such an angle that its range is five times the greatest height attained.

(i) Find the angle of projection

(ii) If with this angle of projection, the range is 800m, calculate the speed of projection.

(b) Sketch a graph of

(i) speed

(ii) distance fallen as a function of time, for a body falling under the influence of gravity.

(c) A stone is dropped from a roof of a high building. A second stone is dropped 1.0 s later. How far apart are the stones when the second one has reached a speed of 23ms⁻.

(d) An athlete executing a long jump leaves the ground at a 30° angle and travels 8.90 m. find the takeoff speed.

(e) A 50g ball is thrown from a window with initial speed of 8.0 ms^{-1} at 30° above the horizontal. Use **energy methods** to determine

(i) the kinetic energy of the ball at the top of its flight.

(ii) the speed of the ball when it is 3.0 m below the window.

14.(a) Show that the motion of a projectile is a parabola.

(b) A projectile is fired at an angle of 45° to the horizontal from point A. The projectile passes through a point B above the level A having coordinates (600m, 225m) with respect to A. calculate

(i) the speed of projection (**Ans 70.7 m/s**)

(ii) the angle which the projectile makes with the horizontal as it passes through B. (**Ans 14.1°**)

(c) A projectile fired at an angle of 60° above the horizontal strikes a building 30m away at a point 15 m above the point of projection.

(i) Find the speed of projection (**Ans 21.8 ms^{-1}**)

(ii) Find the velocity of the projectile when it strikes the building. (**Ans 13.6 ms^{-1} at 36.6° to the horizontal**)

15.(a)(i) Explain the terms **time of flight T** and **range R** as applied to the projectile motion.

(ii) Prove that the time of flight T and the horizontal range R, of a projectile are connected by the equation $gT^2 = 2R\tan\alpha$ where α is the angle of projection.

(b) A stone thrown horizontally at a speed of 24 m/s from the top of a cliff takes 4.0s to hit the sea. Calculate

(i) the height of the cliff top above the sea (**Ans 78.4 m**)

(ii) the distance from the base of the cliff to the point of impact. (**Ans 96m**)

(c) Two footballers, 120 m apart, stand facing each other. One of them kicks a ball from the ground such that the ball takes off at a velocity of 30m/s at 38° to the horizontal. Find the speed at which the second footballer must run towards the first footballer in order to trap the ball as it touches the ground, if he starts running at the instant the ball is kicked. (**Ans 8.2 m/s**)

16.(a) A transport plane travelling at a steady speed of 50 m/s at an altitude of 300 m releases a parcel when directly above a point X on a level ground. Find

(i) the time taken for the parcel to hit the ground (**Ans 7.82 s**)

(ii) the speed of impact of the parcel (**Ans 91.5 m/s**)

(iii) The distance from X to the point of impact (**Ans 391m**)

(b) An object P is projected upwards from a height of 60 m above the ground with a velocity of 20m/s at 30° to the horizontal. At the same time an object Q is projected from the ground upwards towards P at 30° to the horizontal. P and Q collide at a height of 60m above the ground while they are both moving downwards. Find

(i) the speed of projection of Q (**Ans 78.8 m/s**)

(ii) the horizontal distance between the points of projection. (**Ans 174.5m**)

17.(a)(i) Define the term momentum

(ii) State the principle of conservation of linear momentum.

(b) A block of mass m = 2.0 kg slides from a point 5m high, down a plane. At the bottom, it strikes a block of mass M =6kg which is at rest on a smooth surface. If the collision is elastic and friction can be ignored. Find

(i) the speeds of the two blocks after collision. (**Ans 5m/s , 4.93 m/s**)

(ii) How far back the incline will the smaller mass go. (**Ans 2.55 m**)

18)(a)(i) Use Newton's law of motion to show that linear momentum is conserved when two particles moving in a straight line collide.

(ii) Balls A, B and C of masses m_1, m_2 and m_3 respectively lie on a straight line on a smooth surface. The balls are initially at rest. Ball A which is projected with a velocity v_1 towards B makes an elastic collision with B. If B moves and makes a perfectly inelastic collision with C. Show that both B and C move with a common velocity,

$$v_1 = \frac{2m_1m_2v_1}{(m_1+m_2)(m_2+m_3)}$$

(b)(i) A wooden block of mass 3.98kg rest on a smooth horizontal surface. The block is attached to a light spring of force constant $100Nm^{-1}$, whose other ends is fixed. A bullet of mass 0.25 kg fired into the block embeds itself there and the spring is compressed by 0.40m. Find the velocity of the bullet just before it hits the block. **(Ans 400m/s)**

(ii) Suppose the bullet in (b)(i) above was fired into a wooden block of mass 3.98kg placed on a rough horizontal surface and the block was not attached to a spring, through what distance would the composite mass have moved before coming to rest. Coefficient of kinetic friction between the block and the surface is 0.3. **(Ans 0.68m)**

(iii) A bullet of mass 10.0g is fired at close range into a block of mass 9.99kg suspended from a rigid support by an inelastic string and becomes embedded in the block. The block rises through a height of 2.0cm before momentarily coming to rest. Calculate the initial speed of the bullet. **(Ans 630 m/s)**

19.(a)(i) Define momentum and state its units

(ii) State the principle of conservation of linear momentum.

(b) A ball of mass 900g travelling at a speed of 15m/s at 60° to the horizontal strikes a vertical wall and rebounds with the same speed at 120° from the original direction. If the ball is in contact with the wall for 5×10^{-1} s, calculate the average force exerted by the ball. **(Ans 270N)**

(c) A particle slides from rest down a smooth plane inclined at an angle α to the horizontal. Show that the time taken by the particle to cover a distance d, on the plane is $t = \left(\frac{2d}{g sin\alpha}\right)^{1/2}$ where g is the acceleration due to gravity.

(d) (i) Distinguish between perfectly inelastic collision and a perfectly elastic collision giving one example in each case.

(ii) A truck of mass 2000kg is moving at 25m/s down a plane at 30° to the horizontal. The truck collides with another of mass 3000kg moving in the same direction with a velocity of 10m/s. if the collision is perfectly inelastic, find

(i) The velocity of the trucks immediately after collision. **(Ans 16m/s)**

(ii) The kinetic energy lost during collision. **(Ans 1.35×10^5 J)**

(iii) The velocity of the trucks 10s after collision given that the coefficient of kinetic friction is 0.30. **(Ans 38.5 m/s)**

(b) A car of mass 3000kg travels at $108kmh^{-1}$ around an unbanked curve of radius 200m.

(i) What is the minimum coefficient of sliding friction between the road and the car tyres that will permit the car to negotiate the curve without sliding? **(Ans 0.46)**

(ii) At what angle would the road have to be banked if there were to be no frictional force between the tyres and the road surface? **(Ans 24.7°)**

21. A road curve of 200m radius is banked at the correct angle for a speed of 15m/s. if a car rounds this curve at 30m/s, what is the minimum coefficient of friction between the tyres and the road so that the car will not skid? **(Ans 0.345)**

22. A cyclist moving at a speed of $120 kmh^{-1}$ takes a curve of radius 150m. At what angle with respect to the vertical must he lean, if he is to take the curve without skidding. **(Ans 37.0°)**

23 (a) A stone of mass 0.5 kg is whirled round on the end of a 0.8m long string in a vertical circle. If the speed of the stone is $4ms^{-1}$.

(i) At which point in the circle is the tension in the string a minimum and what is its value? **(Ans 5.1N)**

(ii) At which point in the circle is the tension in the string a maximum and what is its value? **(Ans 14.9N)**

24. (a) A small bead of mass m is threaded on a smooth circular wire of radius **r** and centre O which is fixed in a vertical plane. The bead is projected with speed **U** from the highest point **A** of the wire. Show that the reaction on the bead at a point P where <AOP=θ is given by

$$R = mg(3cos\theta - 2) - \frac{mU^2}{r}$$

(b) A steel ball of mass 0.5kg is suspended from a light inelastic string of length 1.0m. The ball is whirled in a horizontal circle of radius 0.5m. Find

(i) The centripetal force and the tension in the string **(Ans 2.83N, 5.66N)**

(ii) The angular speed of the ball. **(Ans 3.36 $rads^{-1}$)**

(iii) The angle between the string and the radius of the circle if the angular speed is increased to such a value that the tension in the string is 10N. **(Ans 29.3°)**

25)(a)(i) State Kepler's laws of planetary motion.

(ii) Assuming circular orbits, show that Kepler's third law can be directly derived from Newton's law of universal gravitation.

(b) An artificial satellite is launched at a height of 3.60×10^7m above the Earth's surface. (radius of Earth =6400 km, acceleration due to gravity at the Earth's surface =9.8 m/s^2)

(i) Determine from first principles, the speed with which the satellite must be launched to maintain it in the orbit. **(Ans 3.08×10^3 m/s)**

(ii) Determine the period of time of the satellite. **(Ans 86.3×10^3 s)**

(iii) What deductions can be made from the result obtained in (b)(ii) above with reference to the satellite?

(iv) To what application can such a satellite be put to?

(c) The satellite Phobos describes nearly circular orbit of radius 9.7×10^6 m round the planet Mars, with a period 2.75×10^4 s.

(i) Calculate the mass of Mars **(Ans 7.11×10^{23} kg)**

(ii) The period of revolution of the other Martian satellite. Deimos, is $1.09\ x10^5\ s$; what is the radius of its orbit? ($G = 6.7\ x\ 10^{-11}Nkg^{-2}m^2$) .(**Ans 24.3 x 10⁶ m**)

26)(a)(i) Show that the acceleration of free fall **g**, at the surface of the Earth and the gravitational constant G, are related by the expression $g = \frac{4\pi}{3}\rho G R_E$ where ρ is mean density of the Earth, R_E is the radius of the Earth.

(ii) Obtain the value of **g** from the motion of the moon assuming that its period of revolution around the Earth is 27.3 days and the radius of its orbits about the earth is 3.85×10^5 km. (radius of Earth = 6.4×10^6 m) (**Ans 9.89 m/s²**)

(iii) Assuming that Mars is a sphere of radius 3,400 km and density 3,900 kgm^{-3} and the Earth is a sphere of radius 6400km and density 5500 kgm^{-3}. Calculate the value of the acceleration due to gravity on the surface of Mars. (Neglect the effects due to the rotation of Mars and of the Earth)(**Ans 3.73 m/s²**)

(b) An artificial satellite in circles the Earth in a circular orbit in the plane of the equator at a height of 30,000 km above the Earth's surface, (mass of Earth $=6.0 \times 10^{24}$ kg, radius of the earth = 6.4×10^6 m, G = $6.66 \times 10^{-11}\ Nm^2kg^{-2}$)

(i) Calculate its speed (**Ans 3.32 x 10³ m/s**)

(ii) What is the time between successive appearance over a point on the equator if it appears to come from the West? (**Ans 19.14 hrs**)

(iii) How much higher would it have to be in order to appear stationary? (**Ans 5.90 x 10⁶ m**)

27.(a) State Newton's law of gravitation and explain how this law is established.

(b) Use Newton's law to deduce expressions for:

(i) the period of a satellite in a circular orbit of radius **r** about the Earth in terms of the mass M_E of the Earth and the gravitational constant G.

(ii) the gravitational field strength g^1 at this orbit in terms of the orbital radius **r**, the gravitational field strength **g** at the Earth's surface, the radius R_E of the Earth (assumed to be a uniform sphere)

(c) A satellite of mass 600 kg is in a circular orbit at a height 2000 km above the Earth's surface .(Take the radius of the Earth to be 6400 km and the value g to be $9.8Nkg^{-1}$). Calculate the satellite's

(i) Orbital speed (**Ans 6.9 x 10³ m/s**)

(ii) Kinetic energy (**Ans 1.43 x 10¹⁰ J**)

(iii) Gravitational potential energy (**Ans -2.86 x 10¹⁰ J**)

(d) Explain why any resistance to the forward motion of an artificial satellite results in an increase in its speed.

28. (a) If the acceleration due to gravity, g_m at the Moon's surface is 1.70 m/s^2 and its radius is 1.74×10^6m, calculate the mass of the Moon. (**Ans 7.72 × 10²² kg**)

(b)(i)To what height would a signal rocket rise on the moon , if an identical one fired on Earth could reach 200m? (Ignore atmospheric resistance). Explain your reasoning. (**Ans 3800m**)

(ii) What is meant by "weightlessness" experienced by an astronaut orbiting the Earth, and hoe it is caused?

(c) Find the period of revolution of a satellite at 400 km about the Earth. (**Ans 5.53 x 10³ s**)

(d) Neglecting air friction, find:

(i) The velocity with which a body must be projected horizontally so that it may revolve as a satellite just above the Earth's surface. (**Ans 7.93 x 10³ m/s**)

(ii) The minimum velocity with which it must be projected vertically upwards in order that it may not return to the Earth. (G=$6.67 \times 10^{-11}\ Nkg^{-2}m^2$, acceleration at the Earth's surface =9.8 m/s^2, radius of earth R_E= 6371 km, mass of Earth = 6.0×10^{24} kg) (**Ans 11.2 kms⁻¹**)

(e) (i) A satellite of mass 1000 kg moves in a circular orbit of radius 7.0×10^6 m round the Earth. At this height, the acceleration due to gravity is 8.2 m/s^2, calculate the total energy of the satellite. (**Ans -57.4 x 10⁹ J**)

(ii) A projectile is fired vertically from the surface of the Earth. Calculate the minimum speed required for the projectile to escape the Earth's gravitational force. (Radius of the Earth = 6.4×10^6 m) (**Ans 11.2 kms⁻¹**)

29) A wooden rod of uniform area of cross-section **A** floats with a height h immersed in aliquid of density ρ. The rod is given a slight downward displacement and then released. Show that

(i) the resulting motion is simple harmonic

(ii) the period $T = 2\pi\sqrt{\frac{h}{g}}$

30.(a) Show that when a simple pendulum of length L is slightly displaced from its position of equilibrium and then allowed to swing freely, it performs simple harmonic motion of period $T = 2\pi\sqrt{\frac{L}{g}}$ where g is the acceleration due to gravity.

(b) Show that a mass **m** attached to a massless vertical spring of force constant k when given a small vertical displacement and then released execute S.H.M of period $T = 2\pi\sqrt{\frac{m}{k}}$

31)(a) Explain what is meant by simple harmonic motion (S.H.M)

(b)(i) Show that a mass attached to a vertical spring when given a small displacement and then released executes S.H.M.

(ii) Describe briefly an experiment to determine the value of the force constant **k** of a helical spring.

(c) In an experiment such as that in (b)(ii) above the time for 50 complete oscillations is measured for various values of **m.**

m (kg)	0.1	0.2	0.4	1.0
t(s) time for 50 complete oscillations	11.7	15.3	20.9	32.4

Using a suitable graph, determine the force constant **k**.

(d) A 1.0 kg mass vibrates according to the equation $x = 0.51cos12.56t$ where x is in metres and t is in seconds. Determine:

(i) the frequency (**Ans 2.0 Hz**)

(ii) the maximum force on the mass (**Ans 80.5N**)

(iii)the total energy of the body (**Ans 20.5 J**)

32.(a) Show that the principle of conservation of mechanical energy applies to an oscillating pendulum.

(b) A bob of mass 30g is suspended on an inelastic string of length 2.0m. the bob is projected from the lowest point with a velocity of 2.0 m/s.

(i) Find the position of the bob when it first momentarily comes to rest. (**Ans 0.2 m**)

(ii) Calculate the period of the bob that follows.(**Ans 2.84 s**)

(c) In an experiment to determine the acceleration due to gravity, the following set of data were obtained for different lengths L of a simple pendulum and t is the time for 20 oscillations.

Length (m)	0.20	0.40	0.60	0.80	1.00
Time t(s)	20.0	26.8	32.2	36.8	40.6

Plot a graph of T^2 against L. what value of g, will you get from the graph? Explain why the graph does not pass through the orign. (**Ans 9.86 m/s²**)

(d) If a pendulum has a period of exactly 1.5s at the Earth's surface, what would be its period at height of 8000km above the earth? (Radius of the earth $R_E = 6.4 x 10^6\ m$) (**Ans 4.1 s**)

33.(a) A particle executing S.H.M in a straight line has speeds of 4 m/s and 2 m/s at positions 3cm and 6 cm respectively, from the equilibrium position. Calculate:

(i) the amplitude of vibration(**Ans 0.067 m**)

(ii) the period. (**Ans 0.1 s**)

(b)The block of mass 0.1 kg resting on a smooth horizontal surface and attached to two spring S_1 and S_2 of force constants 80 Nm^{-1} and 120 Nm^{-1} respectively. The block is pulled through a distance of 6 cm to the right and released.

(i) Show that the mass oscillates with SHM and find its period. (**Ans0.14 s**)

(ii) Find the new amplitude of oscillation when a mass of 0.05 kg is dropped vertically onto the block as the block passes the equilibrium position. Assume that the mass sticks to the block. (**Ans 0.05 m**)

34.(a) A 2kg body oscillates with a frequency 2 Hz and amplitude 2.5 cm. if the oscillations are assumed to be S.H.M and undamped. Calculate:

(i) the maximum velocity of the body(**Ans 0.32 m/s**)

(ii) the total energy of the body (**Ans 0.1 J**)

(iii) The maximum potential energy (**Ans 0.1 J**)

(iv) The kinetic energy when the body is 1.0 cm from the equilibrium position. (**Ans 0.083 J**)

(c) A simple pendulum was suspended from the ceiling of a laboratory. The following readings for the period T of the pendulum was obtained for various lengths of the pendulum. The length was not measured directly, but the height x of the bob above the floor was recorded.

x(cm)	0.10	0.40	0.80	1.20	1.60
T(s)	3.38	3.20	2.95	2.66	2.34

By the graphical method or otherwise find the value of the acceleration due to gravity and the height of the laboratory. (**Ans 9.6 m/s², 3m**)

35.(a) A mass hanging on a spring is given a small vertical displacement and then released.

(i) Show that the mass performs S.H.M and obtain an expression for its **frequency**.

(ii) Discuss briefly the energy transformations which occur as the mass oscillates.

(iii)Explain why the oscillations ultimately die down.

(b) A particle of mass **m** has a displacement **x** given by $x = rsin\omega t$.

(i) Show that the motion is S.H.M.

(ii) Obtain an expression for the kinetic energy and its potential energy at a distance x from its equilibrium.

(iii)Show that its total energy is constant.

(iv)Sketch the variation of K.E, P.E and total energy with time.

(c) A platform moves up and down with S.H.M of period T and amplitude **a**. a particle of mass **m** rests on this platform.

(i) Find an expression in terms of g, T **and** x for the reaction of the platform on the particle when the platform is at a distance **x** from its mean position.

(ii) If **a=10.0 cm**, calculate the minimum value of T for the particle to remain in constant with the platform throughout the motion. (**Ans 0.63** s)

(iii) Given that $T = kT_0$ where k > 0 and $T_0 = 2\pi\sqrt{\frac{a}{g}}$, show that the magnitudes of the greatest and least reactions are in the ratio $(K^2 + 1) : (K^2 - 1)$

36.(a) A hydrometer consists of a spherical bulb and a cylindrical stem of cross-sectional area 0.6 cm^2. The total volume of the bulb and the stem is 15.2 cm^3. When immersed in water, the hydrometer floats with 10.0 cm of the stem above the water surface. In a certain oil, it floats with 2.0 cm of the stem above the surface.

(i) Calculate the density of the oil. (**Ans 660 kgm⁻³**)

With the hydrometer floating in water, it is given a small vertical downward displacement and released.

(ii) Show that the hydrometer executes S.H.M

(iii) Calculate the period of oscillation. (**Ans 0.79 s**)

(iv) What would the period of oscillation be, if the hydrometer were floating in oil instead? (**Ans 0.97** s)

(b) A ball of mass 40g is attached to an elastic spring of natural length 80 cm with one end fixed to a rigid support. The spring is stretched to 110 cm along the frictionless table and then released. If the ball is 100 cm from a fixed point and the elastic constant of the spring is $400Nm^{-1}$, calculate

(i) The K.E of the ball. (**Ans 10J**)

(ii) The velocity of the ball(**Ans 22.4m/s**)

(c) A horizontal platform of mass 50 kg is executing S.H.M along a horizontal line with a frequency of 2 Hz and an amplitude of 3.0 m.

(i) Calculate the maximum acceleration (**Ans 4.74 m/s²**)

(ii) Find the speed when the displacement from the equilibrium position is 1.5 m (**Ans 0.327 m/s**)

(iii) Calculate the maximum energy to the platform (**Ans 3.55 J**)

(iv) Without altering the motion, a small block is placed on the platform, find the maximum value of the coefficient of static friction so that the block will not slip with respect to the platform. (**Ans 0.48**)

37.(a)(i) Define the coefficient of surface tension.

(ii) Define the angle of contact, what does the angle of contact between a liquid and a solid surface depend on?

(iii) How can you measure the angle of contact, in the laboratory?

(iv) What are the dimensions of surface tension?

(b) A clean glass capillary tube, of internal diameter, 0.04 cm is held with its lower end dipping in water in a beaker, and with 12 cm of the tube above the surface.

(i) To what height will the water rise in the tube (**Ans** $7 \times 10^{-2}\ m$)

(ii) What will happen if the tube is now displaced until only 4 cm of its length is above the surface? (surface tension of water $= 7 \times 10^{-2}\ Nm^{-1}$, assume zero angle of contact). (**Ans** θ=55.2° (new angle of contact))

38)(a) What is meant by the term **surface tension** of a liquid and **angle of contact.**

(b) Account for the following

(i) A small needle may be placed on the surface of water in a beaker so that it 'floats' and

(ii) If a small quantity of detergent is added to the water, the needle sinks.

(c) (i) A uniform capillary tube of radius r is held vertically and lowered in a liquid of density ρ and surface tension γ. Show that the liquid rises to the height h given by $h = \frac{2\gamma\cos\theta}{r\rho g}$ where θ is the angle of contact of the liquid with the tube and g is the acceleration due to gravity.

(ii)A capillary tube is immersed in water of surface tension $7.0 \times 10^{-2} Nm^{-1}$ and the water rises 6.2 cm in the capillary tube. What will be the difference in the mercury levels if the same capillary tube is immersed in mercury? (Surface tension of mercury = $0.84\ Nm^{-1}$, angle of contact between mercury and glass= 140°, density of mercury $=13.6 \times 10^3 kgm^{-3}$. (**Ans** The mercury in the tube is depressed **4.2 cm**)

39.(a) A hydrometer has a cylindrical glass stem of diameter 5.0mm. it floats on the water of density $1000\ kgm^{-3}$ and surface tension $7.2 \times 10^{-2}\ Nm^{-1}$. A drop of liquid detergent added to the water reduces the surface tension to $5.0 \times 10^{-2}\ Nm^{-1}$. What will be the change in length of the exposed portion of the glass stem?(Assume that the relevant angle of contact is always zero). (**Ans** $1.8 \times 10^{-3}\ m$)

(b)A circular ring of this wire of radius 2cm is suspended horizontally by a thread passing through the 5 cm mark on a metre rule pivoted at its centre and the ring is balanced by a 5g mass suspended from the 70 cm mark. A beaker of liquid is then placed so that the ring just touches the liquid surface when it is horizontal. If the 5g mass is moved to 80 cm mark, the ring just parts from the liquid surface. Find the surface tension of the liquid. (**Ans** $434 \times 10^{-2}\ Nm^{-1}$)

39) Surface tension may be defined in terms of **force per unit length** or in terms of **energy per unit area.**

(a) Show by consideration an increase in surface are of a liquid that these definitions are relevant. State any necessary condition.

(b) Calculate the work done to break up a droplet of mercury of radius 2.0 mm into drops each of radius 0.50 mm. (surface tension of mercury $0.52\ Nm^{-1}$) (**Ans** $52.3 \times 10^{-6}\ J$)

40 (a) Give a concise explanation of the orign of the surface tension in terms of intermolecular forces

(b) The velocity v of surface waves on a liquid may be related to their wave length λ, the surface tension γ and its density ρ by the following $v = k\lambda^{\alpha}\gamma^{\beta}\rho^{\gamma}$ where k is a dimensionless constant. Find by the method of dimensions the values of α,β and γ.

(c) A spherical drop of mercury of radius 2mm falls to the ground and breaks into 10 smaller drops of equal size.

(i) Calculate the amount of work that has to be done (surface tension of mercury = $4.72 \times 10^{-1}\ Nm^{-1}$) (**Ans** 2.74×10^{-5})

(ii) What is the minimum speed with which the original drop would have hit the ground? (Density of mercury $= 1.36 \times 10^3\ kg/m^3$). (**Ans 0.35 ms⁻²**)

(d) The two vertical arms of a U-tube; containing water have different internal radii of $1 \times 10^{-3}m$ and $2 \times 10^{-3}m$ respectively. Determine the difference in height of the two liquid levels when the arms are open to the atmosphere. (Surface tension and density of water are $7 \times 10^{-2}\ Nm^{-1}$ and $10^3\ kgm^{-3}$ respectively)(**Ans** $7.1 \times 10^{-3}\ m$)

41.(a) Derive an expression relating P_1, the pressure inside a soap bubble of diameter d, to the external pressure P_2 and the coefficient of surface tension γ of the soap solution. It is proposed to measure the coefficient of surface tension of the surface tension of soap solution by blowing soap bubbles in air and measuring the diameters inside them.

(b) If the coefficient of surface tension of the soap solution is known to be about $3 x 10^{-2} Nm^{-1}$. What will be the range of excess pressure of bubbles of diameters between 20 mm and 120 mm? (**Ans 1Nm^{-2} to 12 Nm^{-2}**) Give a sketch of an experimental arrangement suitable for this type of determination. Explain how you would measure excess pressures of the relevant magnitude and suggest a method of the measurement of the diameters of the bubbles.

(c) In another experiment, the diameter, d, of a rubber balloon was measured for various excess pressures (P_1-P_2), and the following readings obtained.

d/mm	100	120	150	200	300
(P_1-P_2)Nm^{-2}	80	93	107	120	133

Investigate whether these results obey the relation which you have derived for the soap bubble and comment on your result.

42. (a) Explain

(i) Why small drops of mercury are spherical where as large drops are flat.

(ii) What is observed when a piece of capillary tubing held vertically with its lower end dipping in water is gradually lowered until its upper end is in the surface of water.

(b) A clean glass capillary tube, of internal diameter 0.04 cm is held with its lower end dipping in water in a beaker and with 12 cm of tube above the surface.

(i) To what height will the water rise in the tube? (**Ans 7.1 cm**)

(ii) What will happen if the tube is now depressed until only 4 cm of its length above the surface? (Surface tension of water= $7 x 10^{-2} Nm^{-1}$, assume zero angle of contact) (**Ans θ = 55.7°**)

(c) A U-tube is made with the internal diameter of one arm 1.0 cm and that of the other 2.0 mm and mercury is poured into the tube. If the angle of contact of mercury with glass after exposure to air is 160°. what will be the difference in level of surfaces in the tubes? (Surface tension of mercury = 0.472Nm^{-1})

(d) In Jaeger's method of measuring the surface tension of a liquid, the lower end of a capillary tube of radius 0.20 mm is 25 mm below the surface of the liquid, whose surface tension is required and whose density is required and whose density is 800 kgm^{-3}. The pressure in a hemispherical bubble formed at the end of the tube is measured as 40 mm on a water manometer. Calculate the surface tension of the liquid.

(e) A capillary tube of radius 0.2 mm is placed vertically with its lower end submerged to a depth of 2 cm beneath the surface of a liquid of density 1200 kg/m^3. Air is forced into the tube until a hemispherical bubble is formed at the lower end and it is found that the pressure inside the tube exceeds atmospheric pressure by 0.5 cm of mercury. Calculate the surface tension of the liquid. (**Ans 0.432 Nm^{-1}**)

43. (a) Explain using a simple molecular theory, why the surface of a liquid behaves in a different manner from the bulk of the liquid.

(b) A microscope slide measures 6.0cm × 1.5 cm × 0.20cm. It is suspended with its face vertical and with its longest side horizontal and is lowered into water until it is half immersed. Its apparent weight is then found to be the same as the weight in air. Calculate the surface tension of water assuming the angle of contact is zero. (**Hint: surface tension force= loss in weight**) (**Ans = $7.1 x 10^{-2} Nm^{-1}$**)

(c) Explain what is meant by the following statements:

(i) The coefficient of surface tension of mercury is 0.46 Nm^{-1}.

(ii) The angle of contact between mercury and glass is 137°.

(d) A clean open-ended glass U-tube has vertical limbs, one of which has a uniform internal diameter of 4.0 mm and the other of 20 mm. mercury is introduced into the tube; it is observed that the height of the mercury meniscus is different for the two limbs. Explain this observation, stating in which tube the level is the higher, and calculate the difference in levels. (Density of mercury = $13.6 x 10^3 kgm^{-3}$) (**Ans 2.0 mm**)

44.(a) A steel wire 30 m long has a cross-section of 0.5 mm^2. Young's modulus for steel is $2.0 x 10^{11} Pa$. Calculate the force constant of the wire. (**Ans $3.3 x 10^3 Nm^{-1}$**)

(b) A uniform wire of unstretched length 2.49 m is attached to two points A and B which are 2.0 m apart and in the same horizontal line. When a 5kg mass is attached to the mid-point C of the wire, the equilibrium position of C is 0.75 m below the line AB. Neglecting the weight of the wire and taking Young's modulus for its material to be $2 x 10^{11} Nm^{-2}$. Find

(i) the strain in the wire (**Ans $4.02 x 10^{-3}$**)

(ii) the stress in the wire.(**Ans $8.04 x 10^8 Nm^{-2}$**)

(iii) The energy stored in the wire. (**Ans $2.04 x 10^{-1} J$**)

45.(a)(i) Define **tensile stress, strain** and **Young's modulus** of elasticity.

(ii) Derive in terms of Young's modulus and strain, an expression for the energy stored in a unit volume of a stretched wire.

(b)(i) State Hooke's law

(ii)A rod of original length 1.2 m and area of cross-section $1.5 x 10^{-4} m^2$ is extended by 3.0 mm when the stretching tension is 6N. Calculate Young's modulus for the material of the rod and the energy density of the stretched material. (**Ans 50 Jm^{-3}**)

(c) Two identical cylindrical steel bars, each of radius 2.0 mm rest in a vertical position with their lower ends on a rigid horizontal surface. A mass 0f 2.0 kg is placed on top of one bar. By how much must the temperature of the other bar be altered so that they are once again of equal length? (Young's modulus for steel = $2.0 x 10^{11} Nm^{-2}$, coefficient

of linear expansion for steel $= 1.2 \times 10^{-5} K^{-1}$)
(Ans 0.65°C)

46. A cylindrical copper rod of length 0.5m and of diameter $4.0 \times 10^{2}\ m$ is fixed between two rigid supports a temperature of 20.0°C. The temperature of the rod is raised to 70.0°C.
   (i) Calculate the force exerted on the rigid supports at 70.0°C.(**Ans** $\mathbf{1.28 \times 10^5}$ ***N***)
   (ii) What is the energy stored in the rod at 70.0°C? (Young's modulus for copper $= 1.2 \times 10^{11} Nm^{-2}$, Linear expansivity of copper $= 1.7 \times 10^{-5} K^{-1}$)(**Ans 27.2 J**)

(b) Two wires each 1 metre long and of $1 mm^2$ cross-section, one of steel and the other of brass, are connected end to end. What tensile force would be required to extend the whole wire by 1 mm? (Young's modulus for steel is $2 \times 10^{11}\ Nm^{-2}$ and for brass is $1 \times 10^{11} Nm^{-2}$) (**Ans 66.7 N**)

(c)(i) Show that the energy stored per unit volume in a stretched wire is equal to half the product of the stress and the strain.

(ii) A catapult consists of two rubber cords, each of unstretched length 10.0 cm and area of cross-section 0.40 cm^2. Assuming that all the energy stored in the stretched cords is converted into kinetic energy of the missile, calculate the maximum height to which a stone of mass 100g could be projected if each of the cords were stretched by 5.0 cm.(Young's modulus for rubber $= 1.00 \times 10^7 Nm^{-2}$) (**Ans 10.2 m**)

UNEB Revision Exercise

1. (a) (i) Define **dimensions of a physical quantity.**

(ii) In the gas equation $\left(p + \frac{a}{V^2}\right)(V - b) = RT$ where p = pressure, V = volume, T = absolute temperature and R = gas constant, what are the dimensions of constants ***a*** and ***b***?

(b) A particle is projected from a point on a horizontal plane with a velocity, u, at an angle, θ, above the horizontal. Show that the maximum horizontal range R_{max} is given by $R_{max} = \frac{u^2}{g}$.

(c) (i) Define **elastic limit** of a material.

(ii) Describe an experiment to determine Young's modulus of a steel wire.

(d) Explain why tyres of a vehicle travelling on a hard surfaced road may burst. **(2016 Paper 1)**

2. (a) (i) What is meant by **efficiency of a machine?**

(ii) A car of mass 1.2×10^3 kg moves up an incline at a steady velocity of 15 ms^{-1} against a frictional force of 6.0×10^3 N. The incline is such that the car rises 1.0m for every 10m along the incline. Calculate the output power of the car engine. **(107,658 W)**

(b) (i) Define **impulse** and **momentum.**

(ii) An engine pumps water such that the velocity of the water leaving the nozzle is 15 ms^{-1}. If the water jet is directed perpendicularly onto a wall and comes to a stop at the wall, calculate the pressure exerted on the wall. **(2.25×10^5 Nm^{-2})**

(c) (i) Define **inertia**.

(i) State the conditions for a body to be in equilibrium under action of coplanar forces.

(ii) Briefly explain the three states of equilibrium. **(2016 Paper 1)**

3. (a) (i) What is meant by a **conservative force**?

(ii) Give two examples of conservative force.

(b) Explain the following:

(i) Damped oscillation (ii) Forced oscillation

(c) (i) State **Newton's law of gravitation.**

(ii) Show that Newton's law of gravitation is consistent with Kepler's third law.

(d) If the earth takes 365 days to make a revolution around the sun, calculate the mass of the sun. **(2.01×10^{30} kg)**

(e) Explain briefly how satellites are used in world-wide radio or television communication. **(2016 Paper 1)**

4. (a) (i) What is meant by **fluid element** and a **flow line** as applied to fluid flow?

(ii) Explain why some fluids flow more easily than others.

(b) (i) State **Bernoulli's principle**.

(ii) Explain how a Pitot-static tube works.

(c) Air flow over the upper surface of an aircraft's wings causes a lift force of 6.4×10^3 N. The air flows under the wings at a speed of 120 ms^{-1} over an area of 28 m^2. Find the speed of air flow over an equal area of the upper surface on the aircraft's wings. (*Assume density of air* = 1.2 kgm^{-3}). **(121.6 ms^{-1})**

(d) (i) What is meant by **surface tension** and **angle of contact** of a liquid.

(ii) A water drop of radius 0.5 cm is broken up into other drops of water each of radius 1 mm. Assuming isothermal conditions, find the total work done to break up the water drop. **(8.8×10^{-5}J)** **(2016 Paper 1)**

5. (a) (i) What is meant by a **conservative force?**

(ii) Give **two** examples of a conservative force.

(b) (i) State the law of conservation of **mechanical energy.**

(ii) A body of mass, *m*, is projected vertically upwards with speed, u. Show that the law of conservation of mechanical energy is obeyed throughout its motion.

(iii) Sketch a graph showing variation of kinetic energy of the body with time.

(c) (i) Describe an experiment to measure the coefficient of static friction.

(ii) State **two** disadvantages of friction.

(d) A bullet of mass 20 g moving horizontally strikes and gets embedded in a wooden block of mass 500 g resting on a horizontal table. The block slides through a distance of 2.3 m before coming to rest. If the coefficient of kinetic friction between the block and the table is 0.3; calculate the:

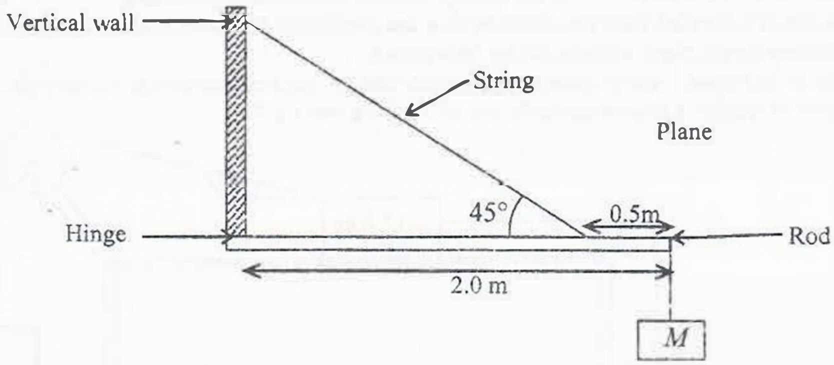
(i) friction force between the block and the table. **(1.53 N)**

(ii) velocity of the bullet just before it strikes the block. **(95.68 ms^{-1})** ***(2015 Paper 1)***

6. (a) (i) State the **principle of moments.**

(ii) Define the terms **centre of gravity** and **uniform body.**

(b) Figure 1 shows a body, *M* of mass 20 kg supported by a rod of negligible mass horizontally hinged to a vertical wall and supported by a string fixed at 0.5 m from the other end of the rod.



Calculate the

(i) tension in the string. **(370 N)**

(ii) reaction at the hinge. **(270 N)**

(iii) maximum additional mass which can be added to the mass of 20 kg before the string can break given that the string cannot support a tension of more than 500 N. **(7.03 kg)**

(c) (i) Define **Young's Modulus.**

(ii) Explain the precautions taken in the determination of Young's modulus of a wire.

(iii) Explain why a piece of rubber stretches much more than a metal wire of the same length and cross-sectional area.

(2015 Paper 1)

7. (a) State **Keplers' laws** of planetary motion.

(b) (i) What is a **parking orbit?**

(ii) Derive an expression for the period, T, of a satellite in a circular orbit of radius r, above the earth in terms of the mass of the earth m, gravitational constant G and r.

(c) (i) A satellite of mass 200 kg is launched in a circular orbit at a height of 3.59×10^7 m above the earth's surface. Find the mechanical energy of the satellite. **(-9.41×10^8 J)**

(ii) Explain what will happen to the satellite if its mechanical energy was reduced.

(d) Describe a laboratory method of determining the universal gravitational constant, G ***(2015 Paper 1)***

8. (a) (i) What is **projectile motion?**

(ii) A bomb is dropped from an aeroplane when it is directly above a target at a height of 1402.5 m. The aeroplane is moving horizontally with a speed of 500 kmh^{-1}. Determine whether the bomb will hit the target. **(the bomb misses the target by 2347.2m)**

(b) (i) Define **angular velocity.**

(ii) A satellite is revolving around the earth in a circular orbit at an altitude of 6.0×10^5m where the acceleration due to gravity is 9.81 ms^{-2}. Assuming that the earth is spherical, calculate the period of the satellite. **(5.42×10^3 s)**

(c) (i) State **Newton's laws** of motion.

(ii) Explain how a rocket is kept in motion.

(iii) Explain why passengers in a bus are thrown backwards when the bus suddenly starts moving.

(2014 Paper 1)

9. (a) (i) What is meant by **Young's Modulus?**

(ii) State **Hooke's law.**

(iii) Derive an expression for the energy released in a unit volume of a stretched wire in terms of stress and strain.

(b) A steel wire of length 0.6 m and cross sectional area $1.5 \times 10^{-6}m^2$ is attached at B to a copper wire BC of length 0.39 m and cross sectional area $3.0 \times 10^{-6}m^2$. The combination is suspended vertically from a fixed point at A and supports a weight of 250 N at C. Find the extension in each of the wires, given that Young's Modulus for steel is 2.0×10^{11} Nm^{-2} and that of copper is 1.3×10^{11} Nm^{-2}. **(2.5×10^{-4} m)**

(c) With the aid of a labelled diagram, describe an experiment to determine the Young's Modulus of a steel wire.

(d) Explain the term plastic deformation in metals. ***(2014 Paper 1)***

10. (a) Define **work** and **energy**.

(b) Explain whether a person carrying a bucket of water does any work on the bucket while walking on a level road.

(c) A pump discharges water through a nozzle of diameter 4.5 cm with a speed of 62 ms^{-1} into a tank 16 m above the intake.

(i) Calculate the work done per second by the pump in raising the water if the pump is ideal. **(2.05×10^5 J s^{-1})**

(ii) Find the power wasted if the efficiency of the pump is 73%. **(7.6×10^4 W)**

(iii) Account for the power lost in (c) (ii).

(d) (i) State the **work - energy theorem.**

(ii) Prove the work - energy theorem for a body moving with constant acceleration.

(e) Explain briefly what is meant by internal energy of a substance. ***(2014 Paper 1)***

11. (a) Using the molecular theory, explain the laws of friction between solid surfaces.

(b) With the aid of a labelled diagram, describe how the coefficient of static friction for an interface between a rectangular block of wood and a plane surface can be determined.

(c) The diagram in Figure 1 shows three masses connected by inextensible strings which pass over smooth pulleys. The coefficient of friction between the table and the 12.0 kg mass is 0.25.

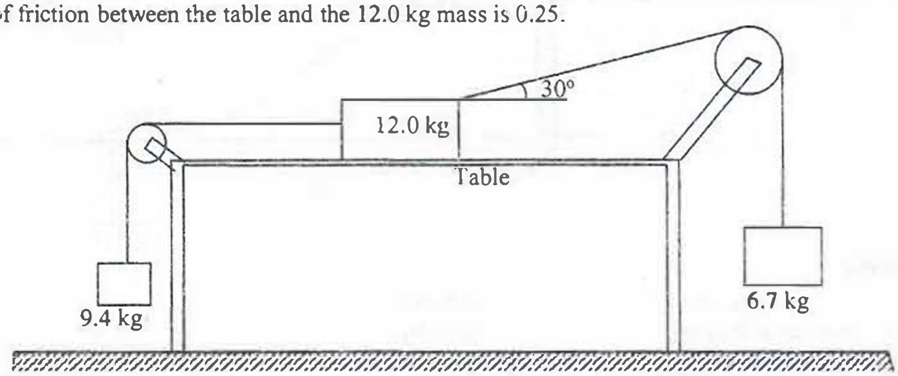


Fig. 1

If the system is released from rest, determine the

(i) acceleration of the 12.0 kg mass. **(0.53 ms^{-2})**

(ii) tension in each string. **(87.2 N, 69.3 N)** *(2013 Paper 1)*

12. (a) (i) State the law of conservation of linear momentum.

(ii) A body explodes and produces two fragments of masses m and M. If the velocities of the fragments are u and v respectively, show that the ratio of the kinetic energies of the fragments is

$$\frac{E_1}{E_2} = \frac{M}{m}$$

where E_1 is the kinetic energy of m and E_2 is the kinetic energy of M.

(b) Show that the centripetal acceleration of an object moving with constant speed, v, in a circle of radius, r, is $\frac{v^2}{r}$

(c) A car of mass 1000 kg moves round a banked track at a constant speed of 108 km h^{-1}. Assuming the total reaction at the wheels is normal to the track, and the radius of curvature of the track is 100 m, calculate the;

(i) angle of inclination of the track to the horizontal. **(42.5°)**

(ii) reaction at the wheels. **(1.33 × 10^{4}N)**

(d) (i) Define uniformly accelerated motion.

(ii) A train starts from rest at station A and accelerates at 1.25 m s^{-2} until it reaches a speed of 20 m S^{-1}. It then travels at this steady speed for a distance of 1.56 km and then decelerates at 2 m s^{-2} to come to rest at station B. Find the distance from A to B. **(1820 m)** *(2013 Paper 1)*

1. (a) (i) State **Kepler's laws** of planetary motion.

(ii) Estimate the mass of the sun, if the orbit of the earth around the sun is circular. **(2.0 × 10^{30} kg)**

(b) Explain **Brownian motion**.

(c) Explain the energy changes which occur when a pendulum is set into motion.

(d) A simple penduium of length 1 m has a bob of mass 100 g. It is displaced from its mean position A to a position B so that the string makes an angle of 45° with the vertical. Calculate the:

(i) maximum potential energy of the bob. **(0.287 J)**

(ii) velocity of the bob when the string makes an angle of 30^0 with the vertical. [Neglect air resistance]. **(1.766 ms^{-1})**

(2013 Paper 1)

13. (a) State **Hooke's law.**

(b) A copper wire is stretched until it breaks.

(i) Sketch a stress-strain graph for the wire and explain the main features of the graph.

(ii) Explain what happens to the energy used to stretch the wire at each stage.

(iii) Derive the expression for the work done to stretch a spring of force constant, k by a distance, e.

(c) (i) Define **Young's Modulus.**

(ii) Two identical steel bars A and B of radius 2.0 mm are suspended from the ceiling. A mass of 2.0 kg is attached to the free end of bar A. Calculate the temperature to which B should be raised so that the bars are again of equal length. (*Young's Modulus of steel* = 1.0 × 10^{11} Nm^{-2}; *Linear expansively of steel* = 1.2 × 10^{-5} K^{-1}) **(1.3 K)**

(d) Why does an iron roof make cracking sound at night? *(2012 Paper 1)*

14. (a) Define the following terms as applied to oscillatory motion.

(i) Amplitude.

(ii) Period.

(b) State **four** characteristics of simple harmonic motion.

(c) A mass, m is suspended from a rigid support by a string of length, l. The mass is pulled aside so that the string makes an angle, θ with the vertical and then released.

(i) Show that the mass executes simple harmonic motion with a period, $T = 2\pi\sqrt{\frac{l}{g}}$.

(ii) Explain why this mass comes to a stop after a short time.

(d) A piston in a car engine performs a simple harmonic motion of frequency 12.5 Hz. If the mass of the piston is 0.50 kg and its amplitude of vibration is 45 mm, find the maximum force on the piston. **(138.79 N)**

(e) Describe an experiment to determine the acceleration due to gravity, g using a spiral spring, of known force constant

(2012 Paper I)

15. (a) Explain what is meant by centripetal force.

(b) (i) Derive an expression for the centripetal force acting on a body of mass, m moving in a circular path of radius, r.

(ii) A body moving in a circular path of radius 0.5m makes 40 revolutions per second. Find the centripetal force if the mass is lkg. **(3.16×10^4 N)**

(c) Explain the following:

(i) A mass attached to a string rotating at a constant speed in a horizontal circle will fly off at a tangent if the string breaks.

(ii) A cosmonaut in a satellite which is in a free circular orbit around the earth experiences the sensation of weightlessness even though there is influence of gravitational field of the earth.

(d) (i) Derive an expression for the maximum horizontal distance travelled by a projectile in terms of the initial speed, u and the angle of projection, θ to the horizontal.

(ii) Sketch a graph to show the relationship between kinetic energy and height above the ground in a projectile.

(2012 Paper I)

16. (a) Define the following terms:

(i) uniform acceleration,

(ii) angular velocity.

(b) (i) What is meant by banking of a track?

(ii) Derive an expression for the angle of banking, θ for a car of mass, m, moving at speed, v, round a banked track of radius , r.

(c) A bob of mass, m is tied to an inelastic thread of length, l, and whirled with constant speed in a vertical circle.

(i) With the aid of a sketch diagram, explain the variation of tension in the string along the circle.

(ii) If the string breaks at one point along the circle, state the most likely position and explain the subsequent motion of the bob.

(d) A body of mass 15kg is moved from the earth's surface to a point 1.8×10^6 m above the earth. If the radius of the earth is 6.4×10^6m and its mass is 6.0×10^{24} kg, calculate the work done in taking the body to that point.

(2.06×10^8 J) ***(2011 Paper I)***

17. (a) State Newton's laws of motion.

(b) Use Newton's laws of motion to show that when two bodies collide, their momentum is conserved.

(c) Two balls P and Q travelling in the same line in opposite directions with speeds of 6ms -1 and 15ms-^{1} respectively make a perfect inelastic collision. If the masses of P and Q arc 8kg and 5kg respectively, find the

(i) final velocity of P. **(-2.08 ms^{-1} in the same direction as that of Q)**

(ii) change in kinetic energy. **(678.38 J)**

(d) (i) What is an impulse of a force?

(ii) Explain why a long jumper should normally land on sand.

(2011 Paper I)

18. (a) (i) What is meant by simple harmonic motion?

(ii) State two practical examples of simple harmonic motion.

(iii) Using graphical illustrations, distinguish between under damped and critically damped oscillations.

(b) (i) Describe an experiment to measure acceleration due to gravity using a spiral spring.

(ii) State **two** limitations to the accuracy of the value obtained in (b) (i).

(c) A horizontal spring of force constant 200Nm^{-1} fixed at one end has a mass of 2kg attached to the free end and resting on a smooth horizontal surface. The mass is pulled through a distance of 4.0 cm and released. Calculate the:

(i) angular speed, **(4 rad s^{-1})**

(ii) maximum velocity attained by the vibrating body, **(0.4 ms^{-1})**

(iii) acceleration when the body is half way towards the centre from its initial position. **(2ms^{-2})**

(2011 Paper I)

19. (a)(i) State the law of conservation of linear momentum.

(ii) Use Newton's laws to derive the law in (a) (i).

(b) Distinguish between elastic and inelastic collisions.

(c) An object X of mass M, moving with a velocity of 10 ms^{-1} collides with a stationary object Y of equal mass. After collision, X moves with a speed U, at an angle of 30° to its initial direction, while Y, moves with a speed of V at an angle of 90° to the new direction of X

(i) Calculate the speeds U and V. **(u = 8.66 ms^{-1}, v = 5 ms^{-1})**

(ii) Determine Whether the collision is elastic or not

(d)(i) Define uniform acceleration,

(ii) With the *aid* of a velocity-time graph, describe the motion of a body projected vertically upwards.

(iii) Calculate the range of a projectile which is fired at an angle of 45° to the horizontal with a speed of 20ms^{-1}.

(40.77m)

(2010 Paper 1)

20. (a)(i) State Archimedes' Principle

(ii) A solid weighs 20.0 g in air, 15.0 g in water and 16.0 g in a liquid, R. Find the relative density of liquid R. **(0.80)**

(b) (i) What is meant by **simple harmonic motion**?

(ii) Distinguish between **damped** and **forced** oscillations.

(c) A cylinder of length, l, cross-sectional area, A, and density σ floats in a liquid of density ρ. The cylinder is pushed down slightly and released.

(i) Show that it performs simple harmonic motion.

(ii) Derive the expression for period of the oscillation,

(d) A spring of force constant 40 Nm^{-1} is suspended vertically. A mass of 0.1 kg suspended from the spring is pulled down a distance of 5 mm and released. Find the

(i) period of oscillation, **(0.14 s)**

(ii) maximum acceleration of the mass. **(2 ms^{-2})**

(iii) net force acting on the mass when it is 2 mm below the centre of oscillation, **(0.08 N)** ***(2010 Paper 1)***

21. (a)(i) Define the terms tensile stress and tensile strain as applied to a stretched wire.

(ii) Distinguish between elastic limit and proportional limit.

(b) With the aid of a labelled diagram, describe an experiment to investigate the relationship between tensile stress and tensile strain of a steel wire.

(c)(i) A load of 60N is applied to a steel wire of length 2.5 m and cross-sectional area of 0.22 mm^2. If Young's Modulus for steel is 210 GPa, find the expansion produced. **(3.25 × 10^{-3} m)**

(ii) If the temperature rise of 1K causes a fractional increase of 0.001%, find the change in length of a steel wire of length 2.5 m when temperature increases by 4K. **(1.0 × 10^{-4} m)**

(d) The velocity, V, of a wave in a material of Young's Modulus, E, and density, ρ, is given by $V = \sqrt{\left(\frac{E}{\rho}\right)}$. Show that the relationship is dimensionally correct. ***(2010 Paper 1)***

22. (a)(i) Define the term **impulse**.

(ii) State Newton's Laws of motion.

(b) A bullet of mass 10g travelling horizontally at a speed of 100 ms^{-1} strikes a block of wood of mass 900g suspended by a light vertical string and is embedded in the block which subsequently swings freely. Find the

(i) vertical height through which the block rises. **(0.062 m)**

(ii) kinetic energy lost by the bullet. **(49.994 J)**

(c) Explain the terms time of flight and range as applied to projectile motion.

(d) A stone Is projected at an angle of 20° to the horizontal and just clears a wall which is 10 m high and 30 in from the point of projection. Find the

(i) speed of projection. **(73.8 ms^{-1})**

(ii) angle which the stone makes with the horizontal as it clears the wall **(16.8°)** ***(2009 Paper 1)***

23. (a)Define the following terms:

(i) velocity. (ii) moment of a force.

(b)(i) A ball is projected vertically upwards with a speed of 50ms^{-1}. On return it passes the point of projection and falls 78 m below. Calculate the total time taken. **(11.57 s)**

(ii) State the energy changes that occurred during the motion of the ball in (b)(i) above.

(c)(i) State the conditions required for mechanical equilibrium to be attained.

(ii) A uniform ladder of mass 40 kg and length 5 m, rests with its upper end against a smooth vertical wall and with its lower end at 3 m from the wall on a rough ground. Find the magnitude and the direction of the force exerted at the bottom of the ladder. **(4.2 × 10^2 N, 20.6° to the vertical)**

(d) State four instances where increasing friction is useful.

(2009 Paper 1)

24. (a) What is meant by **simple harmonic motion**?

(b) A cylindrical vessel of cross-sectional area, A, contains air of volume, V, at a pressure, P, trapped by frictionless air tight tight piston of mass, M. The piston is pushed down and released.

(i) If the piston oscillates with simple harmonic motion, show that the frequency is given by: $f = \frac{A}{2\pi}\sqrt{\frac{P}{MV}}$

(ii) Show that the expression for f in (b)(i) above is dimensionally correct.

(c) A particle executing simple harmonic motion vibrates in a straight line. Given that the speeds of the particles are 4 ms^{-1} and 2 ms^{-1} when the particle is 3 cm and 6 cm respectively from the equilibrium, calculate the:

(i) amplitude of oscillation, **(6.7 cm)**

(ii) frequency of the particle. **(10.68 Hz)**

(d) Give two examples of oscillatory motion which approximate to simple harmonic motion and state the assumptions made in each case. ***(2009 Paper 1)***

25. (a) (i) Define the terms velocity and displacement,

(ii) Sketch a graph of velocity against time for an object thrown vertically upwards.

(b) Three forces of 3.5 N, 4.0N and 2.0 N, act at point O as shown in Figure 1. Find the resultant force.

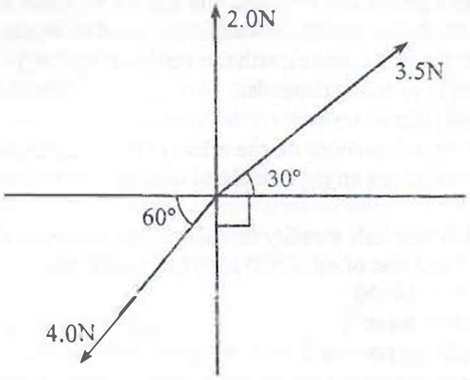


Figure 1

(1.07 N reaction, 15.5° with the horizontal)

(c)(i) What is meant by saying that a body is moving with velocity, v relative to another?

(ii) A ship, A is travelling due north at 20 km h^{-1} and ship B is travelling due east at 15 km h^{-1}. Find the velocity of A relative to B. **(25 km/h, N36.9°W)**

(iii) If the ship B in (c)(ii) is 10 km due west of A at noon, find their shortest distance apart and when this occurs. **(8 km, 14.4 minutes)**

(d)(i) What is meant by a couple in mechanics?

(ii) State the conditions for equilibrium of a system of coplanar forces. ***(2008 Paper 1)***

26. (a)(i) State the laws of friction between solid surfaces in contact.

(ii) Explain the origin of frictional force between two solid surfaces in contact.

(iii)Describe an experiment to measure the coefficient of kinetic friction between two solid surfaces.

(b) (i) A car of mass 1000 kg moves along a straight surface with a speed of 20 ms^{-1}. When brakes are applied steadily, the car comes to rest after travelling 50 m. Calculate the coefficient of friction between the surface and the tyre. **(0.408)**

(ii) State the energy changes which occur from the time the brakes are applied to the time the car comes to rest.

(c) (i) State two disadvantages of friction

(ii) Give one method of reducing friction between Solid surfaces.

(d) Explain what happens when a small steel ball is dropped centrally in a tall jar containing oil.

(2008 Paper 1)

27. (a) (i) Define simple harmonic motion.

(ii) A particle of mass m executes simple harmonic motion between two points A and B about equilibrium position O. Sketch a graph of the restoring force acting on the particle as a function of distance, r, moved by the particle.

(b) Two springs A and B of spring constants K_A and K_B respectively are connected to a mass m as shown in Figure 2. The surface on which the mass slides is friction less.

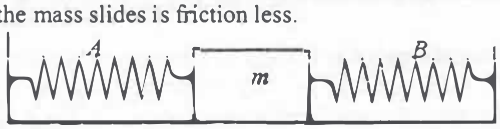


Fig. 2

(i) Show that when the mass is displaced slightly, it oscillates with simple harmonic motion of frequency, f, given by

$$f = \frac{1}{2\pi}\sqrt{\frac{K_A + K_B}{m}}$$

(ii) If the two springs in Figure 2 are identical such that $K_A = K_B = 5.0\ Nm^{-1}$ and mass m = 50 g, calculate the period of the oscillation. **(0.44 s)**

(c)(i) With the aid of a diagram, describe an experiment to determine the universal gravitational constant, G.

(ii) If the moon moves round the earth in a circular orbit of radius = 4.0×10^8 m and takes exactly 27.3 days to go round once, calculate the value of acceleration due to gravity, g, at the earth's surface. **(11.08 ms^{-2})**

(2008 Paper I)

28. (a) State :

(i) Newton's laws of motion,

(ii) the principle of conservation of momentum.

(b) A body A of mass m_1 moves with velocity u_1, and collides head on elastically with another body B of mass m_2 which is at rest. If the velocities of A and B are v_1, and v_2 respectively and given that $X = \frac{m_1}{m_2}$

Show that (i) $\frac{u_1}{v_1} = \frac{X+1}{X-1}$ (ii) $\frac{v_2}{v_1} = \frac{2X}{X-1}$

(c) Distinguish between conservative and non-conservative forces.

(d) A bullet of mass 40 g is fired from a gun at 200 ms^{-1} and hits a block of wood of mass 2 kg which is suspended by a light vertical string 2 m long. If the bullet gets embedded in the wooden block,

(i) calculate the maximum angle the string makes with the vertical. **(52.4°)**

(ii) state a factor on which the angle of swing depends. ***(2008 Paper I)***

29. (a) Define **coefficient** of viscosity and state its **units.**

(b) Explain the origin of viscosity in air and account for the effect of temperature on it.

(c) Describe, stating the necessary precautions an experiment to measure the coefficient of viscosity of a liquid using Stoke's law.

(d) A steel ball bearing of diameter 8.0 mm falls steadily through oil and covers a vertical height of 20.0 cm in 0.56 s. If the density of steel is 7800 kgm^{-3} and that of oil is 900 kgm^{-3}, calculate the

(i) up-thrust on the ball. **(2.37×10^{-3}N)**

(ii) viscosity of the oil. **(0.674 Ns m^{-2})** ***(2014 Paper I)***

30. (a) Using the molecular theory, explain the laws of friction between solid surfaces.

(b) With the aid of a labelled diagram, describe how the coefficient of static friction for an interface between a rectangular block of wood and a plane surface can be determined.

(c) The diagram in Figure 1 shows three masses connected by inextensible strings which pass over smooth pulleys. The coefficient of friction between the table and the 12.0 kg mass is 0.25.

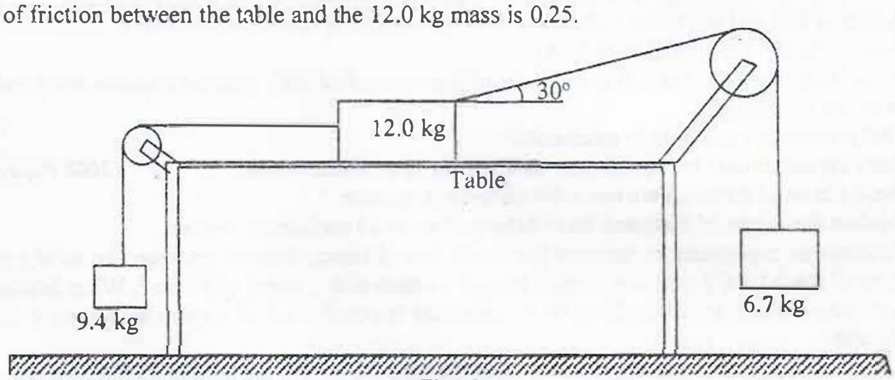


Fig. 1

If the system is released from rest, determine the

(i) acceleration of the 12.0 kg mass. **(0.53 ms^{-2})**

(ii) tension in each string. **(87.2 N, 69.3 N)** ***(2013 Paper I)***

31. (a) Define terminal velocity.

(b) Explain laminar flow and turbulent flow.

(c) Describe an experiment to measure the coefficient of viscosity of water using Poiseulle's formula.

(d) (i) State Bernoulli's principle.

(ii) Explain why a person 'standing near a railway line is sucked towards the railway line when a fast moving train passes

(e) A horizontal pipe of cross-sectional area 0.4 m^2, tapers to a cross-sectional area of 0.2 m^2. The pressure at the large section of the pipe is 8.0×10^4 N m^{-2} and the velocity of water through the pipe is 1.2 m s^{-1}. If atmospheric pressure 1.01×10^5N m^{-2}, find the pressure at the small section of the pipe. **(7.784×10^4 Pa)** ***(2013 Paper I)***

32. (a) (i) State the law of conservation of linear momentum.

(ii) A body explodes and produces two fragments of masses m and M. If the velocities of the fragments are u and v respectively, show that the ratio of the kinetic energies of the fragments is

$$\frac{E_1}{E_2} = \frac{M}{m}$$ where E_1 is the kinetic energy of m and E_2 is the kinetic energy of M.

(b) Show that the centripetal acceleration of an object moving with constant speed, v, in a circle of radius, r, is $\frac{v^2}{r}$

(c) A car of mass 1000 kg moves round a banked track at a constant speed of 108 km h^{-1}. Assuming the total reaction at the wheels is normal to the track, and the radius of curvature of the track is 100 m, calculate the;
   (i) angle of inclination of the track to the horizontal. **(42.5°)**
   (ii) reaction at the wheels. **(1.33 × 10⁴N)**

(d) (i) Define uniformly accelerated motion.
   (ii) A train starts from rest at station A and accelerates at 1.25 m s^{-2} until it reaches a speed of 20 m S^{-1}. It then travels at this steady speed for a distance of 1.56 km and then decelerates at 2 m s^{-2} to come to rest at station B. Find the distance from A to B. **(1820 m)** ***(2013 Paper 1)***

33. (a) State **Hooke's law.**
   (b) A copper wire is stretched until it breaks.
      (iv) Sketch a stress-strain graph for the wire and explain the main features of the graph.
      (v) Explain what happens to the energy used to stretch the wire at each stage.
      (vi) Derive the expression for the work done to stretch a spring of force constant, k by a distance, e.
   (c) (i) Define **Young's Modulus.**
      (ii) Two identical steel bars A and B of radius 2.0 mm are suspended from the ceiling. A mass of 2.0 kg is attached to the free end of bar A. Calculate the temperature to which B should be raised so that the bars are again of equal length. (*Young's Modulus of steel* = 1.0×10^{11} Nm^{-2}; *Linear expansively of steel* = 1.2×10^{-5} K^{-1}) **(1.3 K)**
   (d) Why does an iron roof make cracking sound at night? ***(2012 Paper 1)***

34. (a) Define the following terms as applied to oscillatory motion.
      (i) Amplitude. (ii) Period.
   (b) State **four** characteristics of simple harmonic motion.
   (c) A mass, m is suspended from a rigid support by a string of length, l. The mass is pulled aside so that the string makes an angle, θ with the vertical and then released.
      (i) Show that the mass executes simple harmonic motion with a period, $T = 2\pi\sqrt{\frac{1}{g}}$.
      (ii) Explain why this mass comes to a stop after a short time.
   (d) A piston in a car engine performs a simple harmonic motion of frequency 12.5 Hz. If the mass of the piston is 0.50 kg and its amplitude of vibration is 45 mm, find the maximum force on the piston. **(138.79 N)**
   (e) Describe an experiment to determine the acceleration due to gravity, g using a spiral spring, of known force constant ***(2012 Paper 1)***

35. (a) (i) What is meant by the following terms; steady flow and viscosity?
      (ii) Explain the effect of increase in temperature on the viscosity of a liquid.
   (b) (i) Show that the pressure, P, exerted at a depth, h, below the free surface of a liquid of density, ρ, is given by: $P = h\rho g$.
      (ii) Define **relative density**.
      (iii) A U-tube whose ends are open to the atmosphere, contains water and oil as shown in Figure 1.

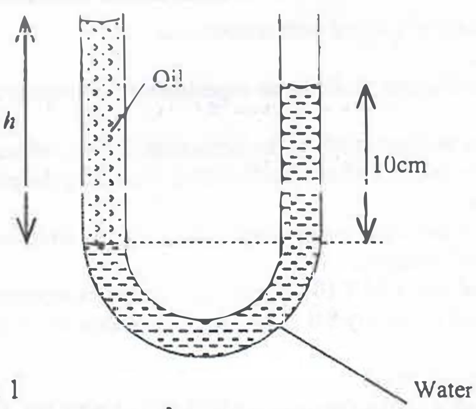


Fig. 1

Given that the density of oil is 800 kgm^{-3}, find the value of h. **(12.5 cm)**

   (c) A metal ball of diameter 10 mm is timed as it falls through oil at a steady speed. It takes 0.5 s to fall through a vertical distance of 0.30 m. Assuming that density of the metal is 7500 kgm^{-3} and that of oil is 900 kgm^{-3}, find

(i) the weight of the ball. **(3.85×10^{-2} N)**
(ii) the upthrust on the ball. **(4.62×10^{-3} N)**
(iii) the coefficient of viscosity of the oil. (Assume the viscous force = $6\pi\eta r v_o$, where η is the coefficient of viscosity, r is radius of the ball and v_o is terminal velocity). (0.5994 Pas (OR = 0.5994 $Nm^{-2}s$))

(2012 Paper 1)

36. (a) Define the following terms:
(i) uniform acceleration,
(ii) angular velocity.
(b) (i) What is meant by banking of a track?
(ii) Derive an expression for the angle of banking, θ for a car of mass, m, moving at speed, v, round a banked track of radius , r.
(c) A bob of mass, m is tied to an inelastic thread of length, l, and whirled with constant speed in a vertical circle.
(i) With the aid of a sketch diagram, explain the variation of tension in the string along the circle.
(ii) If the string breaks at one point along the circle, state the most likely position and explain the subsequent motion of the bob.
(d) A body of mass 15kg is moved from the earth's surface to a point 1.8×10^6 m above the earth. If the radius of the earth is 6.4×10^6m and its mass is 6.0×10^{24} kg, calculate the work done in taking the body to that point. **(2.06×10^8 J)**

(2011 Paper 1)

37. (a) (i) What is meant by viscosity?
(ii) Explain the effect of temperature on the viscosity of a liquid.
(b) Derive an expression for the terminal velocity of a sphere of radius, a, falling in a liquid of viscosity, η].
(c) Explain why velocity of a liquid at a wide part of a tube is less than that at a narrow part.
(d) A solid weighs 237.5g in air and 12.5g when totally immersed in a fluid of density 9.0×10^2kg m^{-3}. Calculate the density of the liquid in which the solid would float with one fifth of its volume exposed above the liquid surface.

(1187.5 kgm^{-3})

(e) Describe an experiment to measure the coefficient of static friction between a rectangular block of wood and a plane surface. ***(2011 Paper 1)***

38. (a)(i) State the law of conservation of linear momentum.
(ii) Use Newton's laws to derive the law in (a) (i).
(b) Distinguish between elastic and inelastic collisions.
(c) An object X of mass M, moving with a velocity of 10 ms^{-1} collides with a stationary object Y of equal mass. After collision, X moves with a speed U, at an angle of 30° to its initial direction, while Y, moves with a speed of V at an angle of 90° to the new direction of X
(iii) Calculate the speeds U and V. **(u = 8.66 ms^{-1}, v = 5 ms^{-1})**
(iv) Determine Whether the collision is elastic or not
(d)(i) Define uniform acceleration,
(ii) With the *aid* of a velocity-time graph, describe the motion of a body projected vertically upwards.
(iii) Calculate the range of a projectile which is fired at an angle of 45° to the horizontal with a speed of 20ms^{-1}.

(40.77m)
(2010 Paper 1)

39. (a) Define viscosity of a fluid.
(b)(i) Derive an expression for terminal velocity attained by a sphere of density, σ, and radius, a, falling through a fluid of density ρ, and viscosity, η.
(ii) Explain the variation of viscosity of a liquid with temperature.
(c) (i) State the laws of solid friction.
(ii) With the aid of a well labelled diagram, describe an experiment to determine the coefficient of kinetic friction between two surfaces.
(d) A body slides down a rough plane inclined at 30° to the horizontal. If the coefficient of kinetic friction between the body and the plane is 0.4, find the velocity after it has travelled 6 m along the plane. ***(2010 Paper 1)***

40. (a) (i) State **Archimedes' principle.**
(ii) Use Archimedes' principle to derive an expression for the resultant force on a body of weight, W, and density, σ, totally immersed in a fluid of density ρ.
(b) A tube of uniform cross sectional area of 4×10^{-3} m^2 and mass 0.2 kg is separately floated vertically in water of density 1.0×10^3 kgm^{-3} and in oil of density 8.0×10^2 kgm^{-3}. Calculate the difference in the lengths immersed.

(0.0125 m)

(c) (i) Define surface tension in terms of work.
(ii) Use the molecular theory to account for the surface tension of a liquid
(iii) Explain the effect of increasing temperature of a liquid on its surface tension

(iv) Calculate the excess pressure inside a soap bubble of diameter 3.0 cm if the surface tension of the soap solution is 2.5×10^{-2} Nm^{-1}. **(6.67 Pa)** ***(2009 Paper 1)***

41. (a)(i) State the laws of friction between solid surfaces in contact.

(ii) Explain the origin of frictional force between two solid surfaces in contact.

(iii) Describe an experiment to measure the coefficient of kinetic friction between two solid surfaces.

(b) (i) A car of mass 1000 kg moves along a straight surface with a speed of 20 ms^{-1}. When brakes are applied steadily, the car comes to rest after travelling 50 m. Calculate the coefficient of friction between the surface and the tyre. **(0.408)**

(ii) State the energy changes which occur from the time the brakes are applied to the time the car comes to rest.

(c) (i) State two disadvantages of friction

(ii) Give one method of reducing friction between Solid surfaces.

(d) Explain what happens when a small steel ball is dropped centrally in a tall jar containing oil. ***(2008 Paper 1)***

42. (a) Define simple harmonic motion (SHM).

(b) Sketch a graph of:

(i) velocity against displacement ,

(ii) acceleration against displacement, for a body executing SHM.

(c) A glass U - tube containing a liquid is tilted slightly and then released.

(i) Show that the liquid oscillates with simple harmonic motion.

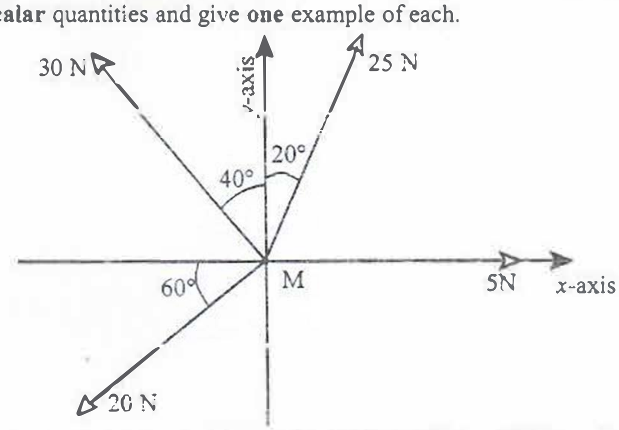
(ii) Explain why the oscillations ultimately come to rest.

(d) A small bob of mass 0.20 kg is suspended by an inextensible string of length 0.80 m. The bob is then rotated in a horizontal circle of radius 0.40 m. Find the:

(i) linear speed of the bob. **(1.51 ms^{-1})**

(ii) tension in the string. **(2.29 N)** ***(2007 Paper 1)***

43. (a) (i) Define **vector** and **scalar** quantities and give **one** example of each.



A body, M of mass 6 kg is acted on by forces of 5 N, 20 N, 25N and 30 N as shown in figure 1. Find the acceleration of M. **(5.52 ms^{-2})**

(b) (i) What is meant by **acceleration due to gravity**?

(ii) Describe how you would use a spiral spring, a retort stand with a clamp, a pointer, seven 50 g masses, a metre rule and a stop clock to determine the acceleration due to gravity.

(iii) State any two sources of errors of the experiment in (b)(ii) above.

(iv) A body of mass 1 kg moving with simple harmonic motion has speeds of 5 ms^{-1} and 3 ms^{-1} when it is at distances of 0.10 m and 0.20 m respectively from the equilibrium point. Find the amplitude of the motion. **(0.24m)**

(2007 Paper 1)