

Question (1972 STEP II Q9)

Two particles, of masses M and m , lie in contact and at rest on a smooth horizontal table. They are connected together by a light elastic string of natural length l and modulus λ . If the particle of mass m is set in motion with a horizontal velocity v , show that the particles will collide after a time

$$\frac{2l}{v} + \pi \sqrt{\frac{Mm}{\lambda(M+m)}}.$$

Find their distance, at the instant of collision, from their initial position.

Question (1974 STEP II Q13)

One end A of a uniform rod AB of length $2a$ and weight W can turn freely about a fixed smooth hinge; the other end B is attached by a light elastic string of unstretched length a to a fixed support at the point vertically above A and distant $4a$ from A . If the equilibrium of the vertical position of the rod with B above A is stable, find the minimum modulus of elasticity of the string.

Question (1975 STEP II Q10)

A breakdown truck tows away a car of mass m by means of an extensible rope whose unstretched length is l and whose modulus of elasticity is λ . Initially the rope is slack and the car stationary; the truck then moves off with speed v which it maintains constant. The movement of the car is opposed by a constant frictional force F . Determine the motion of the car as a function of time elapsed from the instant the rope becomes taut.

Question (1976 STEP II Q13)

An aeroplane flies at a constant air speed v around the boundary of a circular airfield. When there is no wind it takes a time T to complete one circuit of the airfield. Show that when there is a steady wind blowing, whose speed u is small compared with v , the increase in the time required for one circuit is approximately $3Tu^2/4v^2$.

Question (1976 STEP II Q15)

A light elastic string of unstretched length $3l$ passes over a small smooth horizontal peg. Particles A and B of masses m and $3m$ respectively are attached to the ends of the string. Initially B is held fixed at a distance $2l$ vertically below the peg, and the string hangs in equilibrium with A and B at the same level. Particle B is now released. Show that A moves upwards until it strikes the peg, and that the maximum length of the string during this motion is $5l$.

Question (1981 STEP II Q12)

A small body of mass M is moving with velocity v along the axis of a long, smooth, fixed, circular cylinder of radius L . An internal explosion splits the body into two spherical fragments, with masses qM and $(1 - q)M$, where $q \leq \frac{1}{2}$. After bouncing elastically off the cylinder (one bounce each) the fragments collide and coalesce. The collision occurs a time $5L/v$ after the explosion and at a point $\frac{3}{4}L$ from the axis. Show that $q = \frac{3}{8}$. Find the energy imparted to the fragments by the explosion, and find the velocity after coalescence. The effect of gravity may be neglected.

Question (1982 STEP II Q15)

A uniform rod BC is suspended from a fixed point A by stretched springs AB , AC . The springs are of different lengths but the ratio of tension to extension is the same constant k for each. The rod is not hanging vertically. Show that the ratio of sums of the stretched springs is equal to the ratio of the lengths of the unstretched springs.

Question (1969 STEP III Q10)

A mountaineer falls over a cliff. He is attached to a rope which, providentially, catches so that he just touches the ground at the foot of the cliff. Find the height of the cliff and the time taken for the mountaineer to reach the ground (in terms of his mass, the length of the unstretched rope and the elastic modulus of the rope).

Question (1971 STEP III Q17)

A bead of mass m slides on a smooth horizontal rail; a particle, also of mass m , is attached to the bead by a light inelastic string of length $2a$. The system is released from rest with the string taut, in the vertical plane through the rail, and making an angle α with the downward vertical. Prove that, if the inclination of the string to the downward vertical at time t is θ , then

$$\frac{1}{2}\dot{\theta}^2 = \frac{g}{a} \left(\frac{\cos \theta - \cos \alpha}{2 - \cos^2 \theta} \right).$$

Hence or otherwise find an expression for the tension in the string at any time in the subsequent motion.

Question (1977 STEP III Q12)

An elastic string, of natural length l and modulus of elasticity mg/k , has one end fixed at the point O . To the other end is attached a particle of mass m . The particle is dropped from O . Find the distance through which it falls before it first comes to rest instantaneously, and show that the time taken for this to happen is

$$\left[\sqrt{2} + \sqrt{k} \left\{ \frac{1}{2}\pi + \cos^{-1} \left(\sqrt{\frac{2}{2+k}} \right) \right\} \right] \sqrt{\frac{l}{g}}.$$

Question (1979 STEP III Q14)

When a soap film is punctured, a circular hole grows rapidly under the action of surface tension. It is observed that the mass of the film from the hole is concentrated on the rim of the hole and is spread evenly around the rim. Let the soap film, before being punctured, have a thickness h and a density ρ , and let the radius of the hole at time t be $r(t)$. How much mass is there in that segment of the rim which subtends a small angle $\delta\theta$ at the centre of the hole? Write down Newton's equation of motion for this small segment given that the surface tension gives rise to a net outwards force on the segment of $2T \cdot r\delta\theta$. Thence show that

$$r^4 \ddot{r} = \frac{2T}{\rho h} r^4 + \text{constant},$$

and conclude that when the hole is large it grows like

$$r = t \left(\frac{2T}{\rho h} \right)^{\frac{1}{2}} + \text{constant}.$$

Question (1981 STEP III Q14)

A light frictionless pulley is supported by a mounting of mass m , which is attached to the ceiling of a room by an elastic string with force constant k . A light inextensible string has one end attached to the floor of the room. It passes over the pulley and carries a load of mass M at its other end. The whole system rests in equilibrium with the straight sections of both strings being vertical. Find the extension of the elastic string. The load is now pulled vertically downwards through a distance a and then released. If neither string becomes slack in the subsequent motion, show that a must be less than $(m + 4M)g/k$ and find the period of oscillation of the system. [The tension in the string is the product of the force constant and the extension.]

Question (1982 STEP III Q16)

It may be assumed without proof that, in a position of equilibrium of a system, the potential energy has a stationary value; the position of equilibrium is stable when the potential energy is a minimum and unstable when it is a maximum. Three points B , A , C are in a horizontal line, A is the midpoint of BC and $BC = 2l$. A uniform rod AD , of mass M and length l , is free to turn about A in the vertical plane through BAC . Two light strings are attached to the rod at D : one passes through a smooth ring fixed at B and supports a mass m which hangs vertically below B ; the other passes through a smooth ring fixed at C and supports an equal mass m which hangs vertically below C . Show that the potential energy, V , of the system when AD makes an angle θ with the downward vertical is given by the equation

$$V = 2\sqrt{2}mgl \cos \frac{1}{2}\theta - \frac{1}{2}Mgl \cos \theta + \text{constant}.$$

Prove that there is always at least one position of equilibrium with D below the line BAC , and that there are three such positions when $M < 2m < \sqrt{2}M$. Determine for what values of M/m the position with AD vertical is stable.

Question (1961 STEP III Q102)

A uniform elastic ring has weight W , unstretched length $2\pi r$ and modulus of elasticity λ . It rests horizontally around a smooth cone of semi-angle α of which the axis is vertical. Find the depth below the apex of the cone at which the ring will be in equilibrium.

Question (1959 STEP III Q201)

A uniform elastic ring rests horizontally on a smooth sphere of radius a . The natural length of the ring is $2\pi a \sin \alpha$, and the tension needed to double its length is k ; 2π times its weight. By consideration of potential energy, or otherwise, show that the ring rests in equilibrium at a height $a \cos \theta$ above the centre of the sphere, where θ is given by

$$\tan \theta + k = k \sin \theta / \sin \alpha.$$

Show graphically that there is a value below which k must not fall if such an equilibrium position is to exist. What is the physical meaning of this restriction?

Question (1962 STEP III Q304)

A particle A of mass m , and a particle B of larger mass M , are attached to the ends of a light inelastic thread which hangs over a smooth peg; the particle A is also attached to one end of a light elastic string, whose unstretched length is a and whose other end is attached to a fixed point C which is vertically below the peg. Originally the system is at rest in equilibrium, and then the stretched length of the elastic string is $(a + c)$. The system is set in motion by a downward impulse $(M + m)v$ on the particle B . Show that during the subsequent motion the string and the thread both remain taut if

$$v^2 < \frac{M - m}{M + m} gc.$$

Question (1959 STEP III Q405)

A particle is released from rest and slides under gravity down a rough rigid wire in the shape of a loop of a cycloid held fixed in a vertical plane with its line of cusps horizontal and uppermost. If the particle starts from a cusp and comes to rest at the lowest point, prove that the coefficient of friction μ must satisfy the equation $\mu^2 = e^{-\mu\pi}$. [The usual parametric equations for the cycloid may be taken in the form:

$$x = a(\theta + \sin \theta), \quad y = a(1 - \cos \theta).]$$

Question (1961 STEP III Q405)

A bead of unit mass is projected with horizontal velocity u at the vertex of a smooth rigid parabolic wire held fixed in a vertical plane with its axis vertical and its vertex uppermost and moves under gravity on the wire. Prove that when the bead is at depth y below the vertex, the pressure on the wire is given by

$$\left(\frac{a}{a+y}\right)^{\frac{1}{2}} \left(g - \frac{u^2}{2a}\right),$$

where $2a$ is the length of the semi-latus rectum of the parabola. Explain what happens when $u^2 = 2ga$. Show also that if the wire is made to terminate at any point and the bead allowed to fly off at a tangent, the resulting path is a parabola with the same directrix whatever the point at which the bead leaves the wire. Find the position of this directrix.

Question (1965 STEP III Q7)

A , B and C are three equal particles attached to a light inextensible string at equal intervals a . The system is placed on a smooth horizontal table with the three particles in a straight line. B is suddenly started moving with velocity v perpendicular to the string. Show that, until the first impact, the angular velocity of AB is given by $v/a(2 + \cos^2 \theta)$, where θ is the angle ABC .

Question (1950 STEP II Q211)

Two beads each of mass m are threaded on to a smooth straight rod one end of which is freely hinged to a fixed point. They are connected by an elastic string of natural length l and modulus λ . The rod is set in uniform rotation in a horizontal plane with angular velocity ω . Show that, if $2\lambda < ml\omega^2$, the string must in general ultimately break.

Question (1951 STEP II Q310)

A particle P of mass m is attached by a light elastic string, of unstretched length l and modulus of elasticity λm , to a point O on a smooth horizontal plane. Initially the particle is at rest on the plane and OP is of length l . The particle is then given an initial velocity V on the plane in a direction perpendicular to OP . Prove that, if $3V^2 < 4\lambda l$, the length of OP in the ensuing motion never exceeds $2l$.

Question (1954 STEP II Q306)

A bead of mass m is free to slide on a smooth circular wire of radius a which is fixed in a vertical plane. The bead is attached to the highest and lowest points of the wire by two light elastic strings of natural length a and moduli λ_1 and λ_2 respectively. Show that the bead will be in equilibrium at a point of the circle with vertical tangent if

$$\lambda_1 - \lambda_2 = mg(2 + \sqrt{2}).$$

Investigate the stability of this equilibrium.

Question (1950 STEP III Q205)

A catapult is formed by holding a particle of mass m against the mid-point of a light elastic string of natural length $2l$ and modulus λ , whose ends are fixed at a distance $2l$ apart, and then pulling back horizontally a distance $\frac{3}{4}l$. The whole system lies in contact with a smooth horizontal table. Show that when the particle is released it attains a final velocity of

$$\sqrt{(\lambda l/8m)}.$$

What difference, if any, does it make if the catapult is made from two elastic strings of length l and modulus λ joined end to end by a non-elastic connection whose length and mass may be neglected?

Question (1951 STEP III Q207)

The ends of a light elastic string of modulus of elasticity λ , whose unstretched length is $2l$, are attached to two fixed points which are separated by a horizontal distance $2l$. A particle of weight w is attached to the centre of the string. Verify that if $\lambda = w/2$ the tension in the string is approximately $0.57w$ when the system is in equilibrium.

Question (1951 STEP III Q209)

A particle of mass m is suspended by a light inelastic string of length l from a point A which is constrained to move in a horizontal circle of radius a at a constant speed $a\omega$. Prove that, if the particle can describe a horizontal circle of radius x with constant speed, then x satisfies the equation

$$\omega^4 x^2 \{l^2 - (x - a)^2\} = g^2 (x - a)^2.$$

If ω , l and a are given, show how to decide which of the four roots of this equation can be an actual value of x .

Question (1953 STEP III Q203)

Show that the work done in stretching an elastic string AB , of natural length l and modulus λ , from tension T_1 to tension T_2 is

$$\frac{l}{2\lambda}(T_2^2 - T_1^2).$$

A weight w is attached at B and weights w/n are attached at each of the points A_1, A_2, \dots, A_n , where in the unstretched position

$$AA_1 = A_1A_2 = \dots = A_{n-1}A_n = A_nB.$$

Show that the potential energy of the string in the equilibrium position when it is suspended from A is $lw^2(14n + 1)/(12\lambda n)$.

Question (1956 STEP III Q209)

A light elastic string of modulus λ and natural length a is fixed at one end and carries a particle of mass m at the other. When the particle is held at depth d ($> a$) below the fixed end of the string and released, it is found that in the subsequent motion it just rises to the fixed end. Show that $\lambda(d - a)^2 = 2mgad$. Find also an expression for the time taken by the particle from its release to reach the fixed end of the string.

Question (1950 STEP III Q305)

One end of a uniform rod of weight w and length $5l$ is freely hinged, while the other is attached by a light elastic string of unstretched length $2l\sqrt{2}$ to a point at the same level as the hinge and distant $7l$ from it. In equilibrium the length of the string is $3l\sqrt{2}$. A weight W is now attached to the mid-point of the rod, and the length of the string in the new equilibrium position is $4l\sqrt{2}$. Show that $W = 5w/3$.

Question (1954 STEP III Q301)

Four uniform bars AB, BC, CD and DA of length a and weights $w, 2w, 2w$ and w respectively are freely jointed at A, B, C and D . A and C are connected by a light elastic string of natural length a . When the system is hung from A , the length of AC is observed to be $\frac{9}{8}a$. Show that the modulus of elasticity of the string is $7w$. Find the reactions at the joints B and D .

Question (1954 STEP III Q308)

A particle is tied to a fixed point O by a light elastic string. The natural length of the string is a , and the stretched length, when the particle hangs in equilibrium, is $5a/4$. The particle is allowed to fall from rest at O . Prove that the greatest depth below O reached by the particle is $2a$. How long does the particle take to reach this depth after it is released from O ?

Question (1954 STEP III Q310)

The end A of a light string AB is held fixed, and a particle of mass m is attached to the end B . The particle moves in a horizontal circle with angular velocity ω . Prove that if the string is inelastic and of length l , the inclination α of the string to the downward vertical during the motion is given by the equation

$$\cos \alpha = \frac{g}{l\omega^2}.$$

If the string is elastic, its natural length being a , and if the tension required to double its length is kmg , prove that the inclination is given by the equation

$$\cos \alpha = \frac{g}{a\omega^2} - \frac{1}{k}.$$

Question (1951 STEP III Q406)

A bead of mass m moves on a smooth wire bent in the form of a circle of radius a which is held fixed in a vertical plane. An elastic string of natural length μa ($0 < \mu < 2$) has one end attached to the bead and the other end to the highest point of the wire. When the bead is released from rest at the position where the string is just taut, it is found that it comes to rest again at the lowest point of the wire. Prove that μ must be the positive root of the equation

$$x^2 + x(2 + n) - 2n = 0,$$

where n is the ratio of the modulus of the string to the weight of the bead.

Question (1952 STEP III Q410)

Two equal heavy beads A, B each of mass m move on a smooth horizontal wire in the form of a circle of radius a and centre O . They are joined by a light spring of natural length $2a \sin \alpha$ and modulus of elasticity λ . If the angle AOB is denoted by 2θ show that during the motion

$$ma \sin \alpha \dot{\theta}^2 + \lambda(\sin \theta - \sin \alpha)^2$$

remains constant. If when the spring is at its greatest compression $\theta = \beta$, show that maximum extension occurs when $\sin \theta = 2 \sin \alpha - \sin \beta$. What happens if $2 \sin \alpha - \sin \beta > 1$?

Question (1955 STEP III Q404)

A small heavy sphere suspended from a fixed point O by a light elastic string will hang in equilibrium at a height a above a horizontal plane with the extension of the string from its natural length at the same value a . The sphere is released from rest at a height b vertically above the plane where $b > 2a$. If e is the coefficient of restitution for impact with the plane, show that after n impacts the sphere comes instantaneously to rest at a height above the plane $2a + e^{2n}(b - 2a)$.

Question (1957 STEP III Q407)

A heavy particle P can move under gravity in a vertical straight line AB and is attached to the ends of two similar elastic strings PA and PB of natural length l . The particle can rest in equilibrium at a point O between A and B , the lower string PB being just in tension while the upper string AP is extended a distance a . If the particle is released from rest when at a height h above O , where $h > a$, find the appropriate equations of motion for the downward path, and prove that the particle first comes to rest when at a depth x below O given by $x^2 = h^2 + 2ah - a^2$.

Question (1947 STEP III Q103)

Two particles A and B , of masses α and β respectively, lie on a smooth horizontal plane and are joined by a light spring of modulus k and natural length l . At first the spring is unstretched. The particle B is then set in motion with speed u in the direction AB . Calculate the maximum extension of the spring in the subsequent motion.

Question (1947 STEP III Q203)

A uniform rod AB of length d and weight W is smoothly pivoted at B to a fixed support and A is attached to one end of a light elastic string of unstretched length l , the other end of which is fastened to a fixed peg C vertically above B , where $BC = h$ and $h > d + l$. When the length x of the string exceeds l , the tension in the string is $\lambda(x - l)/l$. Show that the position of equilibrium in which AB is vertical, with A above B , is stable if

$$2\lambda h(h - d - l) > Wl(h - d).$$

If a position of equilibrium exists in which AB is inclined to the vertical, show that in this position the length of the string is $2\lambda hl/(2\lambda h - Wl)$.

Question (1948 STEP III Q208)

The weight of a man, as measured by a spring balance, at the equator is 196 lb. Prove that his weight, as measured by a spring balance, is increased or diminished by about 0.4 oz. if he travels on a train going at 20 m.p.h. along the equator, according as the train travels W. or E. respectively. (Take $g = 32$ ft. per sec. per sec. at the equator.)

Question (1946 STEP III Q306)

An engine is required to raise a weight of 1 ton from the bottom of a mine 900 feet deep in 5 minutes. What must be the average horse-power of the engine? What must it be if the load, starting from rest at the bottom, has a velocity of 12 feet per second on reaching the surface?

Question (1948 STEP III Q310)

Two particles P_1, P_2 of masses m_1, m_2 are connected by a light elastic string of modulus λ and natural length l and lie at rest on a smooth horizontal table at a distance l apart. If an impulse I is applied to P_1 in the direction P_2P_1 , prove that in the subsequent motion the greatest extension of the string is

$$I\sqrt{\frac{m_2 l}{m_1(m_1 + m_2)\lambda}},$$

and find when it is first attained.

Question (1913 STEP I Q114)

The melting point of lead is 333°C ., its specific heat is $.031$ and its latent heat of fusion 5.36 . Find the least velocity in feet per second with which a lead bullet must strike a target into which it does not penetrate so that it may be melted, if the temperature of the bullet on striking the target be 150°C . The work required to raise 1 lb. of water 1°C . is 1400 ft. lbs.

Question (1920 STEP I Q106)

A coil of rope of mass $\frac{1}{2}\text{ lb.}$ per foot length lies on the ground. One end is started from rest and is pulled up vertically with a constant acceleration of $10\text{ ft. per sec. per sec.}$ for 2 seconds . Find the total work which has been done by the pulling agent during the 2 seconds .

Question (1914 STEP I Q110)

A pulley $3\text{ ft. }6\text{ ins.}$ in diameter, making 150 revolutions a minute, drives by a belt a machine which absorbs 7 horse-power ($1\text{ horse power} = 33000\text{ ft. lbs. of work per minute}$). If the tension on the driving side is twice that on the slack side, and the maximum tension is to be $35\text{ lbs. per inch width}$, find the width of the belt.

Question (1915 STEP I Q113)

Water issues vertically from the nozzle of a fire hose, the sectional area of which is one square inch, with a velocity of $130\text{ feet per second}$. Find the discharge in cubic feet per second, and the horse-power of the pump engine, assuming the efficiency to be 70% , and that the nozzle is 50 feet above the pump.

Question (1921 STEP I Q110)

The resistance to an airship is proportional to the square of the speed. It is required to cover a fixed distance in a fixed time. Shew that the work done is a minimum when the speed is constant.

Question (1932 STEP I Q107)

A uniform thin chain, 20 feet long and weighing 10 lb. , rests in a small space on the ground. One end of it is given a constant vertical acceleration of $5\text{ feet per second per second}$ by a force applied to that end. Determine the work which has been done by this force when the whole chain is just clear of the ground.

Question (1936 STEP I Q108)

A train of mass M is moving with velocity V when it begins to pick up water at a uniform rate. The power is constant and equal to H . If after time t a mass m of water has been picked up, find the velocity and shew that the loss in energy is

$$\frac{m(Ht + MV^2)}{2(m + M)}.$$

Question (1940 STEP I Q104)

A force F acts in a given plane at a point P . Define the work done by F when P is displaced from A to B along a given curve in the plane. If two such forces F_1 and F_2 acting at P have a resultant F , prove that the work done by F in the displacement is the sum of the work done by F_1 in the displacement and that done by F_2 .

If the coordinates of P referred to rectangular axes are (x, y) , and a force F acting at P has components $(Ay, 0)$ along these axes, prove that the work done by F when P is displaced along a straight line from (x_1, y_1) to (x_2, y_2) is $\frac{1}{2}A(x_2 - x_1)(y_1 + y_2)$.

Prove also that the work done when P is displaced round a closed path is proportional to the area enclosed by the path.

Question (1933 STEP I Q106)

A circular area is rotated through 180° about a coplanar axis which does not intersect the circumference of the circle. Prove that the centre of gravity of the volume generated is at a perpendicular distance

$$\frac{2}{\pi} \left(h + \frac{a^2}{4h} \right)$$

from the axis, where a is the radius of the circle, and h the perpendicular distance of its centre from the axis.

Question (1933 STEP I Q110)

Two thin uniform rods AB and BC , each of mass m and length l , are smoothly hinged together at B and are supported in a vertical plane with their ends A and C resting on a fixed smooth horizontal plane. The angle ABC is 60° . If the system is released so that it is free to collapse in a vertical plane, determine the velocity with which the hinge B will strike the horizontal plane and the resultant impulse which brings the system to rest, assuming that there is no rebound.

Question (1920 STEP I Q114)

Find the volume of the surface generated by the complete revolution of a circle about a tangent.

Question (1917 STEP I Q207)

A pile driver weighing 2 cwt. falls through 5 feet and drives a pile weighing 6 cwt. through a distance of 4 inches. Find the average resistance to the pile in cwt., assuming the two to remain in contact. Find in foot-pounds the energy dissipated in one stroke.

Question (1934 STEP I Q207)

Define work and power.

The engine of a car of mass $17\frac{1}{2}$ cwt. works at a constant rate of 10 horse-power, the resistance to motion being proportional to the speed. The maximum speed is 60 miles per hour. Prove that the car will increase its speed from 30 miles per hour to 45 miles per hour in about a quarter of a mile.

Question (1937 STEP III Q309)

A heavy ring of mass m slides on a smooth vertical rod, and is attached to a light string which passes over a small light pulley at a distance a from the rod and is attached to a mass $M(> m)$ which hangs freely. The system is released from rest when the string is taut, m level with the pulley, and M vertically beneath the pulley. Shew that the ring drops a distance

$$\frac{2Mma}{M^2 - m^2}$$

before coming to rest again. At this point the ring suddenly splits into two rings of equal mass, one of which falls freely while the string remains attached to the upper one. Shew that the upper ring rises to a height

$$\frac{2M^2 - m^2}{4M^2 - m^2} \frac{2Mma}{M^2 - m^2}$$

above the pulley before coming momentarily to rest.

Question (1913 STEP III Q407)

The energy of 1 lb. of powder is 75 foot-tons. Shew that the weight of charge necessary to produce an initial velocity of 1500 feet per second in a projectile weighing 600 lbs. is at least 125 lbs. (Neglect the recoil of the gun.)

Question (1934 STEP III Q401)

A Venetian blind is 7 feet long when fully stretched out, and 1 foot long when completely drawn up. There are 30 movable strips, and each weighs one pound. Find the work done in raising the blind against gravity.

Question (1920 STEP III Q507)

A spring requires a force of P lb. weight to stretch it 1 inch. Find an expression for the potential energy stored in the spring when it is stretched x inches. A spring that requires a force of 18 lb. to stretch it 1 inch is placed on a smooth horizontal table, is fixed at one end, and is connected at the other to a mass of 12 lb. A bullet of mass half an ounce is fired along the axis of the spring with a velocity of 1540 feet per second, and embeds itself in the 12 lb. mass. Prove that the greatest extension of the spring in the subsequent motion is very nearly 2 inches.

Question (1925 STEP III Q506)

Find the horse power required to lift 1000 gallons of water per minute from a canal 20 feet below and project it from a nozzle of cross section 2 sq. inches. [1 c. foot of water weighs $62\frac{1}{2}$ lb. and 1 gallon of water weighs 10 lb.]

Question (1925 STEP III Q507)

A pile-driver weighing 200 lb. falls through 5 feet and drives a pile which weighs 600 lb. through a distance of 3 inches. Find the average resistance offered to the motion of the pile, assuming that the two remain in contact after the blow. How many foot pounds of energy are dissipated during the blow?

Question (1926 STEP I Q612)

A motor car weighing one ton attains a speed of 40 miles per hour when running down an incline of 1 in 20 with the engine cut off. It can attain the speed of 30 miles up the same incline when the engine is working. Assuming that the resistance varies as the square of the velocity, find the horse-power developed by the engine.

Question (1913 STEP III Q611)

Define Kinetic Energy. State and prove the principle of energy for a particle moving in a straight line under the action of a constant force in that line.

Question (1915 STEP III Q604)

A fire engine raises n gallons of water per minute from a reservoir and discharges it at a height h feet above the surface of the reservoir through a pipe whose cross-section is A square inches; find the horse power consumed, assuming a gallon of water to weigh 10 lbs.

Question (1925 STEP II Q706)

A uniform rod 8' long standing vertically on the ground falls over so that its centre strikes a horizontal bar: the bar is perpendicular to the length of the rod at the moment of impact and is 2' above the ground. Find the velocity with which the upper end of the rod strikes the ground, assuming that neither rod nor bar is bent by the impact.

Question (1919 STEP I Q813)

Define work and power, and shew that, when a force F is moving its point of application with velocity v , the power is measured by Fv . An engine of 300 horse-power pulls a train of 200 tons mass up an incline of 1 in 120, the resistance of wind and rails being 10 lb. weight per ton. Find the maximum velocity acquired, correct to one place of decimals in miles per hour.