PHYSICS

BOOKS - HC VERMA

WORK AND ENERGY

Example

1. A spring of spring constant 50 N/m is compressed from its natural position through

1 cm. Find the work done by the spring force on the agency compressing the spring.

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2. A ball of mass 0.5 kg thrown upwards reaches a maximum height of 5m.Calculate the work done by the force of gravity during this vertical displacement considering the value of $g = 10m/s^2$.

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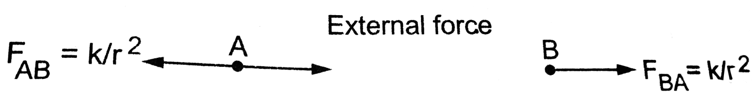
3. Two charged particle A and B repel each other by a force $\frac{k}{r^2}$ where is a constant and r is th separation between them. The particle A is clamped to a fixed point in the lab and the particle B which has a mass m, is released from rest with asn initial separartion r_0 form A. Find the change in the potential energyof hte wo particle system as the separation increases to a large value. What will be the speed o the particle b in this situation?



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4. A block of mass m slides along a frictionless surface as shown in the figure. If it is releases from rest from A what is its speed at B?

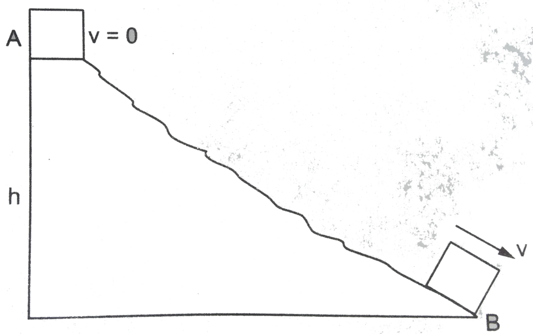

Figure 8.10

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5. A pendulum bob has a speed 3m/s while passing through its lowest position. What is its speed when it makes an angle of 60^0 with the vertical? The length of the pendulum is 0.5m Take $g = 10\frac{m}{s^2}$.

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6. An ideal spring of spring constant k, is suspended from the ceiling of a room and a blok of mass m is fastened to its lower end. If the block is released when the spring is un-stretched, then then maximum extension in the spring is :

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7. A block of mass m is suspended through a spring of spring constant k and is in equilibrium. A sharp blow gives the block an initial downward velocity v. How far below the equilibrium position, the block comes to an instantaneous rest?

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Worked Out Examples

1. A porter lifts a suitcase weighing 20 kg from the platform and puts it on his head 2.0 m above the platform. Calculate the work done by the porter on the suitcase.

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2. An elevator weighing 500 kg is to be lifted up at a constant velocity of 0.20 m/s. What would be the minimum horse power of the motor to be used? take 1 hp -750 watts

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3. A block of mas 2.0 kg is pulled up on a smooth incline of angle 30^0 with the horizontal. If the block moves wth an acceleration of $1.0\frac{m}{s^2}$, find the power delivered by the pulling force at a time 4.0 s after the motion starts. What is the average power delivered during the 4.0 s after the motion starts?

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4. A force $F = (10 + 0.50x)$ acts on a particle in the x direction, where F is in newton and x in meter./find the work done by this force during a displacement form x=0 tox=2.0m

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5. A body dropped from a height H reaches the ground with a speed of 1.2 $\sqrt{gH}$. Calculate the work done by air friction.

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6. A block of mass M is pulled along a horizontal surface by applying a force at angle θ with the horizontal. The friction coefficient between the block and the surfasce is μ. If the block travels at a uniform velocity, find the

work donen by this applied force during a displacement d of the blcok.

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7. Two identical cylindrical vessel with their bases at the same level each contain a liquid of density ρ. The height of the liquid in one vessel is h_1 and in the other is h_2 the area of either base is A. What is the work done by gravity is equalising the levels when the two vessels are connected?

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8. What minimum horizontal speed should be given to the bob of a simple pendulum of length l so tht it describes a complete circle?

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9. A uniform chain of length l and mass m overhangs a smooth table with its two third part lying on the table. Find the kinetic energy of the chain as it completely slips off the table.

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10. A block of mass m is pushed against a spring of spring constant k fixed at the end to a wall. The block can side on a frictionless table as shown in figure. The natural length of the spring is L_0 and it is compressed ti half its natural length when the block is relesed. Find teh velocity of the block aa s function of its distance x from the wall .

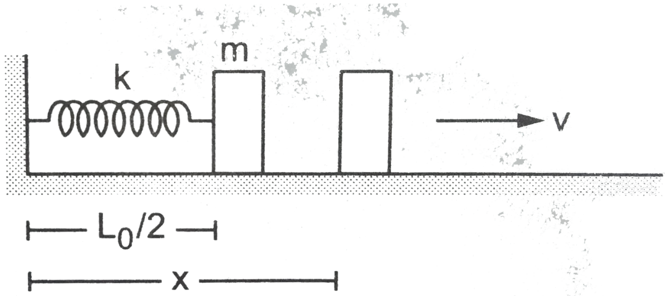

Figure 8-W6

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11. A particle is placed at the point A of a frictionless track ABC as shown in figure. It is pushed slightly towards right. Find its speed when it reches the point B. Take $g = 10\frac{m}{s^2}$.

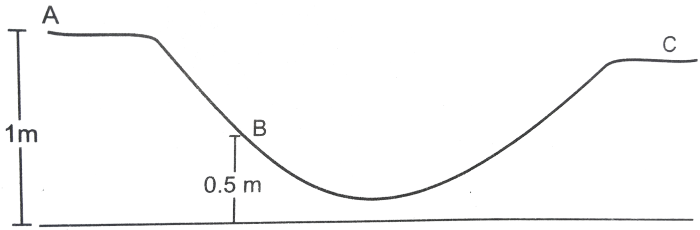

Figure 8-W7

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12. Figure shows a smooth curved track terminating in a smooth horizontal part. A spring of sprng constant 400 N/m is asttached at one end ot a wedge fixed rigidly with the horizontal part. A 40 g mas is released from rest at a height of 4.9 m n the curved track. Find the maximumcompression of the spring.

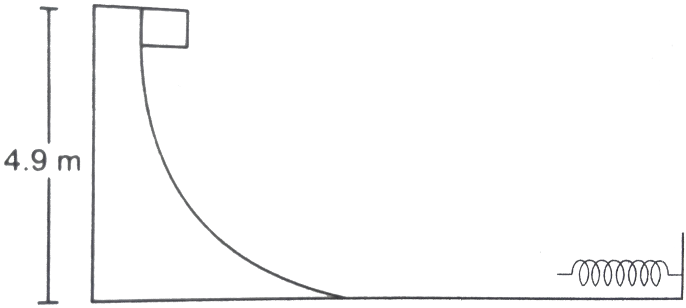

Figure 8-W8

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13. Figure shows a loop the loop track of radius R. A car (without engine) starts from a platform at a distance h above the top of the loop and goes around the loop without falling off the track. Find the minimum value of h for a successful looping. Neglect friction.

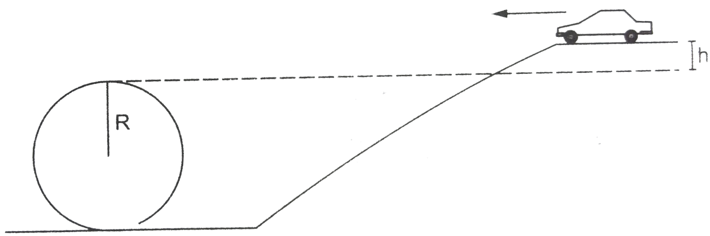

Figure 8-W9

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14. A heavy particle is suspended by a stirng of length l. The particle is given a horizontal velocity v_0. The stirng becomes slack at some angle and the particle proceeds on a parabola.find the value of v_0 if the prticle psses through the ponit of suspension

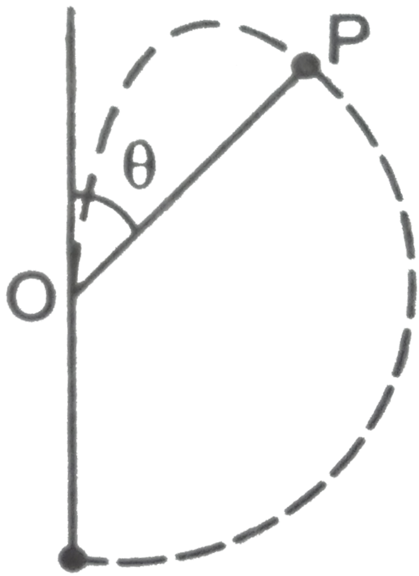

Figure 8-W10

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Question For Short Answer

1. When you lift a box from the floor and put it one an almirah the ptotential energy of the box increases, but thre is no change in its kinetic energy. Is it a violation of consevation of energy?

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2. A particle is released from the top of an incline of height h. Does the kinetic energy of the particle at the bottom of the incline depend on the angle of incline? Do you ned any more information to anwer this question in Yes or No?

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3. The kinetic friction

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4. Can static friction do nonzero work on an object? If yes give an example.If no, give reason.

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5. Can normal force do a nonzero work on an object. If yes, give an example. If no, give reason.

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6. Can kinetic energy of a system be increased without applying any external force on the system?

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7. Is work energy theorem valid in noninertial frames?

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8. A heavy box is kept on a smooth inclined plane and is pushed up by a force F acting parallel to the plane. Does the work done by the force F as the box goes from A to B depend on how fast the box was moving at A and B? does the work by the force of gravity depend on this?

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9. One person says that the potentil energy of a particular book kept in an almirah is 20 J and the other says it is 30J. Is one of them necessarily wrong?

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10. One person says that the potential energy of a particular book kept in an almirah is 20 J and the other says it is 30J. Is one of them necessarily wrong?

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11. In one of the exercises to strengthen the wrist and fingers, a person squeezes and releaases a soft rubber ball. Is the work done on the ball positive, negative or zero during compression? During expansion?

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12. In a tug of war the team that pushes harder against the ground wins why

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13. When an apple falls from a tree what happens to its gravitational potential energy just as it reaches the ground ? After it strikes the ground ? (AS_7)

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14. When you push your bicycle up on an incline the potential energy of the bicycle and yourself increses. Where does this energy come from?

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15. A charged particle is moved along a magnetic field line. The magnetic force on the particle is

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16. A ball is given a speed v on a rough horizontal surface. The ball travels through a distance l on the surface and stops. A. What are the initial and final kinetic energies of the ball? b. What is the work done by the kinetic friction?

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17. Consider the situation of the previous question from a frame moving with a speed v_0

parallel to the initial velocity of the block? b. What is the work done by the kinetic friction?

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Objective 1

1. A heavy stone is thrown from a cliff of height h with a speed v. The stone will hit the ground with maximum speed if it is thrown

A. vertically downward

B. vertically upward

C. horizontally

D. the speed does not depend on the initial direction.

Answer: D

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2. Two springs A and B$(k_A = 2k_B)$ are stretched by applying forces of equal magnitudes at the force ends. If the energy stored in A is E, that in B is

A. $\frac{E}{2}$

B. $2E$

C. E

D. $\frac{E}{4}$

Answer: B

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3. Two equal masses are attached to the two ends of a spring of spring constant k. The masses are pulled out symmetrically to stretch the spring by a length x over its natural length. The work done by the spring one each mass is

A. $\frac{1}{2}kx^2$

B. $-\frac{1}{2}kx^2$

C. $\frac{1}{4}kx^2$

D. $-\frac{1}{4}kx^2$

Answer: D

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4. The negative of the work done by the conserative internal forces on a system equals the change iln

A. total energy

B. kinetic energy

C. potential energy

D. none of these

Answer: C

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5. The work done by the external forces on a system equals the change in

A. total energy

B. kinetic energy

C. potential energy

D. none of these

Answer: A

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6. The work done by all the forces (external and internal) on a system equals the change in

A. total energy

B. kinetic energy

C. potential energy

D. none of these

Answer: B

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7. Conduct an experiment to show the space between the particles of matter and write the report.

A. kinetic energy

B. total mechanical energy

C. potential energy

D. total enerty

Answer: C

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8. A small block of mass m is kept on a rough inclined surface of inclination θ fixed in an elevator. The elevator goes up with a uniform velocity v and the block does not slide on the wedge. The work done by the force of friction on the block in time t will be

A. zero

B. $mgvt\cos^2\theta$

C. $mgvt\sin^2\theta$

D. $mgvtsi2\theta$

Answer: C

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9. A block of mass m slides down a smooth vertical circular track. During the motion, the block is in

A. vertical equilibrium

B. horizontl equilibrium

C. radia equilibrium

D. none of these

Answer: D

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10. A particle is rotated in vertical circle by connecting it to string fixed. The minimum speed of the particle when the string is horizontal for which the particle will complete the circle is

A. $\sqrt{gl}$

B. $\sqrt{2ghl}$

C. $\sqrt{3gl}$

D. $\sqrt{5gl}$

Answer: C

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Objective 2

1. A heavy stone is thrown from a cliff of height h with a speed v. The stone will hit the ground with maximum speed if it is thrown

A. must depend on the speed of projection

B. must be larger than the speed of projection

C. must be independent of the speed of projection

D. may be smaller than the speed of projection

Answer: A::B

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2. The total work done on a particle is equal to the change in its kinetic energy

A. always

B. only if the forces acting on ilt are conservative

C. only if gravitational force alone acts on it

D. only if elastic force alone acts on it

Answer: A

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3. A particle is acted upon by a force of constant magnitude which is always perpendicular to the velocity of the particle, the motion of the particles takes place in a plane. It follows that:

A. it velocity is constant

B. its acceleration is constant

C. its kinetic energy is constant

D. it moves in a circular path

Answer: C::D

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4. Consider two observers moving with respect to each other at a speed v along a straight line. They observe a block of mass m moving a distance 1 on a rough surface. The following quantities will be same as observed by the two observers

A. kinetic energy of the block at time t

B. work doen by friction

C. total work done the block

D. acceleration of the block

Answer: D

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5. You lift a suitcase from the floor and keep it on a table. The work done by you on the suitcae does not depend on

A. the path taken by the suitcae

B. the time taken by you in doing so

C. the weight of the suitcase

D. your weight

Answer: A::B::D

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6. Now work is done by a force on an object if

A. the fore is always perpendicular to its velocity

B. the force is always perpendicular to its acceleration

C. the object is stationary but the point of applicaton of the force moves on the object

D. the object moves in such a way that the point of aplication of the forces remains fixed.

Answer: A::C::D

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7. If the kinetic energy of a particle is increased by 16 times, the percentage change in the de-Broglie wavelength of the particle is

A. the resultant force on the particle must be parallel to the velocity at all instants.

B. the resultant force on the particle must be at an angle less than 90^0 all the time

C. Its height above the ground level must continuously decrease

D. the magnitude of its linear momentum is increasing continuously.

Answer: B::D

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8. One end of a light spring of spring constant k is fixed to a wall and the other end is tied to a block placed on a smooth horizontal surface. In a displacement, the work by the spring is $\frac{1}{2}kx^2$. The possible cases are

A. the spring was initially compresed bya distance x and was finaly in its natural length

B. it was initially in its natural distance x and finally was in its natural length

C. it was initially in its natural lenth and finaly in a compressed position.

D. it was initially in its natural length and finally in a stretched positon.

Answer: A::B

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9. A block of mass M is hanging over a smooth and light pulley through a light string. The other end of the string is pulled by a constant force F. The kinetic energy of the block increases by 20J in 1s.

A. the tension in the string is Mg

B. The tension is the string is F

C. The work done by the tension on the block is 20 J in the above 1s.

D. the work done by the force of gravity is -20J in the above 1s.

Answer: B

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Exercises

1. The mass of a cyclist together with the bicycle is 90 kg. Calculate the work done by cyclist if the speed increases from 6km/h to 12 km/h.

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2. A block of mass 2.00 kg moving at a speed of 10.0 m/s accelerates at 3.0 $\frac{m}{s^2}$ for 5.00 s. Compute its final kinetic enegy.

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3. A box is pushed through a distance of 4m across a floor offering 100N resistance. How much work is done by the resisting force ?

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4. A block of mass 5.0 kg slides down an incline of inclination 30^0 and length 10 m. find the work done by the force of gravity.

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5. A constant force of 2.50 N accelerates a stationary particle of mass 15 g through a displacement of 2.50 m. Find the work done and the average power delivered.

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6. The amount of work done by centripetal force on the object moving in a circular path is

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7. A man moves on a straight horizontal road with a block of mass 2 kg in his hand. If he covers a distance of 40 m with an acceleration of $0.5\frac{m}{s^2}$ find the work done by the man on the block during the motion.

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8. A force F=a+bx acts on a particle in the x-directioin, where a and b are constants. Find the work done by this force during a displacement form $x = 0 \rightarrow x = d$.

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9. A block of mass 250 g slides down an incline of inclination 37^0 with a uniform speed. Find the work done against the friction as the block slides through 1.0 m.

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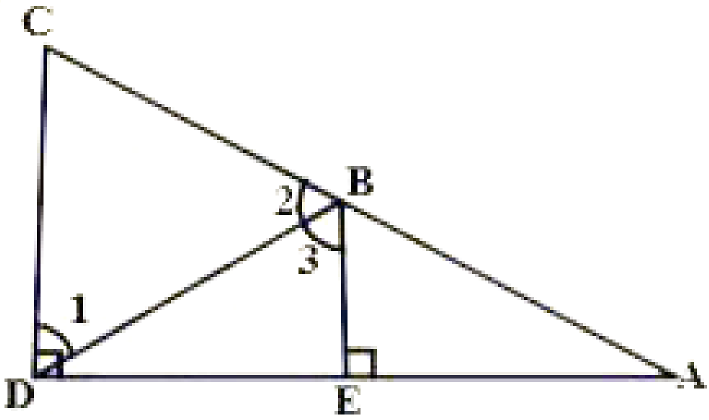
10. In the adjacent figure $BE \perp$ DA and CD $\perp$ DA then prove that m$\angle 1 \cong m\angle 3$.



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11. A box weighing 2000 N is to be slowly slid through 20 m on a straigh track having friction coefficient 0.2 with the box. A find the work done by the person pulling the box wilth a chain at angle θ with the horizontal. B. find the work when the person has chosen a value of θ which ensures him the minimum magnitude of the force.

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12. A block of weight 100 N is slowly slide up on a smooth incline of inclination 37^0 by as person. Calculate the work done by the person in moving the block through a distance of 2.0 m, if the driving force is a. parallel to the incline and b. in the horizontal direction.

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13. Find the average frictional force needed to stop a a car weighing 500 kg in a distance of 25 m (the initial speed is 72 km/h.)

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14. Find the averasge force needed to accelerate a car weighing 500 kg form rest to 72 km/h in a distance of 25 m.

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15. A particle of mass m moves on a straight line with its velocity varying with the distance travelled according to the equation $v = a\sqrt{x}$, where a is a constant. Find the total work done by all the forces during a displacement from $x = 0 \rightarrow x = d$.

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16. A block of mass 2.0 kg kept at rest on an inclined plane of inclination 37^0 is pulled up the plane by applying a constant force of 20 N parallel to the incline. The force acts for one second. A. show that the work done by the applied force does not exceed 40 J.

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17. A block of mass 2.0 kg is pushed down an inclined plane of inclination 37^0 with a force of

20N acting parallel to the incline. It is found that the block moves on the incline with an acceleration of $10\frac{m}{s^2}$. If the block started from rest, find the work done by the applied force in the first second .

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18. A 250 g block slides on aeroug horizontal table. Find the work donen by the frictinal force in bringing the block to rest if it is initially moving at a speed of 40 cm/s. If the friction coefficient between te table and the block is 0.1 how far does the block move before coming to rest?

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19. Water falling from a 50 m high fall is to be used for generating electric enegy. If $1.8 \times 10^5 kg$ of water falls per hour and half the gravitational potential energyh can be converted into electric energy, how many 100 W lamps can be it?

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20. A person is climbing a ladder with a suitcase on his head. Then the work done by that person on that suitcase is

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21. A projectile is fired form the top of a 40 m high cliff with an initial speed of 50 m/s at an unknown angle. Find its speed when it hits the ground.

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22. The 200 m free style women's swimming gold medal at Seol Olympic 1988 went to Heike Friendrich of East Germany when she set a new Olympic record of 1 minute and 57.56 seconds. Assume that she covered most of the distance with a uniform speed and had to exert 460 W to maintain her speed. Calculate the average force of resistance offered by the water during the swim.

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23. The US athlete Florence Griffith oyner won the 100 m spring gold medal at Seol Olympic 1988 setting a new Olympic record of 10.54s. Assume that she achieved her maximum speed in a very short time and then ran the race with that speed till she crossed the line. Take her mas ot be 50 kg. a. Calculate the kinetic energy of Griffith Joyner at her full speed. b. Assuming tht the track the wind etc. offered an average resistance of one tenth of her weight, cfalculate the work done by the resistsnce durng the run. c. What power Griffith Joyner had to exet ot maintain uniform speed?

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24. A water pump lifts water from a level 10 m below the ground. Water is pumped at a rate of 30 kg /minute with negligible velocity.Caculate the minimum horsepower the engine should have to do this.

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25. An unruly demonstrator lifts a stone of mass 200 g from the ground and throws it at his opponent. At the time of projection, the stone is 150 cm above the ground and has a speed of 3.00 m/s. Calculate the work doe by the demonstrator during the process.

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26. In a factory it is desired to lift 2000 kg of metal through a distance of 12 m in 1 minute.

Find the minimum horsepower of the engine to be used.

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27. Express each of the following numbers as a product of its prime factors.

140

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28. A block of mass 30.0 kg is being brought down by a chain. If the block acquires as speed of $40.0\frac{cm}{s}$ in dropping down 2.00 m ,find the work done by the chain during the process.

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29. The heavier block in an atwood machine has a mass twice that of the lighter one. The tension in the string is 16.0 N when the system is set into motion. Find the decrease in the gravitational potential energy during the first second after the system is released from rest.

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30. The two blocks in an Atwood machine have masses 2.0 kg and 3.0 kg. Find the work done by gravity during the fourth second after the system is released from rest.

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31. Consider the situatioin shown in figure. The system is released from rest and the block of mass 1.0 kg is found to have a speed 0.3 m/s ater it has descended thrugh a distance of 1 m. find the coefficient of kinetic friction between the block and the table.

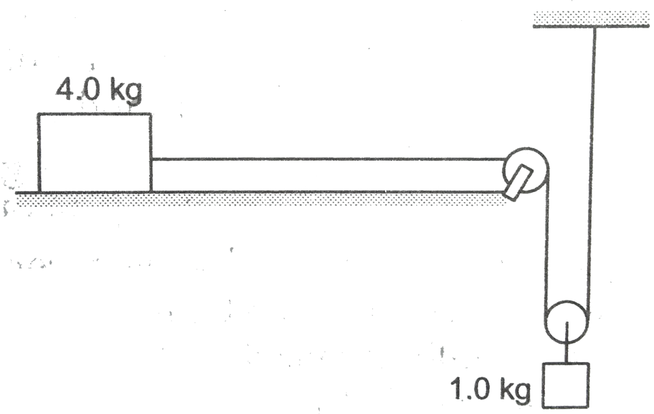

Figure 8-E2

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32. A block of mass 100g is moved with a speed of 5.0 m/s at the highest point in a closed circular tube of radius 10 cm kept in a vertical plane. The cross section of the tube is such that the block just fits in it. The block makes several oscillations inside the tube and finally stops at the lowest point. find the work done by the tube on the block during the process

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33. A car weighing 1400 kg is moving at speed of 54 km/h up a hill when the motor stops. If it is just able to read the destination which is at a height of 10 m above the point calculte the work done against friction (negative of the work done by the friction).

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34. small block of mass 200 g is kept at the top of a frictionless incline which is 10 m long and 3.2 m high. How much work was required to lift the block from the ground nd put it at the top

.

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35. In a children's park, there si a slide which has a total length of 10 and a height of 8.0 m figure. Vertical ladder are provided to reach the top. A boy weighting 200 N climbs up the ladder to the top of the slide and slides down to the ground. The averages friction offered by the slide is three tenth of his weight. Find a.

the work done by the ladder on the boy as he goes up. b. the work done by the slide on the boy as he comes down. Neglect any work done by forces inside the body of the boy.

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36. Figure shows a particle slideing on a frictionles track which terminates in straight horizontal section. If the particle starts slipping from the point. A, how far way from the track will the particle hit the ground ?

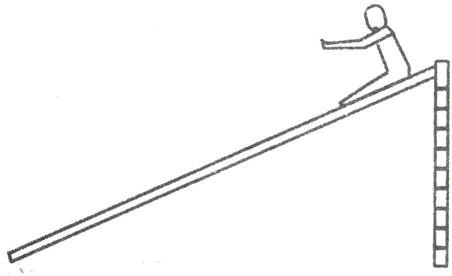

Figure 8-E3

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37. A block weighing 10 N tavels down a smooth curved track AB joined to a rough horizontal surface. The rough surface has a friction coeficient of 0.20 with the block. If the block starts slipping on the track from a point

1.0 m above the horizontal surace, how far will it move on the rough surface?

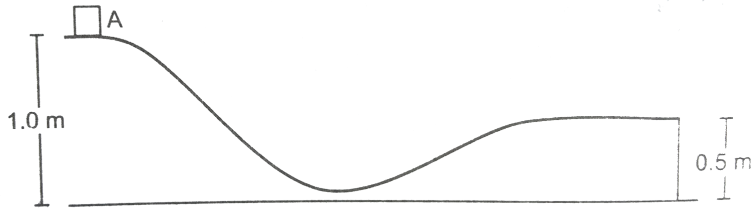

Figure 8-E4

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38. A uniform chain of mass m and length l overhangs a table with its two third part on the table. Fine the work to be done by a person to put the hanging part back on the table.

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39. A uniform chain of length L and mass M overhangs a horizontal table with its two third part n the table. The friction coefficient between the table and the chain is μ. Find the work done by the friction during the period the chain slips off the table.

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40. A block f mas 1 kg is placed at the point A of a rough track shown in figure. If slightly pushed towards right, it stos at the point B of the track. Calculate the work done by the frictional force on the block during its transit from A to B.

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41. A block of mass 5.0 kg is suspended from the end of a vertical spring which is stretched by 10 cm under the load of te block. The block is givena sharp impulse from below so that it acquires an upward speed of 2.0 m/s. How high will it rise? Take $g = 10\frac{m}{s^2}$

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42. A block of mass 250g is kept on a vertical spring of spring constant 100N/m fixed from below. The spring is now compressed to have a length 10cm shorter than its natural length and the system is released from this position. How high does the block rise? take $g = 10\frac{m}{s^2}$.

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43. Figure shows a spring fixed at the bottom end of an incline of inclination 37^0. A small block of mass 2 kg starts slipping down the incline from a point 4.8 m away from the spring. The block compresses the spring by 20 cm, stops momentarily and then rebounds through a distance of 1 m up the incline. Find a. the frictioin coefficient between the plane and the block and b. the spring constant of the spring. Take $g = 10\frac{m}{s^2}$.

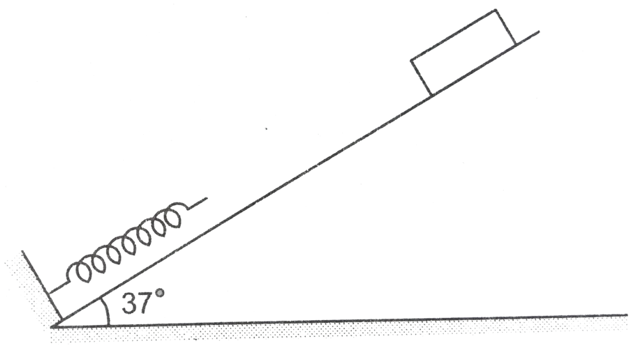

Figure 8-E7

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44. A block of mass m moving at a speed 'v' compresses a spring through a distance 'x' before its speed is halved. Find the spring constant of the spring.

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45. Consider the situation shown in figure. Initially the spring is unstretched when the system is released from rest. Assuming no friction in the puley, find the maximum eleongation of the spring.

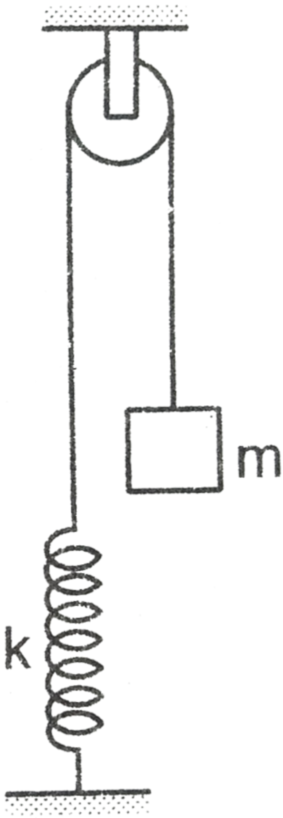

Figure 8-E8

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46. A block of mass m is attached to two unstretched springs of spring constants k_1 and k_2 as shown in figure. The block is displaced towards right through a distance x and is released. Find the speed of the block as it passes through the mean position shown.

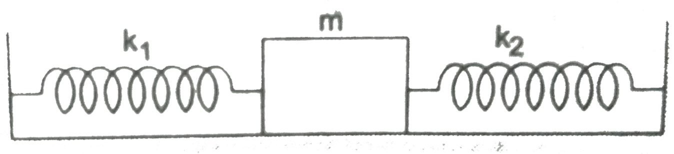

Figure 8-E9

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47. A block of mass m sliding n a smooth horizontal surface with velocity $\overrightarrow{v}$ meets a long horizontal spring fixed ast one end and having spring constant k as shown n figure. Find the maximum compression of the spring.

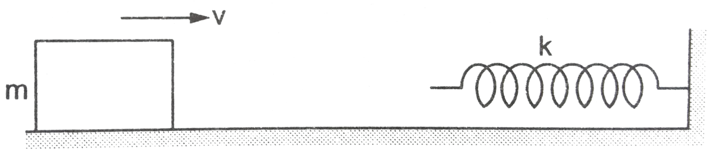

Figure 8-E10

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48. A small block of mass 100 g is pressed against a horizontal spring fixed at one end to compress the spring through 5.0 cm. The spring constant is 100 N/m. When released, the block moves horizontally till it leaves the spring. Where will it hit the ground 2 m below the spring?

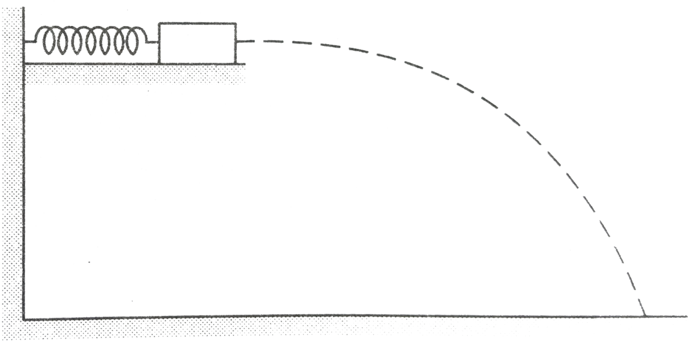

Figure 8-E11

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49. A small hevy block is attached to the lower4 end of a light rod of lenth l which fan be rotated about its clamped upper end. What minimum horizontal velocity should the block be given so that it moves in a complete vertical circle ?

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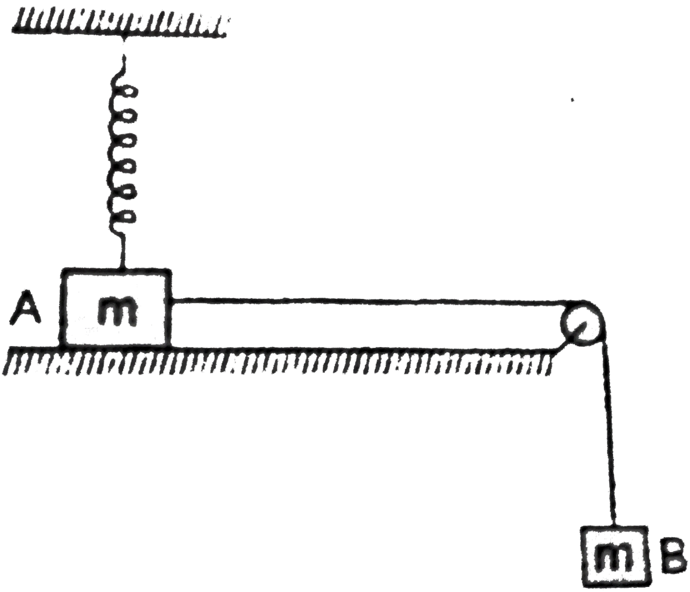
50. Figure shows two block A and B, each having a mass of 320 g connected by a light string passing over a smooth light pulley. The horizontal surface on which the block A can slide is smooth. The block A is attached to spring constant $40N/m$ whose other end is fixed to a support 40 cm above the horizontal surface. Initially, the spring is vertical and unstretched when the system is released to move. Find the velocity of the block A at the instant it breaks off the surface below it. Take

$g = 10m / s^2$.



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51. one end of a spring of natural length h and spring constant k is fixed at the ground and the other is fitted with a smooth ring of mass m which is allowed to slide on a horizontal rod fixed at a height h figure. Initially, the spring makes an angle of 37^0 with the vertical when the system is released from rest. find the speed of the ring when the spring becomes vertical.

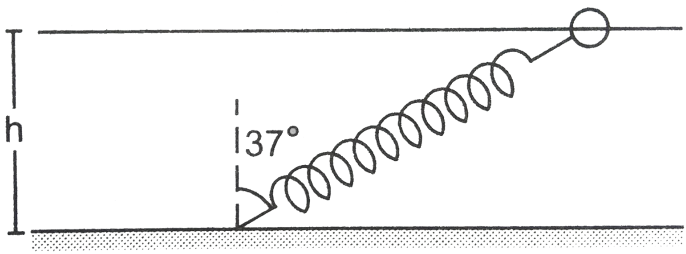

Figure 8-E13

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52. Figure shows a light rod of length l rigidly attached to a small heavy block at one end and a hook at the other end. The system is released from rest with the rod in a horizontal position. There is a fixed smooth ring at a depth h below the initial position of the hook and the hook gets into the ring as it reaches there. What should be the minimum value of h so that the block moves in a complete circle about the ring?

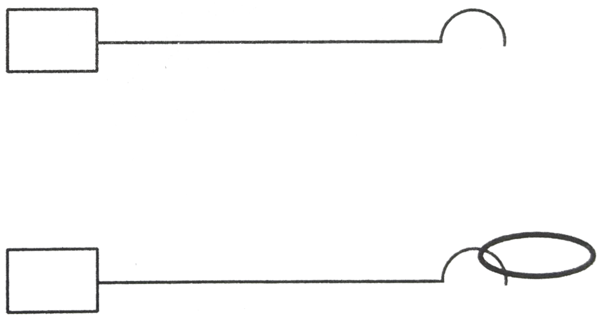

Figure 8-E14

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53. The bob of a pendulum at rest is given a sharp hit to impart a horizontal velocity $\sqrt{10gl}$ where l is the length of the pendulum. Find the tension in the string when a. the string is horizontal. B. The bob is at its highest point and c. the string makes an angle of 60^0 with the upward vertical.

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54. A simple pendulum consists of a 50 cm long string connected to a 100 g ball. The ball is pulled aside so that the string makes an angel of 37^0 with the vertical and is then released. Find the tension in the string when the bob is at its lowest position.

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55. Figure shows a smooth track, a part of which is a circle of radius R. As block of mass m is pushed against a spring of spring constant k fixed at the left end and is then released. Find the initial compression of the spring so that the block presses the track with a force

mg when it reaches the point P, where the radius of the track is horizontal.

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56. The bob of a stationary pendulum is given a sharp hit to impart it a horizontal speed of $\sqrt{3gl}$. Find the angle rotated by the string before it becomes slack.

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57. A heavy particle is usspended by a 1.5 m long string . It is given a horizontal velocityof $\sqrt{57}\frac{m}{s}$. a. Find the angle made by the string with the upward vertical, when it becomes slack. B. Find the speed of the particle at this instant. c.Find the maximum height reached by the particle over the point of suspension. Take $g = 10\frac{m}{s^2}$

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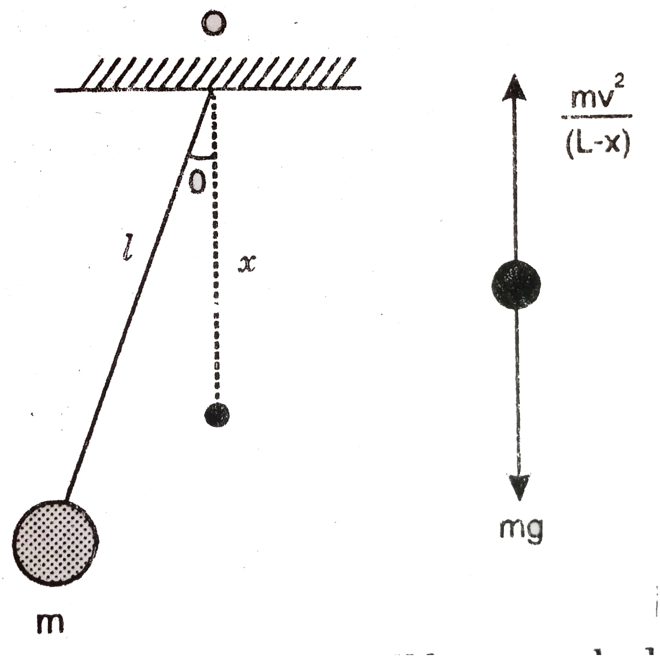
58. A simple pendulum of length L having a bob of mass m is deflected from its rest position by an angle θ and released figure. The string hits a peg which is fixed at distance x below the point of suspension and the bob starts going in a circle centred at the peg. a. Assuming that initially the bob has a height less thasn the peg, show that the maximum height reached by the bob equals its initialheight. b. If the pendulum is released with $\theta = 90^0$ and $m = \frac{L}{2}$ find the maximum height reached by the bob above its lowest positon before the string becomes slack. c. Find the minimum value of x/L for which the bob goes in a complete circle about the pet when the pendulum is released from $\theta = 90^0$.



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59. A particle slides on the surface of a fixed smooth sphere starting from the topmost pont. Find the angle rotated by the radius through the particle, when it leaves contact with the sphere.

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60. A particle of mass m is kept on a fixed, smooth sphere of radius R at a position, where the radius through the particle makes an angle of 30° with the vertical. The particle is released from this position. (a) What is the force exerted by the sphere on the particle just after the release? (b) Find the distance traveled by the particle before it leaves contact with the sphere.

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61. A particle of mass m is kept on the top of a smooth sphere of radius R. It is given a sharp impulse which imparts it a horizontal speed v.

a. find the normal force between the sphere and the particle just after the impulse. B. What should be the minimum value of v for which the particle does not slip on the sphere? c. Assuming the velocity v to be half the minimum calculated in part, d. find the angle made by the radius through the particle with the vertical when it leaves the sphere.

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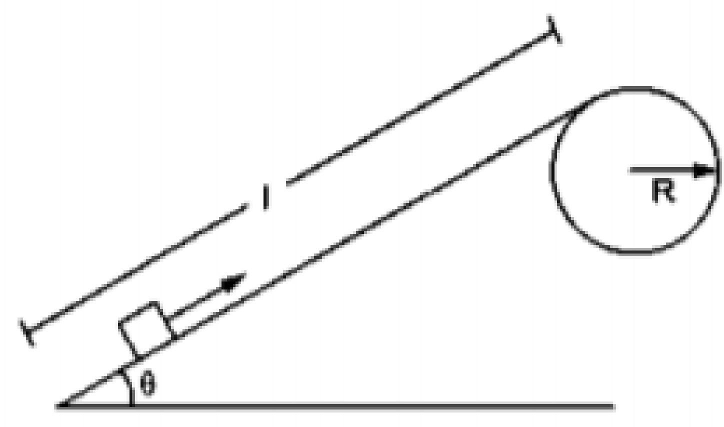
62. Figure shows a smooth track which consists of a straight inclined part of length l joining smoothly with the circular part. A particle of mass m is projected up the incline from its bottom. a.Find the minimum projected speed v_0 for which the particle reaches the top of the track. b. Assuming that the projection speed is $2v_0$ and that the block does not lose contact with the track before reading its top, find teh force acting on it whenit reaches the top. c. Assuming that teh projection speed is only slightly greater than

v_0 where will the block lose contact with the track?



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63. AS chain of length l and mass m lies o the surface of a smooth sphere of radius $R > l$ with one end tied to the top of the sphere.

a.Find the gravitational potential energy of the chain with reference level at the centre of the sphere. B. suppose the chin is released and slides down the sphere. Find the kinetic eneergy of the chain, when it has slid through an angle θ c. find the tangential acceleration $\frac{dv}{dt}$ of the chain when the chain starts sliding down.

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64. A smooth sphere of radius R is made to translate line with a constant acceleration a=g. A particle kept on the top of the sphere is released from there at zero velocity with respect to the sphere. Find the speed of the particle with respect to the sphere as a function of angle θ as it slides down.

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