Work- Energy Principle

U84-P2a A block of mass 4 kg is released from rest at point A, as shown in Fig.U84-P2, on a track which is one quadrant of a circle of radius 2.25 m. It slides down the track and reaches point B with a velocity of 6 m s^{-1}. From point B it continues to slide on a horizontal surface BC, a distance of 4.5 m, to point C where it comes to rest.
What is the coefficient of sliding friction on the horizontal surface BC?
How much work is done against friction as the body slides down the circular track from A to B?
If the circular track becomes smooth but the horizontal surface BC remains as rough as before, how far would the block slide along the horizontal surface before coming to rest?
[Take g = 10 m s^{-2}] [0.4; 18.0 J; 5.63 m]

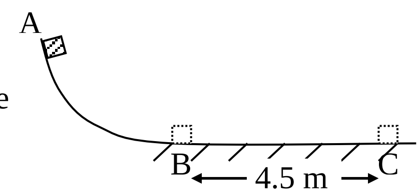


Fig.U84-P2

U85-6 A bullet of certain speed can just pass through a piece of stationary wooden plank. If its speed is double, then it can pass through ___________ pieces of wooden planks of the same kind.
A. 2 B.3 C.4 D.5 E.6

U86-P2 The hammer of a pile-driver has a mass of 200 kg. This hammer is first raised to a height of 20 m above the ground and then released, falling freely before hitting a pile situated vertically below it. If air resistance as well as frictional forces are to be neglected, calculate
(a) the potential energy of the hammer when it is at the highest point;
(b) the kinetic energy of the hammer immediately before it hits the pile, the top of which is 2 m above the ground at that time.
(c) if the ground provides an average resistance of 50000 N to the pile as it penetrates, what depth of penetration would be result from the first driving/hitting?
(d) the actual depth of penetration is less than that calculated in part (c). Why?
[39200 J; 35280 J; 0.7 m]

U87-P2a What is meant by the Law of Conservation of Energy?
Is this law rigidly true in the context of modern science? Discuss its validity?
(b) A waterfall is 100 m high and the specific heat capacity of water is 4200 J kg^{-1} K^{-1}. What is the difference in temperature between the water at the top and that at the bottom? [0.23 K]
(c) State the assumptions made in your calculations in part (b). Do you think that the assumptions made are reasonable? Why?

U89-5 A 5 kg wooden block is projected up a 30° inclined plane with a speed of 20 m s^{-1}. If the average frictional fore between the wooden block and the inclined plane is 25 N, then the distance traveled up along the plane by the block is _________ m.
A. 5 B. 10 C. 20 D. 30 E. 40

U91-P1 As shown in Fig.2, an inclined plane of length 4 m is placed so that its upper end with a fixed pulley attached is 2 m above the ground. Two bodies m_1 and m_2 of masses 0.8 kg and 2.0 kg respectively are tied to the two ends of a light and inextensible string which passes over the pulley. Initially, m_1 is at the bottom of the plane, while m_2 above the ground, and the string is in tension. The body m_2, after falling from rest, acquires a velocity $\sqrt{20}$ m s^{-1} when it strikes the ground. When m_2 stops moving after striking the ground, m_1 continues to move up along the inclined plane until finally it comes to a stop.

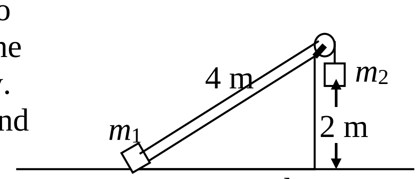


Fig.U84-P2

(a) How much work is done on m_1 by m_2?
(b) What is the greatest kinetic energy acquired by m_1 and where does this occur when m_1 is in motion along the plane?
(c) When m_1 is in its accelerated motion, how much work is spent in overcoming friction along the plane? How long is this acceleration motion?
[Take g = 10 m s^{-2}] [20 J; 8 J, 2 m; 4 J, 2 m]

U92-12 A bullet, traveling with a velocity v, is just able to penetrate through a block of wood. If the velocity of this bullet is increased to $3v$, then through how many blocks of wood similar to the previous one can be penetrated?
A. 2 B. 3 C. 6 D. 9

U92-11 Two metal spheres A and B are of equal mass and different densities of $\rho_A = 8\times10^3$ kg m^{-3} and $\rho_B = 4\times10^3$ kg m^{-3} respectively. If they are dropped from the water surface of a swimming pool so that they sink to the bottom of the pool of uniform depth, what is the ratio of their kinetic energies $E_{kA} : E_{kB}$, when they reach the bottom of the pool? [Given that the density of the water is 1×10^3 kg m^{-3}]

A. 1: 1 B. 2: 1 C. 4: 3 D. 7: 6

[Hint: Try to use the principle of work and energy. The kinetic energy of the sphere reaching the bottom of the pool = $mgh - Fh$, where F is the buoyancy force on the sphere by the pool water, h is the depth of the water in the pool]

U94-P2 Fig.U94-P2 shows one form of diving board of negligible weight used at swimming pools. The board is pivoted at P, and a diver of weight 640 N stands at Q where PQ = 2.4 m. The spring S holds the diving board in a horizontal position.

(i) Calculate the moment of the weight of the diver about P.

(ii) Calculate the force exerted by the spring to balance the weight of the diver, if the distance between the spring S and the point P is 0.4 m.

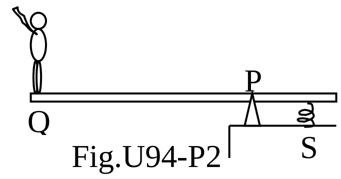


Fig.U94-P2

(iii) Draw a force diagram showing all the forces acting on the diving board.

(b) The diver allows himself to fall from the end of the board, and when his centre of gravity has fallen through 3.2 m from rest, he hits the water. His vertical motion in air may be considered to be a free-fall. Find,

(i) the speed of fall when he hits the water and his time of fall in air;

(i) the work done on him by the force of gravity;

(ii) the depth through which he will penetrate if the average resistance his motion provided by water is 1280 N. [Take g = 10 m s^{-2}] [1536 N m; 3840 N; 8 m s^{-1}; 2048 J; 4 m]

U96-12 The ratio of the masses of three cars X, Y and Z is 1: 2: 3. If they have equal kinetic energy and an equal force is applied to their brakes at the same time, the ratio of the respective distances to bring the cars to rest is ________.

A. 1: 1: 1 B. $1:\sqrt{2}:\sqrt{3}$ C. 1: 2: 3 D. 3: 2: 1

U96-P4a State the law of conservation of mechanical energy.

(b) In Fig.U96-P4b, the object A of mass M is on a plane inclined at an angle θ to the horizontal. Object A pulls up another object B of mass m by using a light string connected between them through a frictionless pulley. The coefficient of friction between A and the inclined plane is μ. When the system consisting of A and B moves a distance l, the velocity increases from zero to v.

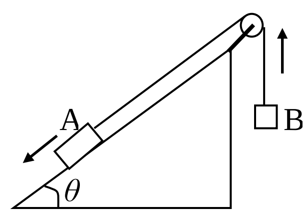


Fig.U96-P4b

(i) How much is the change in mechanical energy of the system?

(ii) What is the work done by friction after A has slide down a distance l?

(iii)If θ = 37°, M = 240 kg, m = 60 kg, μ = 0.3 and l = 8 m, find the acceleration a and final velocity v of the system. [Take g = 10 m s^{-2}]

[$\frac{1}{2}(M+m)v^2 - Mgl\sin\theta + mgl$; $-\mu Mgl\cos\theta$; 3.75 m s^{-1}; 0.88 m s^{-2}]

U98-7 Two bodies A and B with masses m and $2m$ respectively are rested on a smooth floor. They are acted by equal horizontal forces F for time t. The ratio of kinetic energy increase of A to B is ____.

A. 4:1 B. 2:1 C. 1:1 D. 1:2

U2k03-8 If the velocity of an object of initial kinetic energy E_k increases from v to $2v$ when it is acted by a constant force F, then the work done by the constant force F to the object is _______.

A. $4E_k$ B. $3E_k$ C. $2E_k$ D. $3/2\ E_k$

U2k05-P2 (b) In Fig.U2k05-P2b, two objects A and B weighing 50 N and 80 N respectively were connected by a light string over a fixed pulley. A was put on a reasonably long and horizontal table surface. The average coefficient of sliding friction between A and the table surface is μ = 0.3 while the friction between the string and the pulley is neglected. Find the velocity of B after falling downwards for 2 m. (Take g = 10 m s^{-2}) [$2\sqrt{2}$ m s^{-1}] [3%] [Assuming that the string and the table are very long]

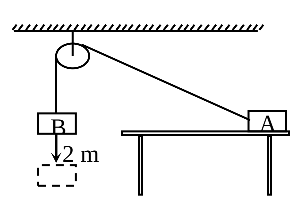


Fig.U2k05-P2b

U2K04-P2 In Fig.U2k04-P2a, a rectangular block of mass m is put on a very long horizontal floor that the average coefficient of sliding friction between the block and the floor is μ. The rectangular block moves to the right when pulled by a light rope which crosses a fixed pulley. The rope makes an angle of φ with the horizontal direction. The friction between the rope and the pulley is negligible.

(a) The rectangle block moves to the right in linear uniform speed motion by the pulling force F. In the process of increasing the angle φ, the pulling force F first decreases and then increases, a smallest value will appear during this process. Given that the pulling force is smallest when $\tan\varphi = \mu$. Prove that the smallest pulling force,

$$F_{\min} = \frac{\mu mg}{\sqrt{1+\mu^2}}$$

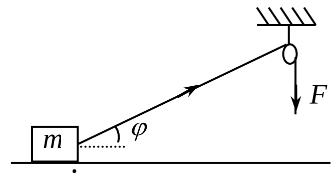


Fig.U2k04-P2a

(b) The rectangular block is accelerated from rest point A to another point B by a constant pulling force F of 3 N, as shown in Fig.U2k04-P2b. Given that $\varphi_A = 30°$, $\varphi_B = 60°$, $m = 0.5$ kg and average coefficient $\mu = 0.3$, the height of the pulley from the floor is $h = 1$ m and the thickness of the rectangular block is neglected. Find the speed of the rectangular block at B. [1.85 m s^{-1}]
(In this problem, the plane is smooth is better, otherwise it is difficult to solve)

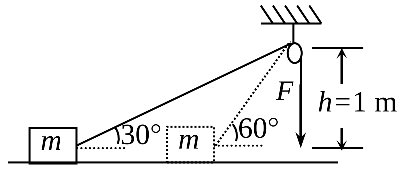


Fig.U2k04-P2b

U2k08-7 Fig2k08-7 shows a spring oscillatory system formed by an object with mass m and a light spring. The object moves in simple harmonic motion between A and B. O is the equilibrium position and C is the mid-point of AO. Given that OC = h, T is the period of oscillation. At one moment during the upward motion, the object passes the point C. Which of the following **correctly** describes the work done during the subsequent half period of oscillation?
A. The work done by the gravitational force is zero.
B. The work done by the gravitational force is $2mgh$.
C. The work done by the restoring force is mgh.
D. The work done by the restoring force is $2mgh$.

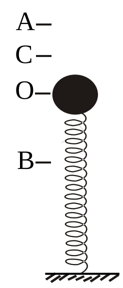


Fig.U2k08-7

U2k08-9 A uniform chain, of mass m and length L, is held on a smooth flat tabletop with ¼ of its length hanging over the edge, as shown in Fig.U2k08-9. What is the minimum work done is required to pull the hanging part back onto the table?

A. $\frac{1}{32}mgL$ B. $\frac{1}{16}mgL$

C. $\frac{1}{8}mgL$ D. $\frac{1}{4}mgL$

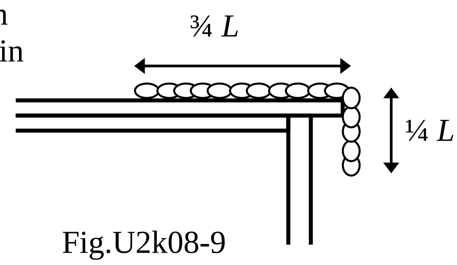


Fig.U2k08-9

U2k08-P3 (b) A wooden block of mass 10 kg slides down from rest on an inclined plane from point A, as shown in Fig.U2k08-P3b. The coefficient of friction between the block and the plane is 0.5. After sliding 5 m to point B, the block compresses a spring by 0.2 m before it stopped. The wooden block then rebounds up the plane. Calculate,
(i) the velocity of the block just before it strikes the spring;
(ii) the coefficient of stiffness (the force constant) of the spring;
(iii) the distance up the plane before the block comes to rest again. [5.88 m s^{-1}; 9019 N m^{-1}; 1.54 m]

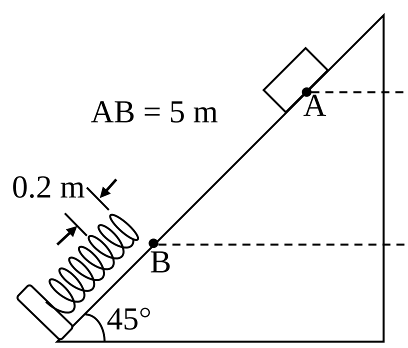


Fig. U2k08-P3b

U2k09-6 When a bullet is shot into a sandbag, the relationship between the kinetic energy of the bullet E and its penetration d is shown in Fig.U2k09-6. What is the retarding force acting on the bullet during its motion in the sandbag?
A. 800 N B. 1600 N
C. 3200 N D. 4000 N

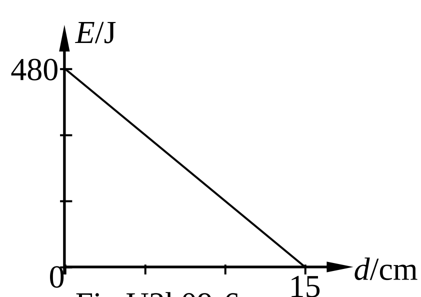


Fig.U2k09-6

U2k-11-P4 (c) As shown in Fig.U2k-11-P4(c), block A of mass 1.9 kg and block B are connected with an unstretched light spring (spring constant is 200 N m^{-1}) and are at rest on a horizontal plane. Two points P, Q on the plane are 40 cm apart, from Q to the left is smooth plane and from Q to the right is rough plane. The coefficient of kinetic friction between block B and the rough plane is 0.4. Directly in front of block A, a 100 g bullet is fired horizontally at a speed of 100 m s^{-1} and embedded in block A. Find,

(i) the distance moved by block B;

(ii) the maximum quantity of compression of the spring.

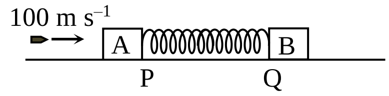
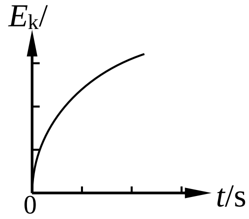
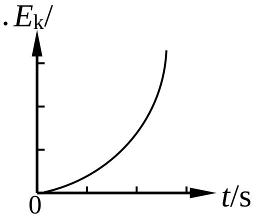
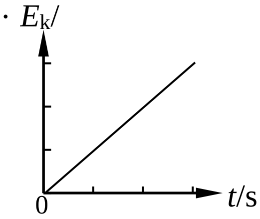


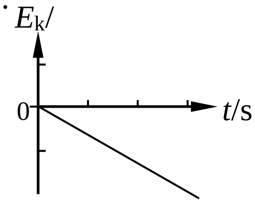
Fig.U2k11-P4

U2k12-8 A body is falling vertically from rest from a certain height. Assume air resistance is constant and is smaller than the weight of the body. Which of the following graphs correctly shows the relationship between its kinetic energy E_k and time t it takes to fall?

A. 

B. 

C. 

D. 

U2k12-10 As shown in Fig.U2k12-10, a small ball of mass m, was hung from a light string of length l at point O. The ball was then pulled from its equilibrium position P by a horizontal force F to point Q slowly. What is the work done by the horizontal force F?

A. $mgl(1-\cos\theta)$ B. $mgl\cos\theta$

C. $\dfrac{F}{\sin\theta}$ D. $\dfrac{F}{\theta}$

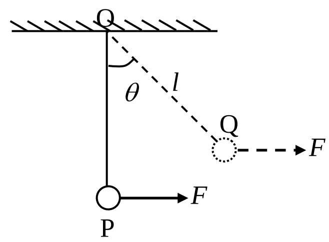


Fig.U2k12-10

U2k12-13 An object of mass m moves vertically upwards with deceleration to a height H under a constant upward force, F. Which of the following statements are **correct**?

I. The kinetic energy of the object decreases by FH.

II. The mechanical energy of object increases by FH.

III. The gravitational potential energy of the object increases by mgH.

IV. The increase in the potential energy of the object is less than the decrease in kinetic energy.

A. I, III B. I, IV C. II, III D. III, IV

U2k14-P3 In Fig.U2k14-P3, two objects A and B are connected with a light string, which passes over a light frictionless pulley, so that A and B rest on rough slopes OR and OS respectively. The inclined angles for slopes OR and OS are 53° and 37° respectively, and its coefficient of friction with the objects is 0.2. The masses of objects A and B are 8 kg and 5 kg respectively.

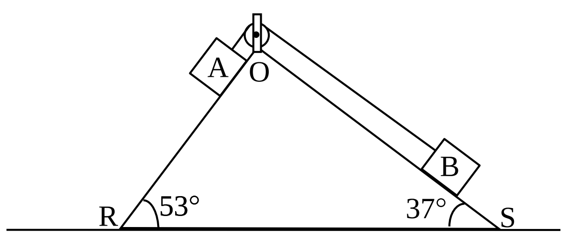


Fig.U2k14-P3

(a) Draw a labelled diagram to show the forces acting on objects A and B, respectively.

(b) Calculate the acceleration of objects A and B when moving along the slopes.

(c) If the length of OR is 2.5 m, what is the final velocity of object A, when it moves from rest from the top of the slope O to the bottom R?

(d) What is the decrease in total potential energy of the system when object A slides down from O to R?

[1.24 m s^{-2}; 2.49 m s^{-1}; - 82.81 J]

U2k18-P3 A car and its passengers have a total mass of 1200 kg. The car is moving down a slope inclining at an angle of 30° with the horizon, as shown in Fig.U2k18-P3. When the speed of the car is 12 m s^{-1}, the driver starts to apply the brake and the car stops after travelling a distance of 100 m on the slope. Determine the average braking force acting on the car. [6.74×10^{3} N]

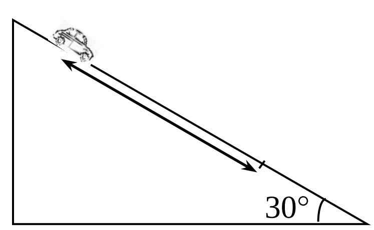


Fig.U2k18-P3

U2k17-10 A steel ball of mass 0.5 kg falls freely from rest at a height of 12 m and sinks into the sand by 20 cm. If the air resistance is negligible, calculate the average resistive force experience by the steel ball as it is sinking into the sane. (Take g = 10 m s^{-2})

A. 290 N B. 305 N C. 400 N D. 405 N

U2k17-P4 Fig.U2k17-P4i shows a cannon of mass 1000 kg. It fires a metal ball of mass 10 kg in order to destroy a fixed target. Assume that the ball travels with a constant horizontal velocity of 100 m s^{-1} towards the target.

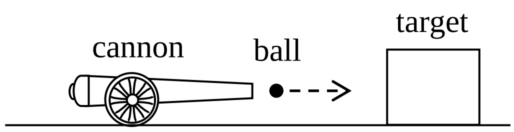


Fig.U2k17-P4i

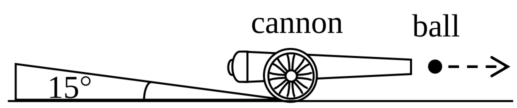


Fig.U2k17-P4ii

(a) If the minimum energy required to destroy the target is 60000 J, explain whether the ball will destroy the target. [2%]

(b) The cannon recoils as the ball is fired.

(i) Find the recoil speed of the cannon; [2%]

(ii) To stop the cannon, a smooth inclined plane at 15° to the horizontal is placed behind the cannon, as shown in Fig.U2k17-P4ii. How far will the cannon move up along the inclined plane? [3%]

(c) During the process of firing the ball, 80000 J of energy is lost as heat, light and sound. Find the efficiency of the cannon in firing the ball. [3%]

[won't destroy; – 1 m s^{-1} to the left; 19.71 m; 38.30 %]

U2k18-P8 A diver of mass 50 kg stands at the end of a uniform diving board of mass 100 kg and length 5 m as shown in Fig.U2k18-P8. The board is fixed at two pillars A and B separated at a distance of 3 m apart and the height of the board from the water surface is 10 m.

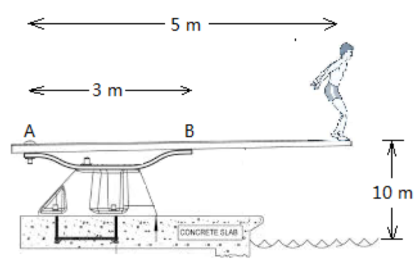


Fig.U2k18-P8

(a) During the jump, the diver achieves an initial upward speed of 4 m s^{-1} in 2 seconds, calculate the total force acted on the right end of the board by the diver.

(b) At the moment when the diver was leaping on the board, calculate the magnitude and direction of the forces acting on the pillars A and B respectively.

(c) After leaping, the diver performed a forward somersault in air and fell vertically into the water. If the air resistance is negligible, calculate the speed of the diver when he entered the water.

(d) After entering the water, the diver experienced an average upward force of 1550 N. Determine the depth achieved by the diver.

[590 N, down; 1800 N, down; 230 N, up; 14.56 m s^{-1}; 5.0 m]