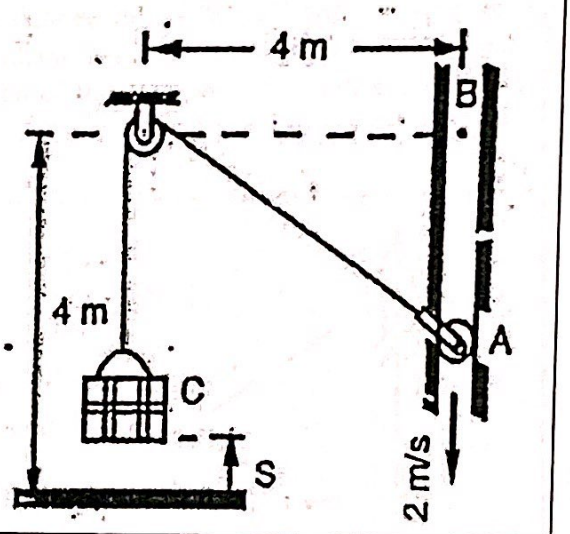
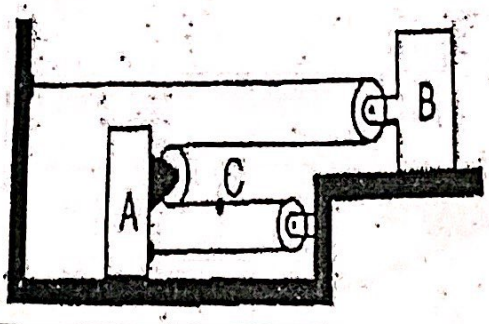
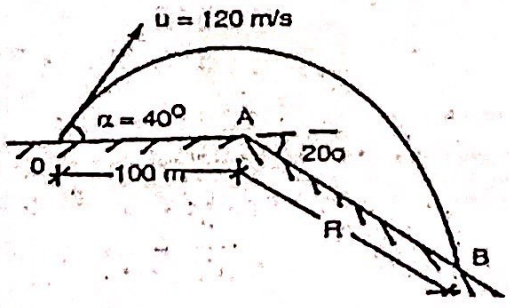
Assignment No. 2
Dynamics

	Kinematics of rectilinear motion
1.	Two cars moving in same direction are 150m apart, car A being ahead of car B. At this instance, velocity of A is 3m / s and constant acceleration of 1.2 m/s^2 while the velocity of car B is 30 m/s and its uniform retardation is 0.6 m/s^2. How many times do the cars cross each other? Find when and where they cross, with respect to the given position of A. (Ans.: At t_1 = 7.363 sec at 54.62 m from A, At t_2 = 22.637 sec at 375.37 m from A)
2.	A balloon going up with a constant velocity drops a stone which takes 4 seconds to reach the ground. The moment this store strikes the ground, another store is dropped from the balloon and this one takes 5 seconds to reach the ground. With what velocity is the balloon rising? From what height is the second stone dropped? (Ans.: 8.829 m/s, 78.48m)
3.	An Auto starts from rest and reaches a speed of 54 km/h in 15 seconds. The acceleration increases uniformly from zero for the first nine seconds after which the acceleration reduces uniformly to zero in the next six seconds. Find the displacement in the 15 seconds interval. (Ans. 1[illegible]5m)
4.	The acceleration of a particle is defined by the relation a = - $kv^{2.5}$, where 'k' is a constant. The particle starts and x = 0 with a velocity of 16 m/s. When x = 6m, the velocity is observed to be 4m/s. Determine the time when the particle has a velocity of 9m/s. (Ans.: 0.171 s)
5.	The acceleration of a particle in rectilinear motion varies linearly from2 m/s^2 to 4 m/s^2 as its position changes from x= 40mm to x = 120 mm. If the velocity of the particle at x = 40 mm is 0.4 m/s. determine the velocity at x = 120 mm. Find the value of x for which the velocity is 0.6 m/s. (Ans. 0.8 m/s, 80 mm)
6.	At a certain instant, a ship INS Marina is at 100 km. East of ship INS Radha. The ship Marina is moving at 50 kmph along a line with whole – circle bearing of 210^0, while ship Radha moves at 40 kmph along a line with whole-circle beaming 135^0. Find the relative velocity of ship INS Radha with respect to the ship INS Marina. What will be the minimum distance between the two ships? (Ans. 53.284i + 15.017j kmph, 27.12556 km)
7.	As observed from a ship moving due east at 9kmph the wind appears to blow from the south. After the ship has changed the course and speed and as it is moving due north at 6 kmph the wind appears to blow from the south west. Assuming that the wind velocity is constant during the period of observation, determine the magnitude and direction of true wind velocity. (Ans.: 17.493 kmph at 59.036^0 North of East)

8.	The crate C is being lifted by moving the roller at A downward with a constant speed of V_A = 2m/s along the guide. Determine the velocity and the acceleration of the crate at the instant s =1m. When the roller is at B, the crate rests on the ground. Neglected the size of the pulley. (Ref. Fig.) (Ans.: 1.2m/s(↑), 0.512m/s^2(↑)	
9.	At the instant shown, slider block B is moving with a constant acceleration, and its speed is 150 mm/s. After slider block A has moved 240 mm to the right Its velocity is 60mm/s. Determine (a) the Accelerations of A and B. (b) the acceleration of portion C of the cable, (c) the velocity and change in position of slider block B after 4s. (Ref. Fig.) (Ans.: 12.33 mm/s^2(←), 20 mm/s^2 (←), (b) 13.33 mm/s^2 (→)(c) 70 mm/s(→), 440 mm	

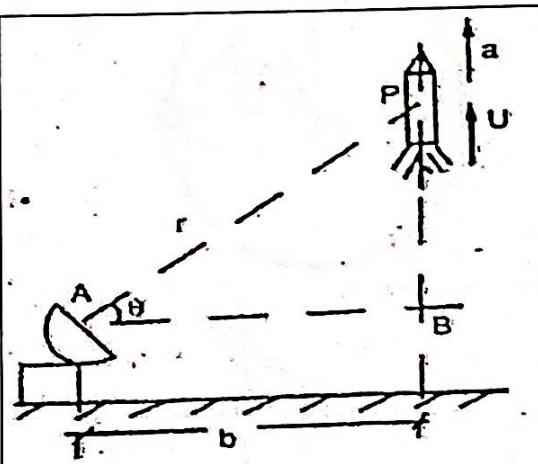
Kinematics of curvilinear motion

10.	A particle travels in the x-y plane on a path defined by $X^2 + Y^2 = 100$. When the particle is at the point x = 6 mm, y = 8 mm, the velocity components V_x = 40 mm/s and the acceleration component a_x = -150 mm / s^2. Determine (a) the velocity and the speed at that instant (b) the x and y components of the acceleration (c) the normal and tangential components of the acceleration. Show your Answers on a sketch. Ans: (a) (40i – 30 j) mm/s, 50 mm /s (b) -150mm/s^2, -200 mm/s^2 (c) 250 mm/s^2, 0
11.	A train enters a curved horizontal section of track at a speed of 100 km/h and slows down with constant deceleration to 50 km/h in 12 seconds. An accelerometer mounted inside the train records a horizontal acceleration of 2m/s^2 when the train is 6 seconds in the curve. Calculate the radius of curvature of the track at that instant. (Ans: 266 m)
12.	A projectile is launched from point 0 as shown in figure. Find The range R and the total time of flight. (Ref. Fig.) (Ans: At t= 22.21 Sec., R = 2066.37 m. At t = 0.333 Sec., R = 73.8 m)



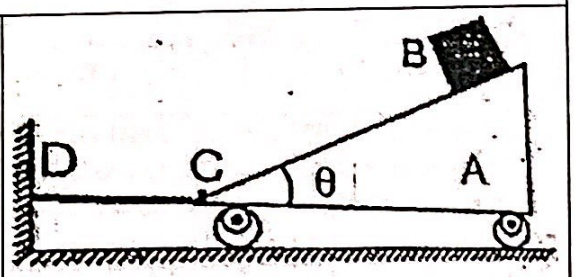
13. The motion of a particle in polar coordinates, is defined by $r = 3(2- e^{-t})$ and $\theta = 4(t + 2e^{-t})$ where r is in meters, t is in seconds, and θ is in radians. Find the velocity and acceleration of the particle as t approaches infinity. Give a sketch of the particle's final path and show its position, velocity and acceleration.
(Ans: $v= 24\ \hat{e}_\theta$, $a = -96\ \hat{e}_r$)

14. A rocket is fired vertically and tracked by the radar station as shown in figure. At the instant shown when $\theta=60^0$ the measurements give $\dot{\theta} = 0.03$ rad/s and r = 7500 m and the vertical acceleration of the rocket is found to be 20 m/s^2. For this instant, determine the values for '$\ddot{r}$' and '$\ddot{\theta}$' (Ref. Fig.)
Ans: $\ddot{r} = 24.07\ m/s^2$, $\ddot{\theta} = 1.7843 \times 10^{-3}\ rad/s^2$)

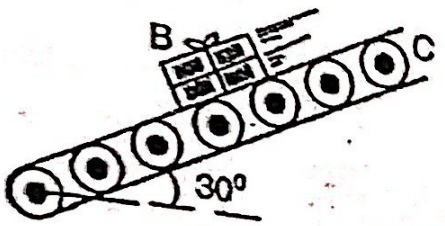


Kinetics of rectilinear motion (Newton's Second Law of Motion)

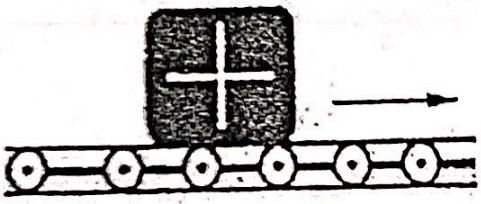
15. Block B has a mass 'm' and is released from rest when it is on top of cart A. Determine the tension in cord "CD' while B is sliding down A. Coefficient of kinetic friction between A and B is μ. Cart A rests on a frictionless floor. (Ref. Fig.)
(Ans: mg cos θ (sin θ - μcos θ)



16. The conveyor belt C is moving downward at 2m/s,. If $\mu_s = 0.8$ Between the box B and the belt, determine the shortest time in which the conveyor can be stopped so that the box does not shift or move on the belt. (Ref. Fig.)
(Ans: 1.06 s)

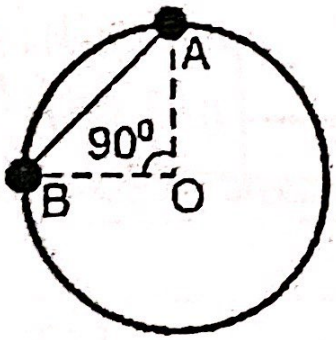


17. A package is at rest on a conveyor belt, which is initially at rest. The belt is started and moves to the right for 1.3 s with a constant acceleration of 2 m/s^2. The belt then moves with a constant deceleration a_2, and comes to a stop after a total displacement of 2.2 m. If μ_s=0.35 and μ_k = 0.25 between the package and the belt, determine (a) the largest allowable a_2 of The belt (b) the displacement of the package relative to the belt as the belt comes to a stop. (Ref. Fig.)
(Ans: (a) 6.63 m/s^2 (b) 0.32m)

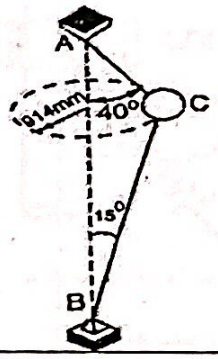


Kinetics of curvilinear motion (Newton's Second Law of Motion)

18. Bodies A and B, each having a weight of 10 N and connected by a light inextensible cord, are constrained to move along a fixed frictionless hoop. Determine the tension in the cord immediately after the bodies are released from the position shown. The plane of the hoop is vertical with point A, directly above the center O. (Ref. Fig.)
(Ans: 7.07 N)



19. As part of an outdoor display, a 5.44 kg model C of the earth is attached to wires AC and BC and revolves at a constant speed 'v' in a horizontal circle. Determine the range of the allowable values of 'v' if both wires are to remain taut and if the tension in either of the wires is not exceed 116N. (Ref. Fig.)
Ans: 2.743 m/s ≤ v ≤ 3.78 m/s

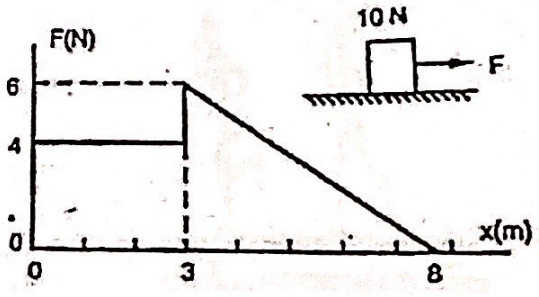


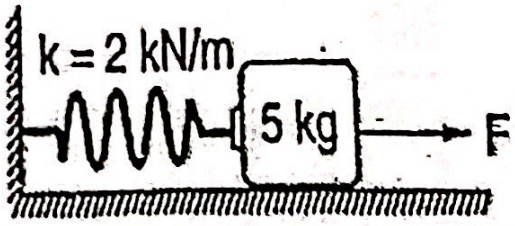
Work, Power, Energy

20. A train of mass 100 000 kg travelling on a horizontal track requires 300 kW to maintain a constant speed of 80 km/h. Determine (a) the total force needed to overcome friction, rolling resistance, and air resistance (b) the additional power required if the train is to maintain the same speed going up a one percent grade.
Ans: (a) 13.5kN (b) 218 kW

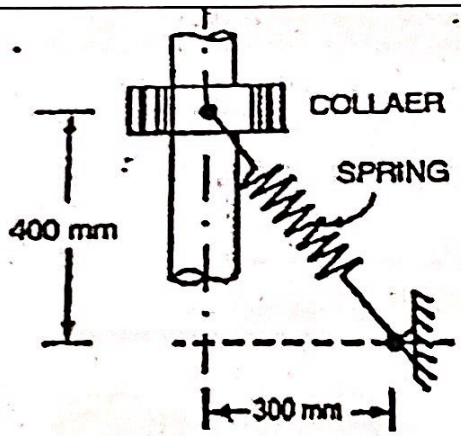
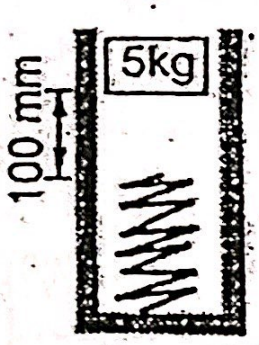
Work – Energy Principle

21. A force, which varies with x as shown, pulls a 10N body, that is originally at rest, along a horizontal floor. If $\mu = 0.2$ between the body and the floor, determine (a) the work done by the force in moving the body from x = 0 to x = 8 m. (b) the speed of the body when it has travelled 3m. (c)the Speed of the body when it has travelled 8m (d) the total distance the body travels before it again comes to rest. (Ref. Fig.)
(Ans: (a) 27 J, (b) 3.4 m/s (c) 4.65 m/s (d) 13.5m)



22.	A 5 kg block is attached to an unstretched spring of constant 2 kN/m, If $\mu = 0.6$ and $\mu = 0.4$ and a force F is slowly applied to the block until the tension in the spring reaches 90 N and then suddenly removed, determine (a) the velocity of the block as it returns to its initial position, (b) the maximum velocity achieved by the blocks (Ref. Fig.) (Ans: (a) 0.676 m/s (b) 0.704 m/a)	

Conservation of Energy

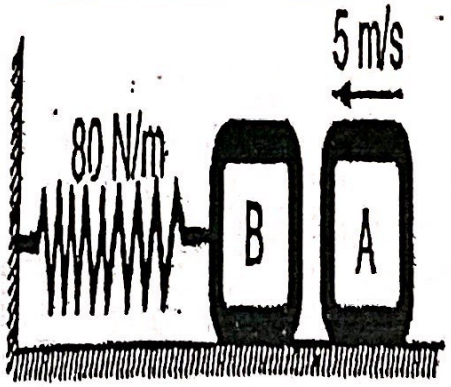
23.	A collar of mass 10 kg moves in a vertical guide as shown in figure. Neglecting friction between the guide and the collar, find its velocity after it has fallen 700 mm, starting from rest from the position shown in the figure. The unstretched length of the spring Is 200 mm. and its stiffness is 200 N/m (Ref. Fig.) Ans.: V = 13. 14 m/s (↓)	
24.	The 5 kg cylinder is released from rest in the position shown and compressed the spring of stiffness k = 1.8 kN/m. Determine the maximum compression of the spring and the maximum velocity of the cylinder(Ref. Fig.) (Ans.: 106 mm, 1.493 m/s)	

Impuluse- Momentum, Conservation of momentum

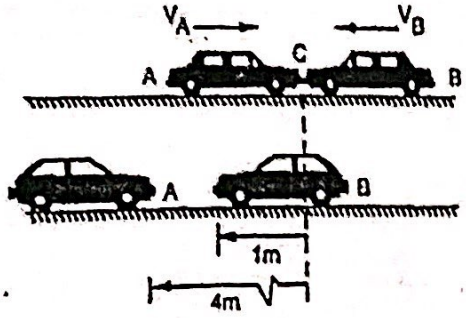
25.	Two 70 kg persons stand on a 100 kg cart, which is at rest. Determine the final speed of the cart, if the man runs at a speed of 1.5 m/s and jumps off the cart at one end and then the lady runs at the same speed and jumps off the same end (Ref. Fig.) (Ans.: 1.06 m/s)	

Direct – Central Impact

26. A 1.5 kg block B is attached to an undeformed spring of constant 80KN/m and is resting on a horizontal surface when it is struck by an identical block A moving at a speed of 5 m/s. If e = 1 for the impact and μ_s = 0.5, μ_k = 0.3 between the blocks and the surface, determine the final position of (a) block A (b) block B (Ref. fig.)
(Ans.: (a) 2.98 m →of the impact point (b) at the impact point

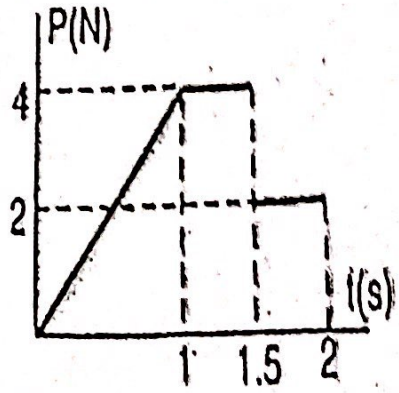


27. Two cars of the same mass collide head on at C. After the collision, the cars skid on the road with their brakes locked and come to a stop in the positions shown in the lower part of the figure. If the speed of car A just before the impact was 5 km / h and μ_k = 0.3 between the tyres and the road, determine (a) the speed of car B just before impact, (b) the effective coefficient of restitution between the two cars (Ref. fig.)
(Ans: (a) 31.2 km / h (b) 0.241)

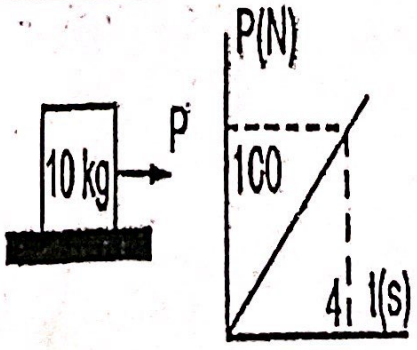


Impulse-momentum principle

28. A 1.25 kg body is travelling in a horizontal straight line with a velocity of 3 m/s when a horizontal force P is applied to it at right angles to the initial direction of motion. The magnitude of P varies as shown but the direction remains constant. Assuming that P is the only force acting on the body, Determine the velocity of the body at t = 2 s. Specify the direction with reference to the direction of P. (Ref. Fig.) (Ans: 5 m/s, 36.9^0)



29. The force P, which is applied to the 10 kg block varies uniformly with time as shown if μ_s = 0.6 and μ_k = 0.4, find velocity of the block when t = 4 s. (Ref. Fig.)
(Ans: 6.614 m/s)



30. The winch delivers a horizontal force F, which varies as shown, to the cable at A. The pulley carries a 70 kg block B. If B is originally moving upwards at 3 m/s, determine the speed of the block at t = 18 s.(Ref. Fig.)

Ans.: 21.85 m/s)