Branch :- First Year Common to all Branches **Semester :- I & II**

Subject :- Engineering Mechanics [1A3]

Unit 1

1) State and Explain :

a. Principle of Transmissibility of Force

b. Principle of Physical Independence of Force

c. Three Force Principle

2) a. State the law of parallelogram of force.

b. Explain Resolution of a Force.

3) Define Force system and discuss the classification of force systems.

4) What is Moment of Force ? State it's types and characteristics of Moment of Force.

5) a. Explain Free body diagram with examples.

b. State Lami's theorem along with its limitations.

c. Explain Hinge support with examples.

6) Find the value of force P and F so that the four forces shown in figure produces an upward resultant of 300N acting at 4 m from left end 'A'.

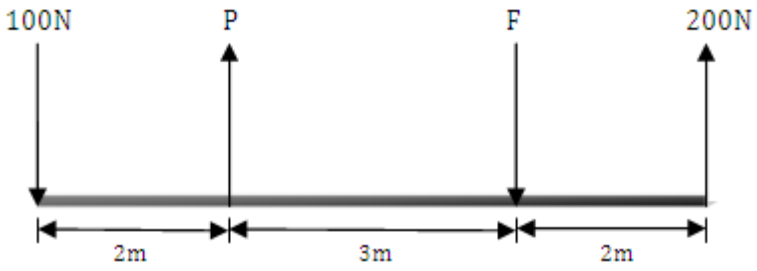

Fig. Q. 6

7) The sum of two concurrent forces P and Q is 270 N. The resultant makes and angle of 90° with force P and has magnitude of 180 N. Calculate the values of forces P and Q along with the included angle between them.

8) The three forces shown in figure are required to cause a horizontal resultant acting through point A. If T = 316 N, determine the values of P and F.

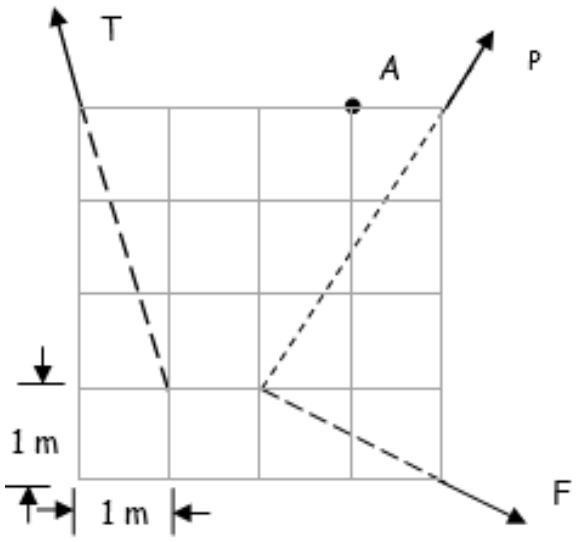

Fig. Q. 8

9) Two cylinder A and B of weight 15 N and 40 N with radius 0.2 m and 0.3 m respectively are kept in a rectangular box of width 0.9 m as shown in figure. Neglecting friction determine reactions at all contacts.

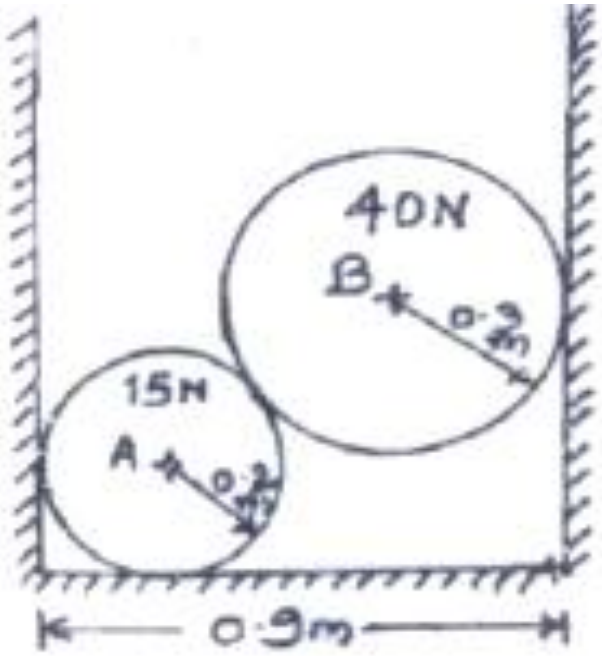

Fig. Q. 9

10) Replace the system of force as shown in figure into a single equivalent force and couple about point A.

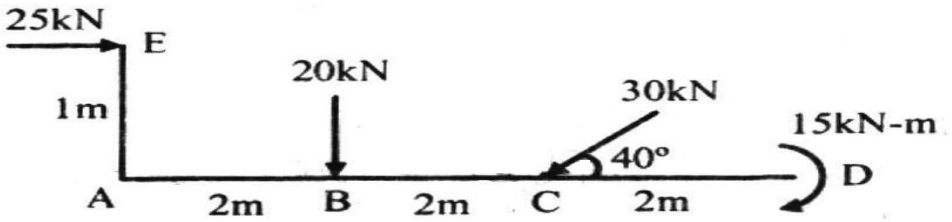

Fig. Q.10

11) Analyse the compound beam loaded as shown in figure.

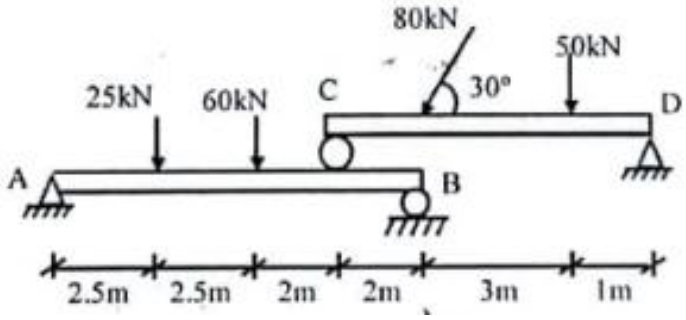

Fig. Q.11

12) Calculate the least value of force P which will drag the cylinder of weight 10 kN on a step of height 0.2 m as shown. Assume the radius of cylinder as 0.3 m and force P to be passing through the centre of cylinder.

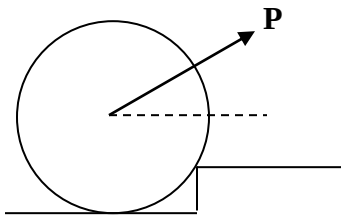

Fig. Q.12

13) Two identical cylinders each of weight 1kN are placed between inclined smooth plane and vertical wall as shown calculate the reactions at all contact surfaces.

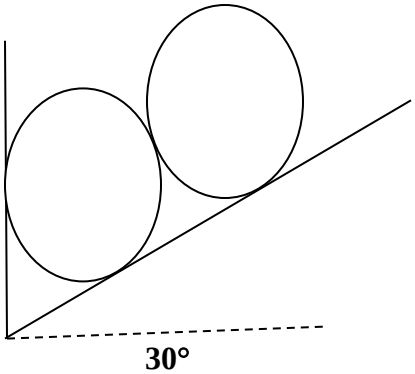

Fig. Q.13

14) A 4m bar of negligible weight is placed between two smooth inclined surfaces as shown. Calculate the distance **x** at which a force of 1000 N should be applied so as to keep the bar horizontal.

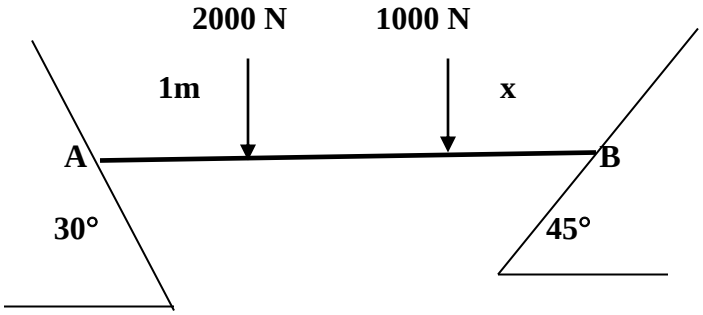

Fig. Q.14

15) A weight W rest on the bar AB as shown in **fig.** The cable connecting weight W and end B passes over frictionless pulleys. If bar AB has negligible weight and is supported by hinge support at A. Show that the reaction at hinge support A is $\frac{W(L-a)}{(L+a)}$

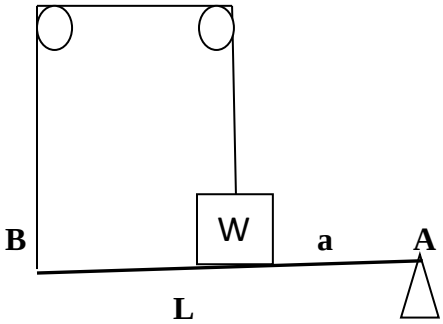

Fig. Q.15

16) Three coplanar forces acts at a point on a bracket as shown in figure. Determine the angle α such that the resultant of three forces will be vertical. Also find the value of magnitude of resultant.

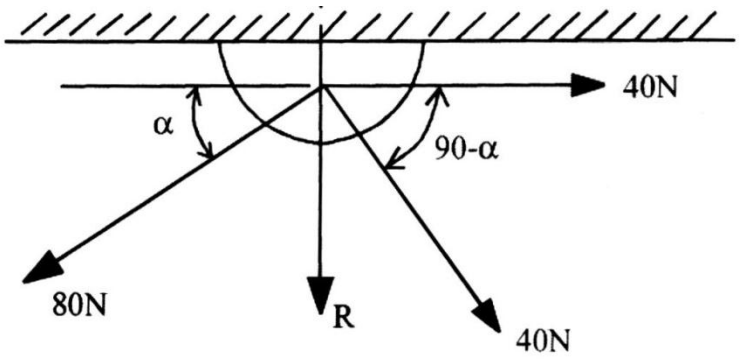

Fig. Q.16

17) Determine magnitude, direction and position of resultant for the force system shown in figure below w. r. t. point A.

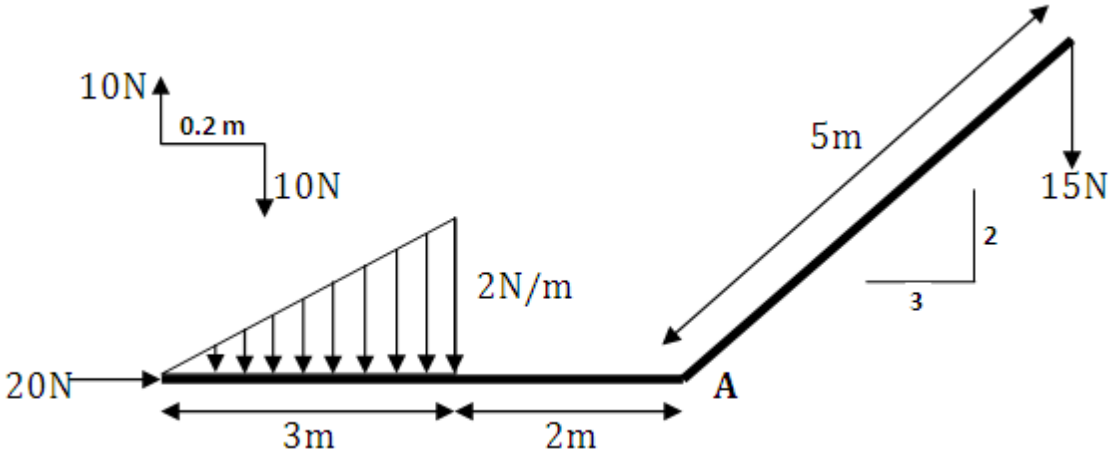

Fig. Q.17

18) A roller of radius 300 mm & weight 2000 N is to be pulled over a block of height 150 mm as shown in **fig.** by a horizontal force P applied to the end of a string wound tightly around the circumference of a roller. Find the magnitude of P required to start the roller move over the block .

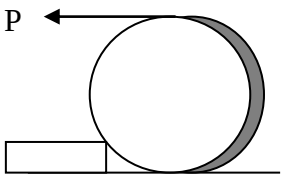

Fig. Q.18

19) a. State both analytical and graphical conditions of Static Equilibrium.

b. The force system shown in figure has a resultant of 200 kN pointing along the Y axis. along the Y axis. Compute the values of F and θ required to give this resultant.

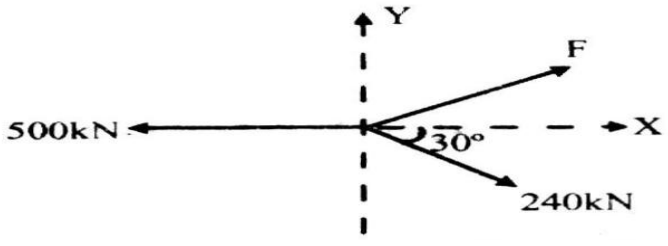

Fig. Q.19

Unit 2

1) a. State the assumptions made in analysis of truss.

b. Classify different types of truss.

2) a. State Coulomb's law of dry friction.

b. Define – i. Angle of Repose

ii. Cone of Friction

iii. Angle of Lap

3) Derive the expression $\frac{T_2}{T_1} = e^{\mu\theta}$ for static belt friction, where μ is coefficient of friction and θ is angle of lap.

4) Determine the forces in each member of the truss as shown in figure. Also tabulate the results.

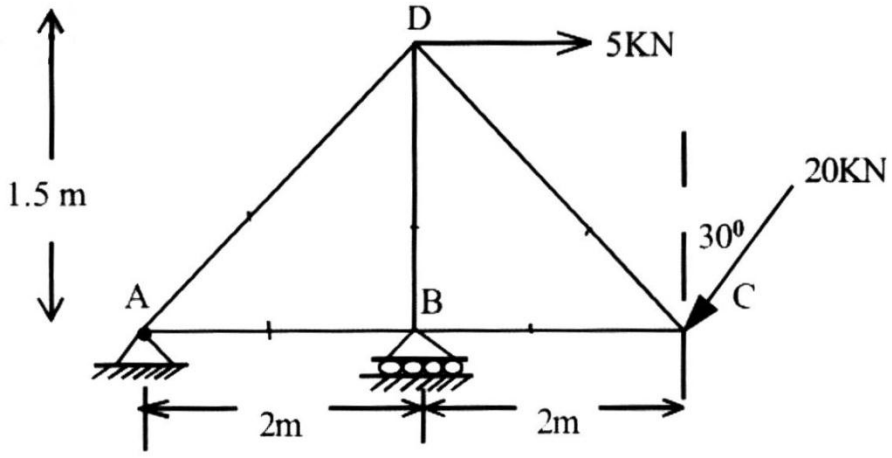

Fig. Q.4

5) Analyse the fixed truss as shown in figure.

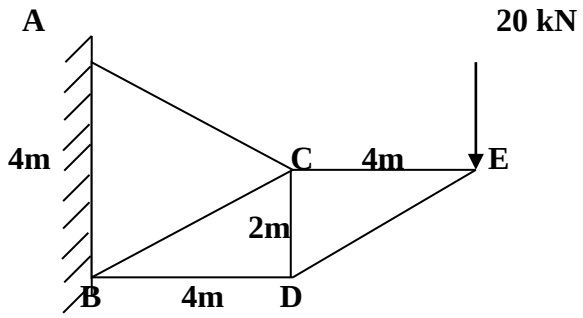

Fig. Q.5

6) a. Define Wedge Friction.

b. What range of Weights (W) can be supported by a force P = 800 N if the rope makes $3\frac{1}{4}$ turns around a drum. The μ is 0.2. Refer the figure as below.

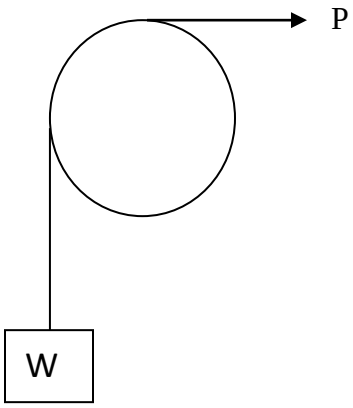

Fig. Q.6

7) A cylinder of weight |**W** and radius **r** rest on a horizontal surface and against a vertical wall as shown. If coefficient of friction is at all contact surface is ‘f ’, show that the moment which will start it rotating anticlockwise is $M = \frac{Wfr[1+f]}{[1+f^2]}$

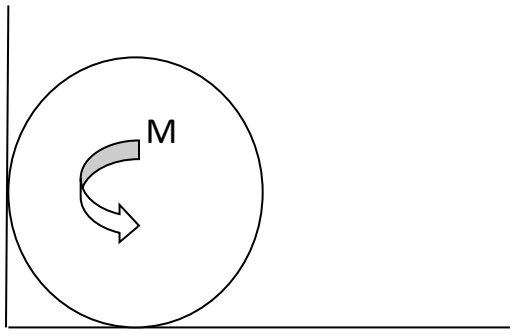

Fig. Q.7

8) Determine the forces in the members of a truss shown in figure.

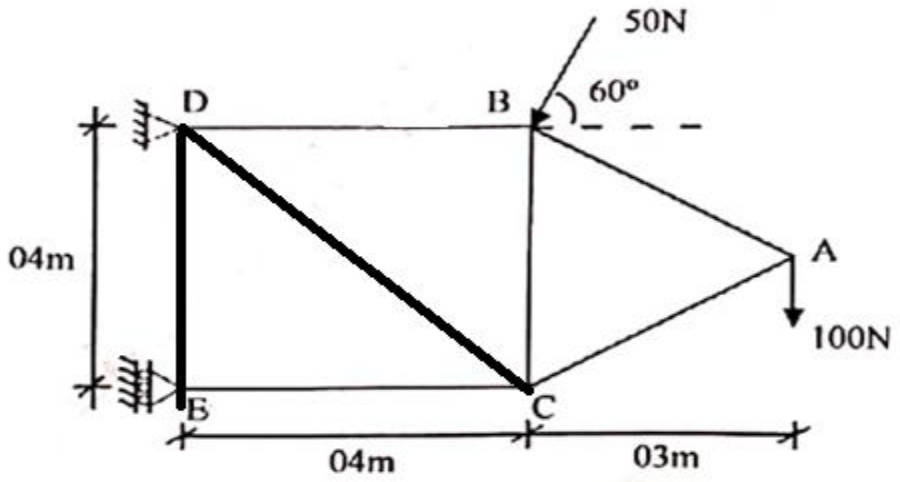

Fig. Q.8

9) Find the forces in all the members of the truss as shown in figure.

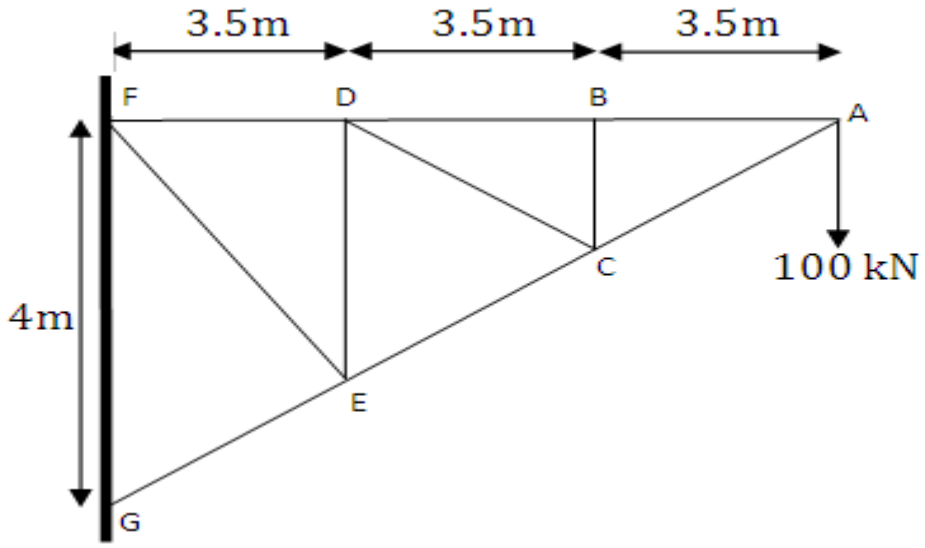

Fig. Q.9

10) Determine the horizontal force P in figure to start the movement of wedge. Assume angle of friction as 15° at all surfaces.

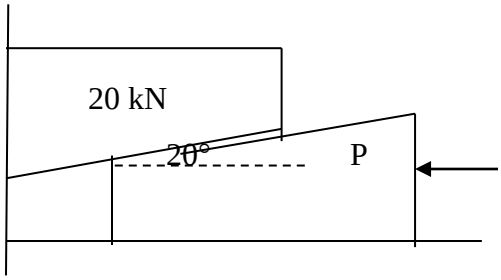

Fig. Q.10

11) Determine the forces in all the members of truss as shown in figure. Length each member is 2m and also tabulate the results.

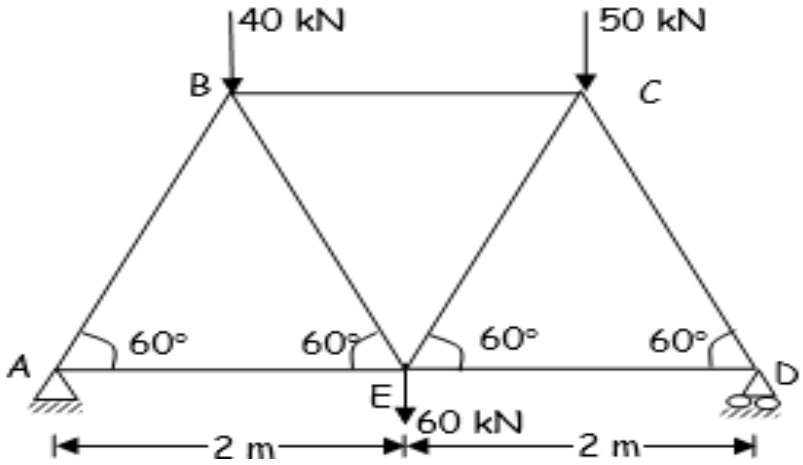

Fig. Q.11

12) Find the least value of P that will just start the system of blocks shown in figure, moving to the right. The coefficient of friction under each block is 0.30 while the pulley is frictionless.

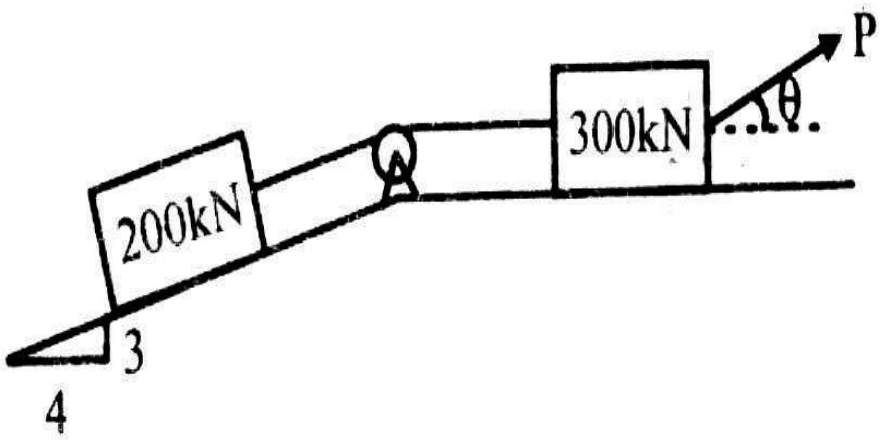

Fig. Q.12

13) A uniform ladder 22 m long and weight 40 N is placed against a vertical wall and horizontal floor at an angle 60° with the horizontal. How far along the ladder can a person of 160 N climb before the ladder impends it's motion. Assume the angle of friction at all contact surfaces as 15°.

14) Determine the forces in all the members of truss as shown in figure.

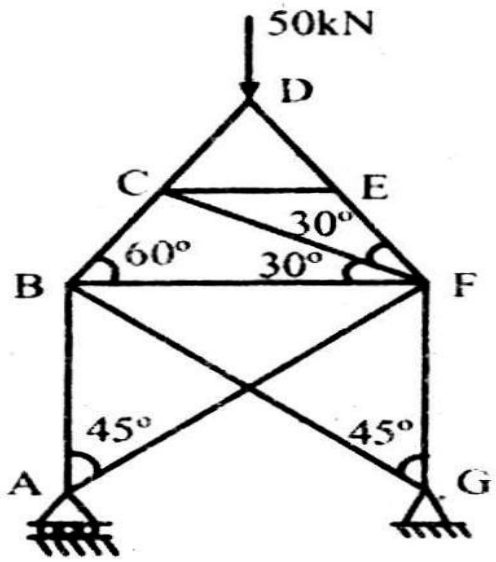

Fig. Q.14

15) Two bodies A and B are connected by a cord parallel to the incline as shown in figure. Determine the value of angle α at which motion impends. What is then tension in cord ?

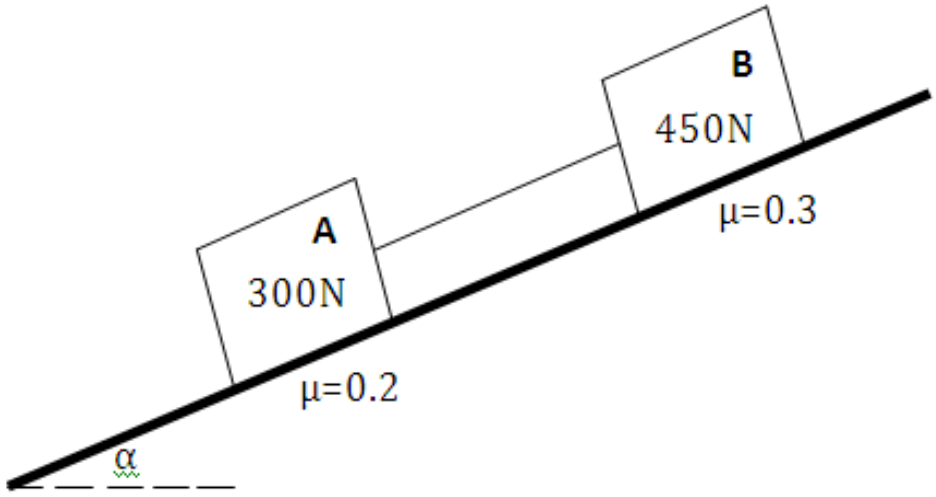

Fig. Q.15

16) a. Show that angle of repose and angle of friction are equal when the body impends its motion.

b. In figure, the coefficient of friction between rope and fixed drum is 0.25. Determine the holding force required to prevent 66 N weight falling down.

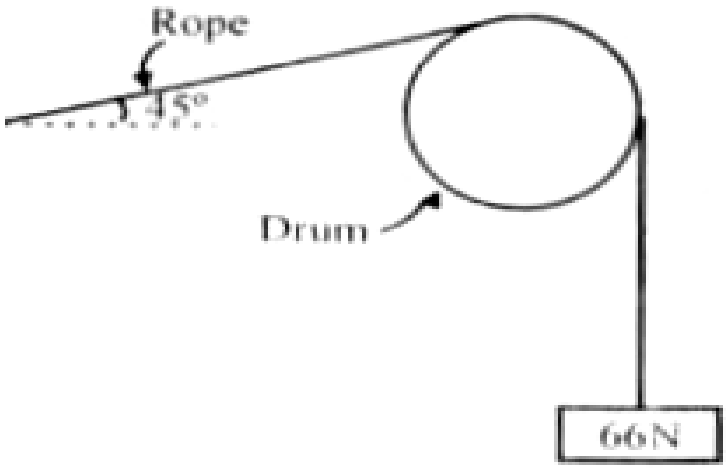

Fig. Q.16

17) Determine the forces in all the members of the truss shown in figure.

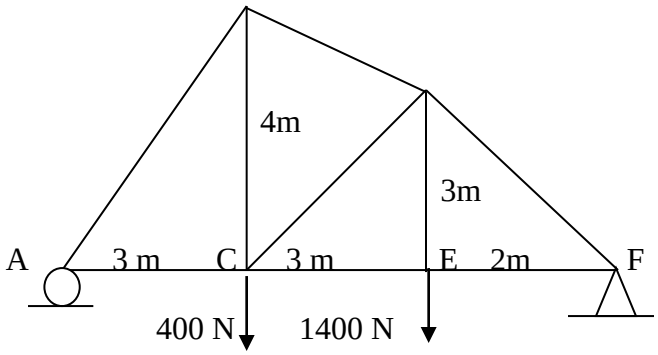

Fig. Q.17

18) Two blocks A and B each of weight 2000 N are held from slipping by the thrust of two weightless rods each of which are connected to blocks A and B other end is connected to point O. If coefficient of friction at all contacts surfaces is 0.25. Calculate the force P required to keep blocks away from slipping.

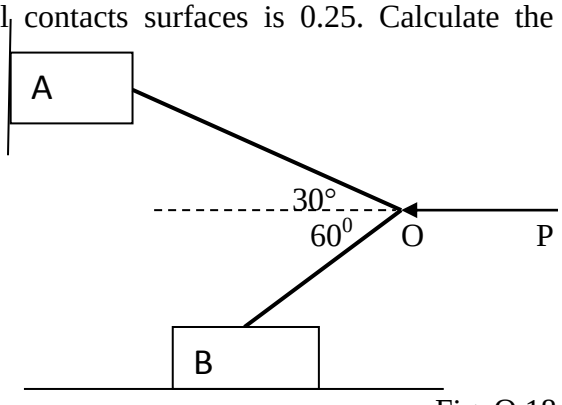

Fig. Q.18

Unit 3

1) a. Define Second Moment of Inertia.

b. Locate the centroid of the area shown in figure. With reference to given X and Y-axes.

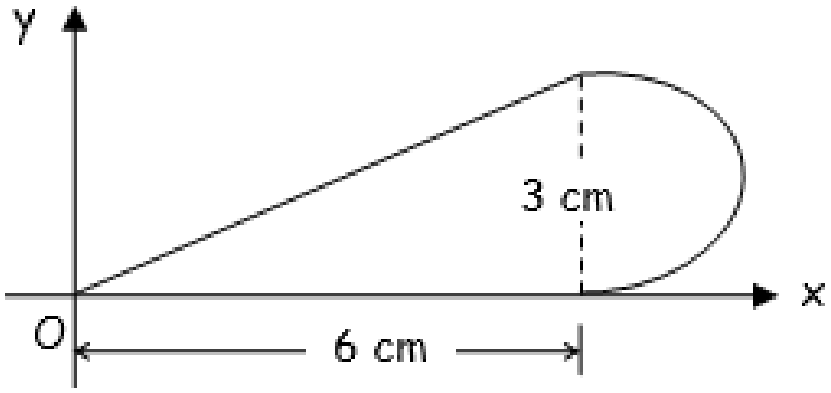

Fig. Q.1.b

2) Locate the position of centroid for a triangle having base b and height h using first principle.

3) a. State and explain Parallel axis theorem.

b. Define Product of Inertia.

4) Determine the centroid of the area shown in figure a with respect to given x and y axes.

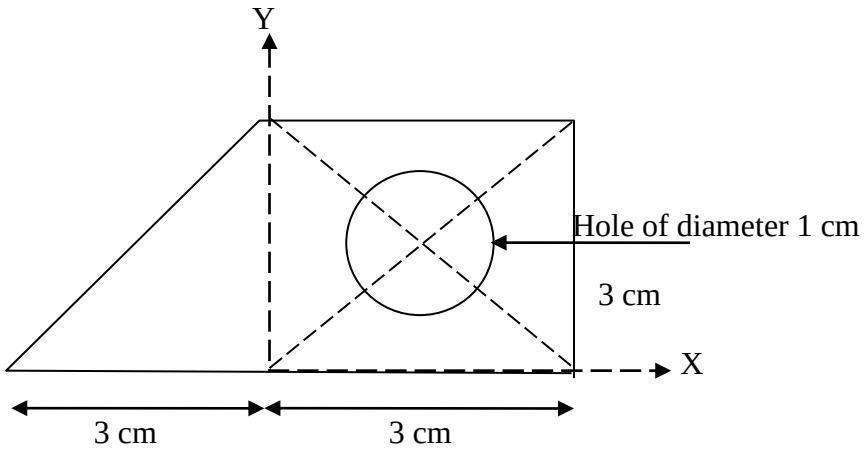

Fig. Q.4

5) a. State Perpendicular Axis theorem.

b. Locate the position of centroid for a rectangle having base b and height h using first principle.

6) Determine principal moment of inertia and locate principal axes for the section as shown in figure.

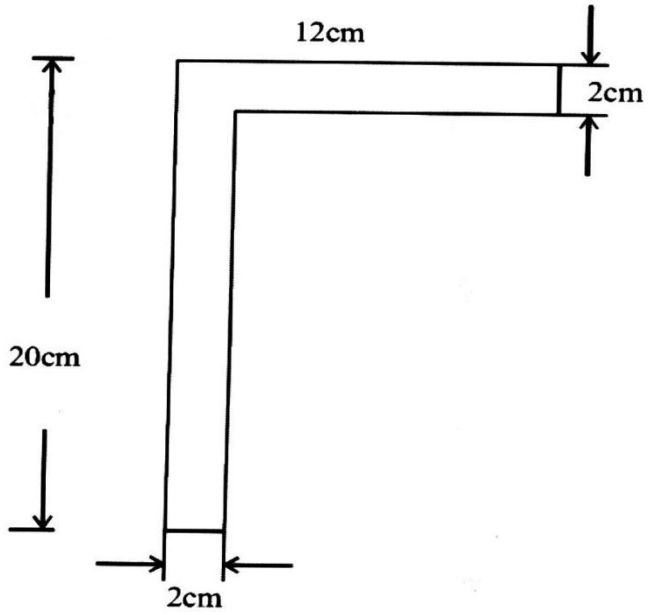

Fig. Q.6

7) Calculate the Second Moment of Area for geometric figure about indicated

X – Y axis.

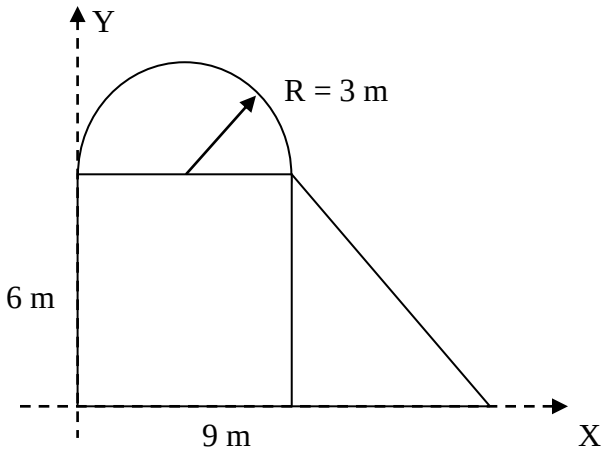

Fig. Q.7

8) Calculate the Moment of Inertia for the given geometric shape about centroidal X and Y axis. Hence, calculate the least radius of gyration.

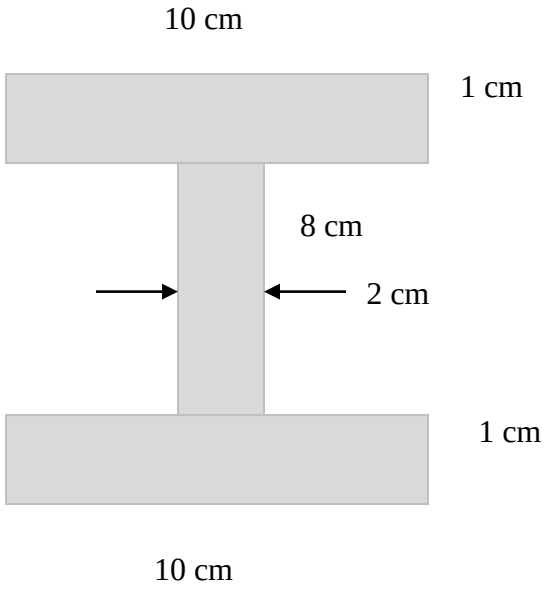

Fig. Q.8

9) Determine moment of inertia about the axis of symmetry. Hence, find out radii of gyration.

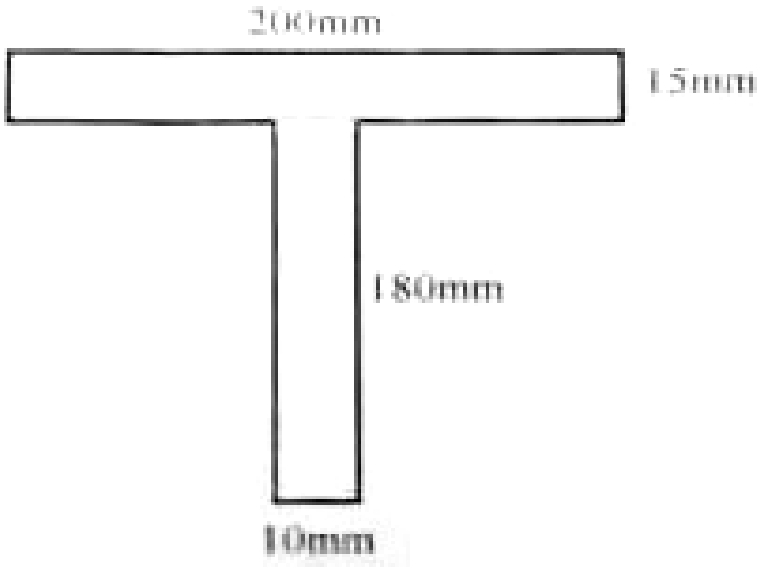

Fig. Q.9

10) Derive the expression for moment of inertia of a triangle of height 'h' and base 'b' about x-axis coinciding with the base.

11) Determine the product of Inertia of shaded area about area centroidal axis as shown in figure.

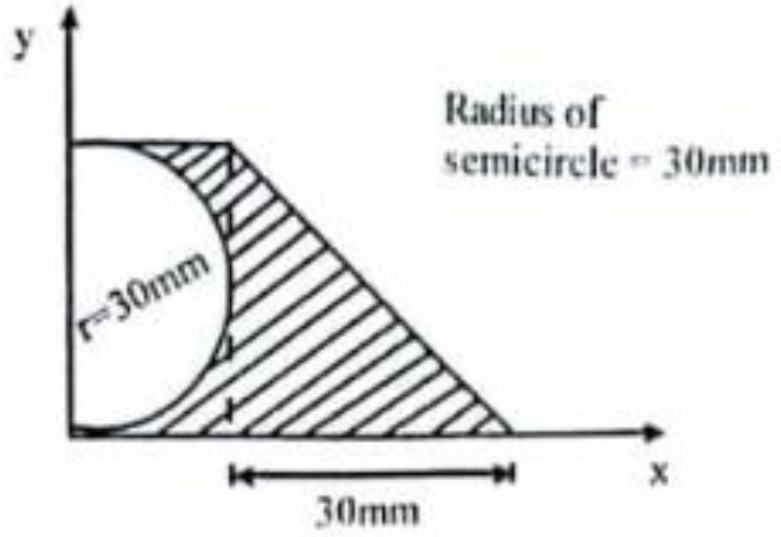

Fig. Q.11

12) Determine maximum and minimum moment of inertia of the 'L' section shown in figure with respect to centroidal X – Y axis.

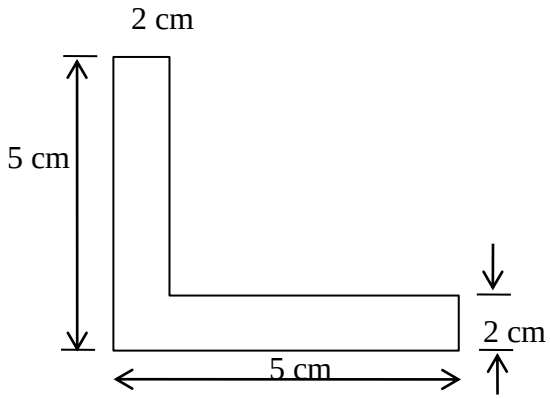

Fig. Q.12

13) Determine the second moment of Inertia about centroidal set of axis for the given shaded portion.

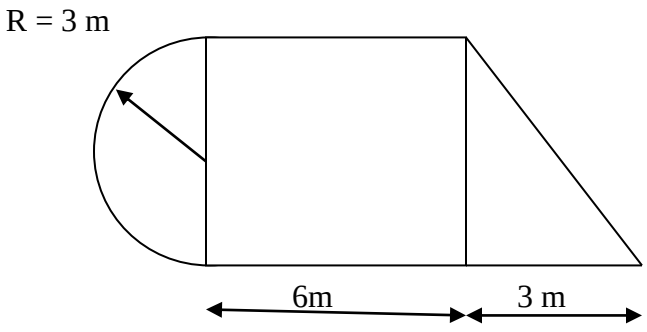

Fig. Q.13

14) Determine Moment of Inertia for a rectangle with sides ‘a’ and ‘b’ about it’s diagonal axis.

15) Using First Principle locate the centroid of a semicircle.

16) Calculate the second moment of area for the Z section with respect to centroidal X and Y axis.

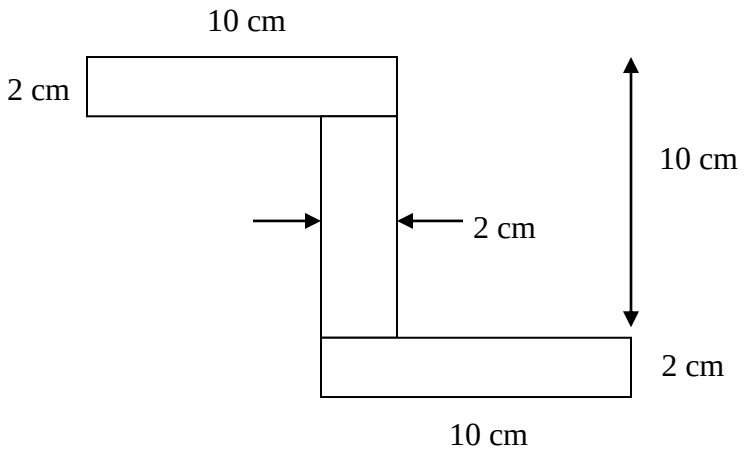

Fig. Q.16

17) Calculate the product of Inertia for the given shaded portion with respect to reference X and Y axis.

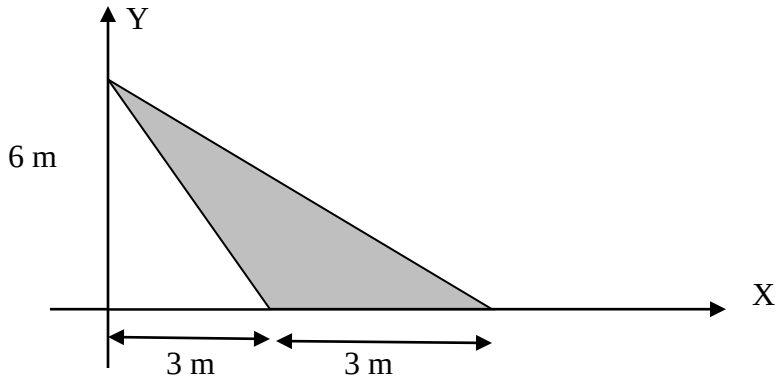

Fig. Q.17

Unit 4

1) A stone is thrown vertically upward and returns to earth in 5 seconds. Find how high does it go?

2) An auto A moving at20 m/s, accelerates at 5 m/s^2 so as to overtake another auto B which is 384 m ahead of auto A and moving at a speed of 60 m/s and decelerating at 3 m/s^2. How soon will auto A overtake auto B.

3) A train moving with constant acceleration covers 24 m during 10^{th} second and 18 m during 12^{th} second of it's motion. Calculate the initial velocity and acceleration along with the distance covered by the train in last second of it's motion.

4) The rotation of a flywheel is governed by the equation $\omega = 4t^{1/2}$, ω is in rad/sec. &'t' is in sec. If θ = 2 rad when t = 2 sec. determine the values of θ and α at t = 3 sec.

5) The rectilinear motion of the particle is governed by $a = -8s^{-2}$. When t = 1, s = 4 m and v = 2 m/s, determine the acceleration of the particle at t = 2 sec.

6) A train, starting from rest, is uniformly accelerated during the first 250 m of its run and runs next 750 m at uniform speed. It is then brought to rest in seconds under uniform retardation. If the time taken for the entire journey is 5 minutes. Find the acceleration with which the train started along with the total distance covered during the journey.

7) A balloon rises from the surface with an acceleration of 0.9 m/s^2. 5 sec later a stone is thrown vertically upwards from same launching site. Calculate initial velocity of stone for it to just touch the balloon. Assume that velocity of balloon and stone are same at the instant of contact.

8) The motion of a particle along a straight line is defined by, $S = \frac{1}{3}t^3 - 36t$

Find the average acceleration during the 4^{th} second. Calculate the acceleration of the particle when it reverses its direction.

9) The motion of a particle moving along a straight line path follows the equation, $S = 18\,t + 3\,t^2 - 2\,t^3$. Find velocity and acceleration at start of motion. Also, calculate maximum velocity and maximum displacement throughout entire motion.

10) A stone is thrown with an initial velocity of u m/sec upwards at α^0 to the horizontal. Compute :

i) Time required to reach maximum height.

ii) Maximum height covered by stone.

iii) Horizontal distance covered by stone (on a leveled ground).

11) A soldier fires a bullet from a cliff of height 150 m with a velocity of 180 m/s at an angle 30° upward with horizontal. Neglecting air resistance,
Determine – **a.** time of flight **b.** Range of motion
c. velocity with which the bullet strikes the target.

12) A cricket ball is thrown by a fielder of height 2 m with an angle of 30° upward with horizontal with a velocity of 20 m/s. The ball hits the wicket of height 0.5 m from ground. Calculate the distance of fielder from wickets.

13) The velocity of a partial moving along the x-axis is defined by, $v = kx^3 - 4x^2 + 6x$ where v is in m/sec & x is in meters. Compute the value of the acceleration when x = 2meters and constant k = 1.

14) A pulley has a constant angular acceleration of 3 rad/sec^2. When the angular velocity is 2 rad/sec, the total acceleration of a point on the rim of the pulley is 3 m/s^2. Compute the diameter of the pulley.

15) The position vector of a particle is defined by the relation,

$\bar{r} = (2t^3 - 12t)i + 6t^2 j$. Calculate the radius of curvature of path traced by particle at t = 2 sec. Also, calculate the Normal and tangential component of acceleration.

16) A motor cyclist wants to jump over a ditch as shown in figure. Find the necessary velocity 'V' at A in km/hr of the motor cycle.

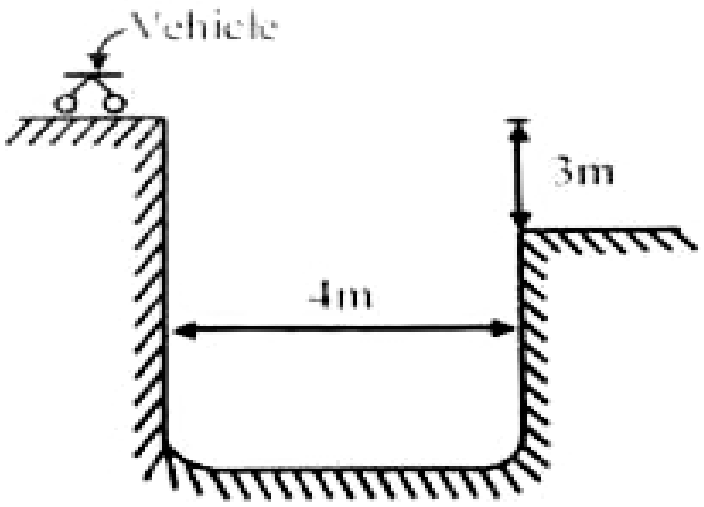

Fig. Q.16

17) The motion of a particle is represented by the relation, $x = 2(t+1)^2$ and $y = 2(t+1)^{-2}$. Calculate the velocity and acceleration of the particle at start of motion. Also, determine the radius of curvature at this instant.

18) A flywheel is rotating at 600 rpm and slows down at constant rate of 3 rad/s^2. Determine angular velocity of flywheel after 5 sec. Also, calculate the time after which flywheel will stop and number of revolutions made by flywheel before it stops.

19) A shaft is uniformly accelerated from 10 rps to 18 rps in 4 seconds. The shaft then continues to accelerate at this rate for next 8 seconds and then after rotates with uniform angular speed. Find the total time required by shaft to complete 400 revolutions.

20) The equation for acceleration of a particle starting from rest and moving in a straight line is given by, a = 10 – 0.006 x^2, where a is in m/sec^2 and x is displacement in m. Determine : **i.** The velocity of the particle, when it has travelled 20 m **ii.** The distance travelled by the particle when it comes to rest.

Unit 5

1) a. State D'Alembert's Principle.

b. State Newton's 2nd Law of Motion.

2) Determine the force P that will give the body as shown an acceleration of 0.2 g m/s^2. Assume coefficient of kinetic friction as 0.20.

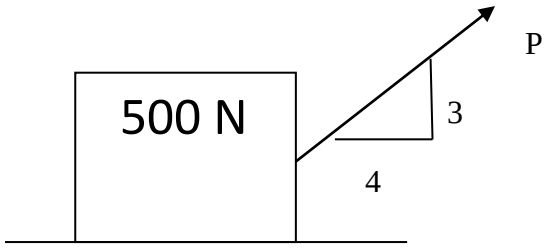

Fig. Q.2

3) Determine acceleration of each block shown in figure.

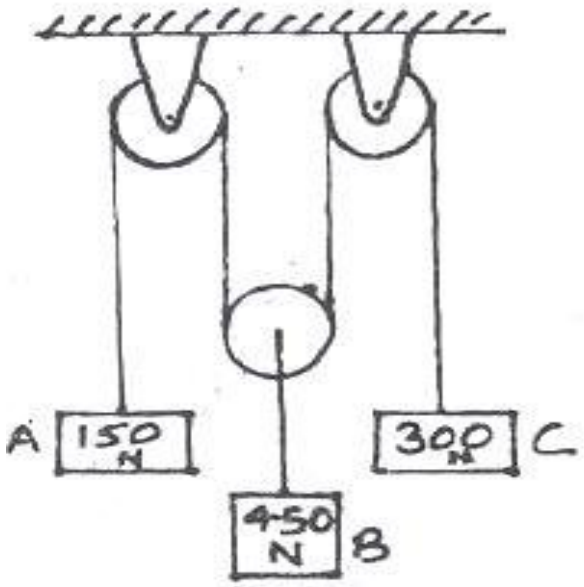

Fig. Q.3

4) State Equations of Kinetics for linear and rotational motion.

5) An elevator weighs 2500 N and is moving vertically downwards with a constant acceleration. Write the equation for the elevator cable tension starting from it travels a distance of 35 m during an interval of 10 seconds. Find the cable tension during this time. Neglect all other resistance to motion.

6) A system of frictionless pulleys carries two weights A and B of 50 N and 80 N hung by inextensible cord as shown in figure. Find the acceleration of the weight A and B. Also, calculate the velocity and displacement of weight B after 5 seconds from start if the system is released from rest.

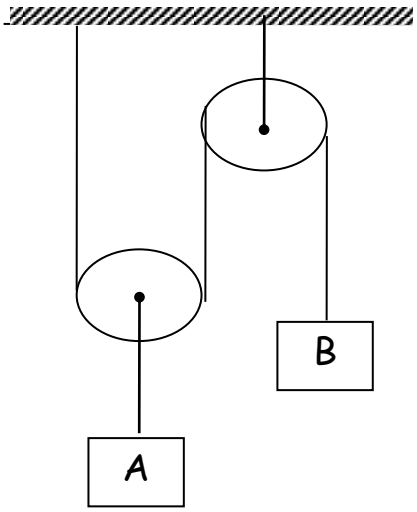

Fig. Q.6

7) Determine the acceleration of block A and B of the connected bodies as shown in figure. The pulleys are weightless and frictionless. The coefficient of friction between block A and surface is 0.1.

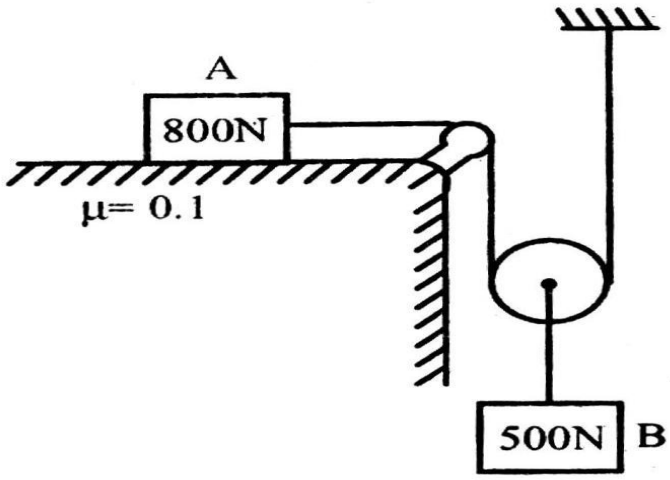

Fig. Q.7

8) Referring to below figure, compute the acceleration of each body. Assume pulleys are frictionless and of negligible weight.

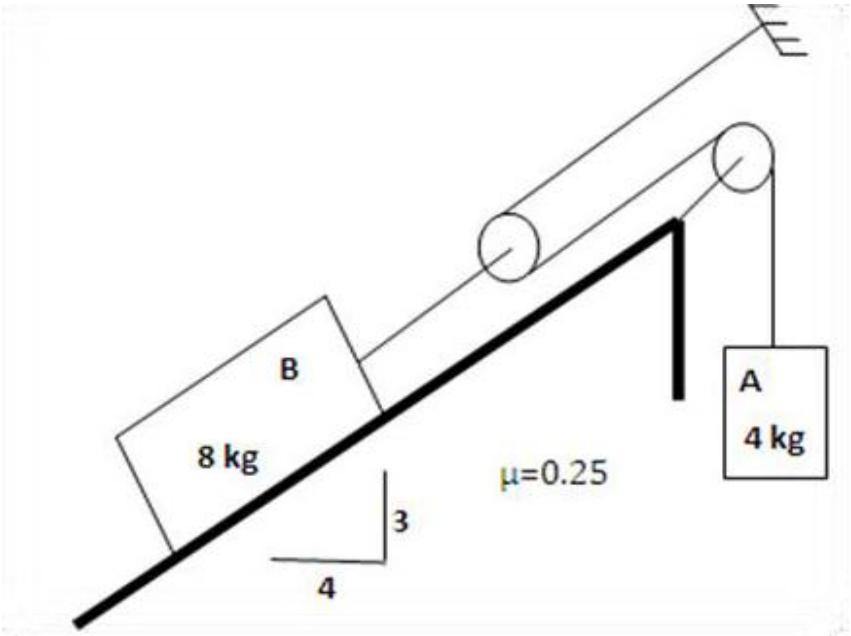

Fig. Q.8

9) If the system as shown in figure is released from rest, Calculate the velocity of block Q after it falls 3 m. Neglect the friction and inertia of pulleys and assume the weight of block P and Q as each 25 N.

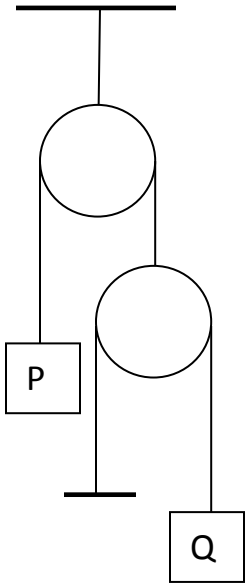

Fig. Q.9

10) Determine the acceleration of body B and the tension in the chord attached to it. Assume coefficient of friction, $\mu = 0.20$ throughout. All pulley are frictionless and weightless.

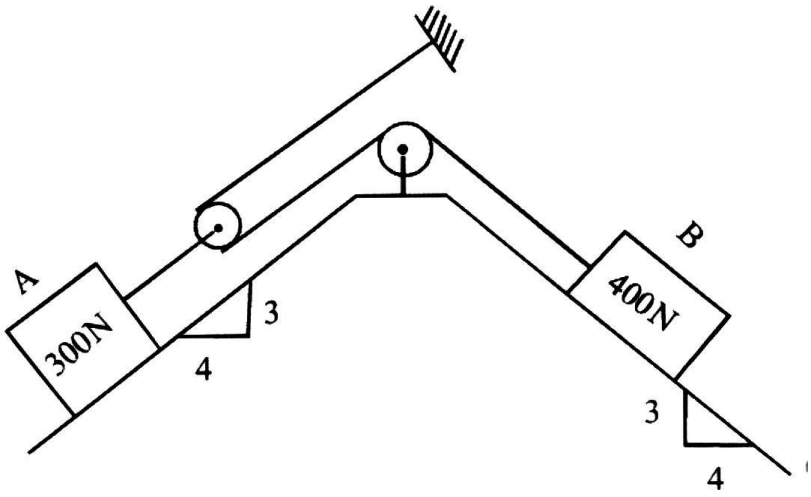

Fig. Q.10

11) Determine the accelerations of block A, B and C for the given system. Assume the pulleys to be frictionless and weightless. Consider weight of blocks A, B and C as 400 N, 600 N and 300 N respectively.

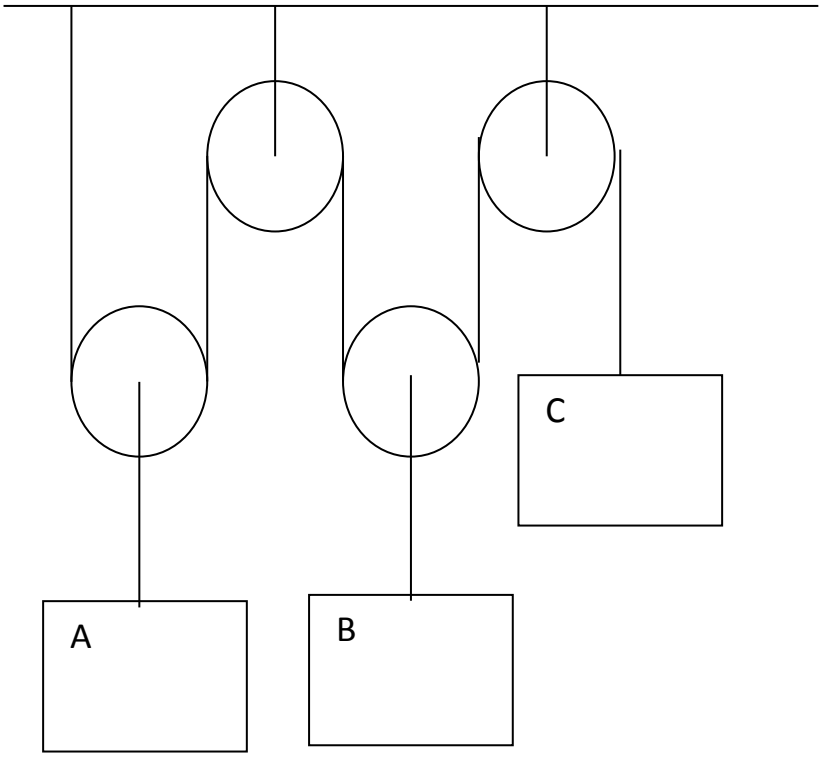

Fig. Q.11

12) Two blocks A and B are released from rest on 30° inclined when they are 18 m apart. The coefficient of friction under upper block A and surface is 0.20 and that under lower block B and surface is 0.40 as shown. After what time will block A strike Block B. Assume weight of Block A and B as 100 N and 80 N respectively.

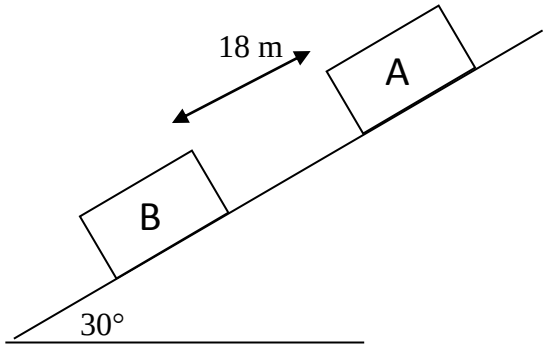

Fig. Q.12

13) Determine the accelerations of block A and B for the given system. Assume the pulleys to be frictionless and weightless. Consider mass of blocks A and B as 25 kg and 100 kg respectively.

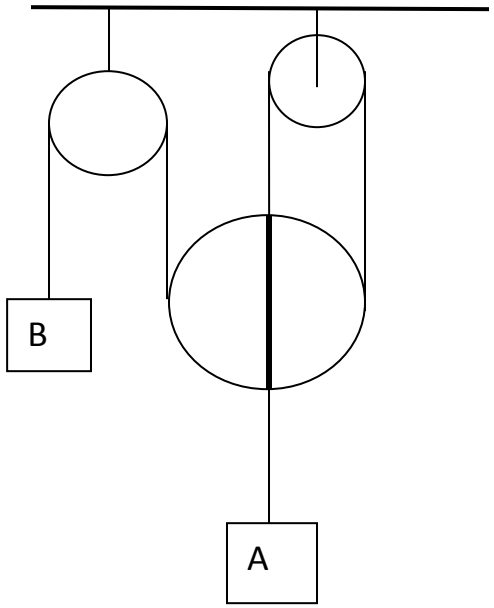

Fig. Q.13

14) Determine the force P that will give the body as shown in figure an acceleration of 3.0 m/s^2. The coefficient of kinetic friction is 0.25.

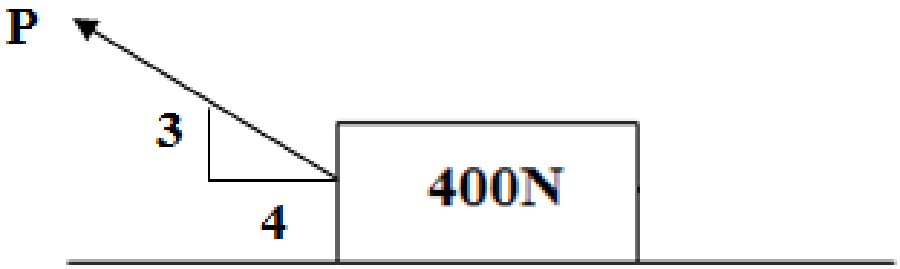

Fig. Q.14

15) The uniform box shown in figure weighs 200 N. It is pulled up the incline by a force of 400 N. Find the maximum and minimum values of 'd' so that the crate does not fall as it slides up the incline. Assume coefficient of kinetic friction as 0.2.

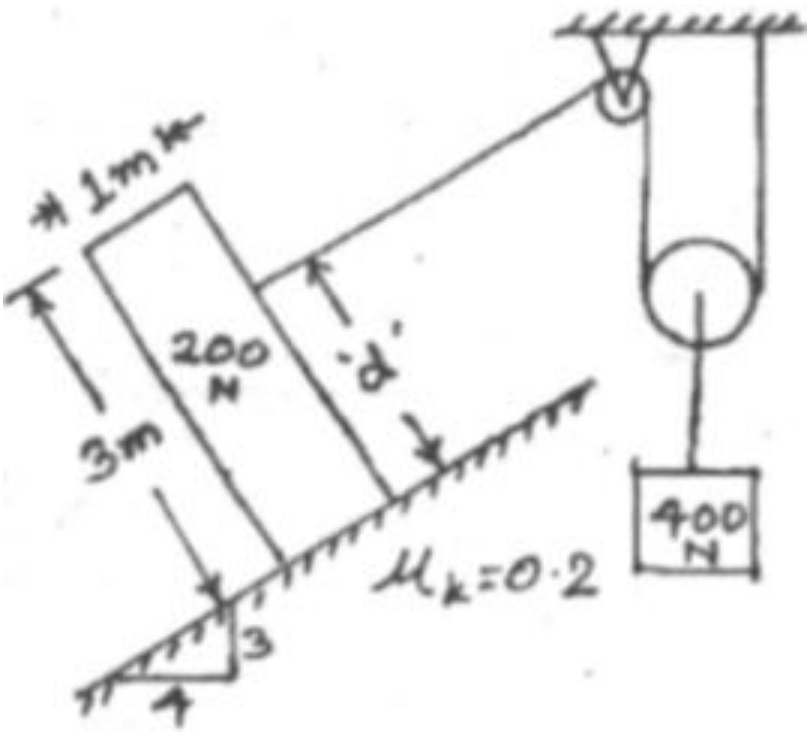

Fig. Q.15

16) Determine the velocity of body B after body A has moved for 10sec starting from rest. Use D'Alembert principle.

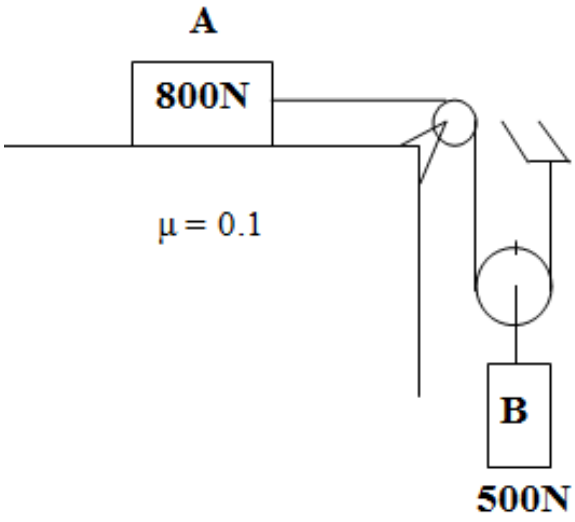

Fig. Q.16

Unit 6

1) Derive work energy equation for translation and rotation.

2) After the block of 200N as shown in figure has moved 4 m from rest constant force P = 150 N is removed. Find the velocity of the block when it returns to its initial position.

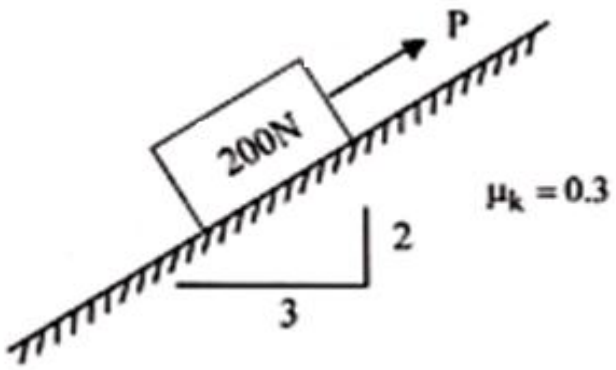

Fig. Q.2

3) Define : **i.** Work. **ii.** Power. **iii.** Energy

iv. Stiffness of spring

4) Determine the constant force P that will give the system of bodies shown in figure a velocity of 3 m/s after moving 4.5 m from rest. The coefficient of friction is 0.2 under every block.

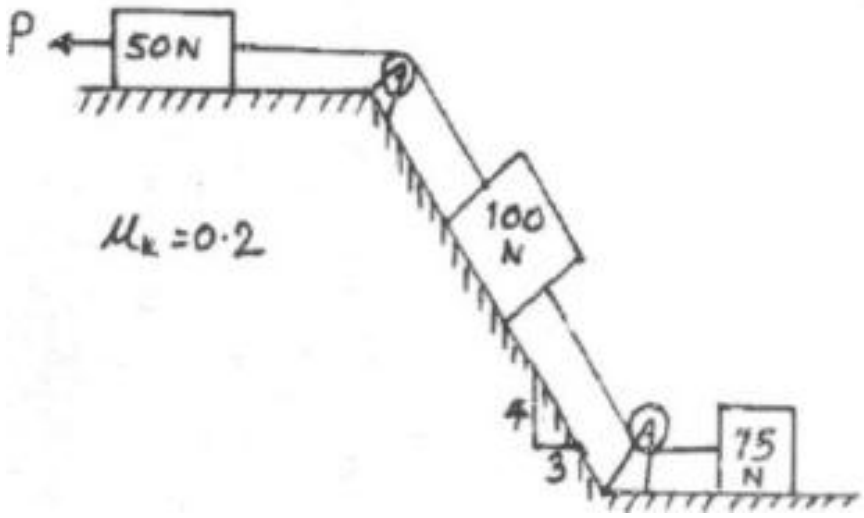

Fig. Q.4

5) The system shown in figure is connected by flexible inextensible cords. If the system starts from rest, find the distance '**d'** between block A and the ground so that the system comes to rest with body B just touching A.

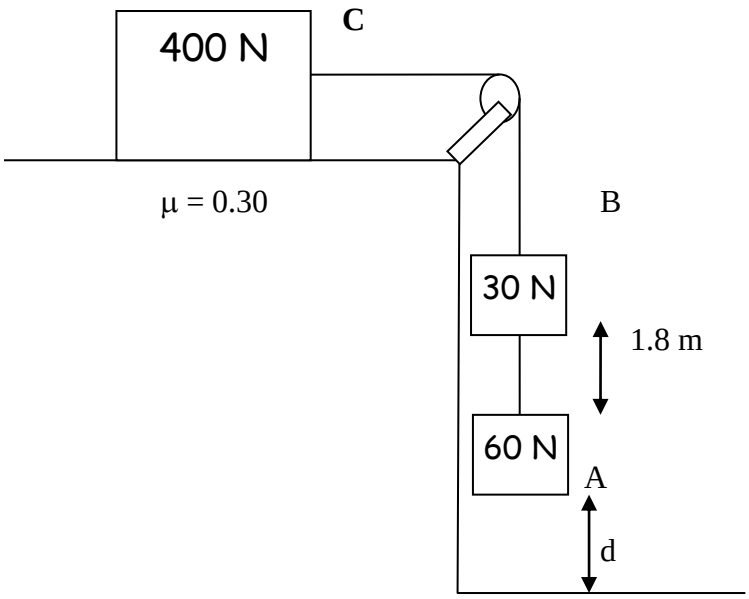

Fig. Q.5

6) A block of mass 100 kg, initially resting at a slide down the plane AB and then up the plane BC. How far will it be up the plane BC. before coming to rest ? Also, find out the velocity of the block at B after sliding down the plane BC.

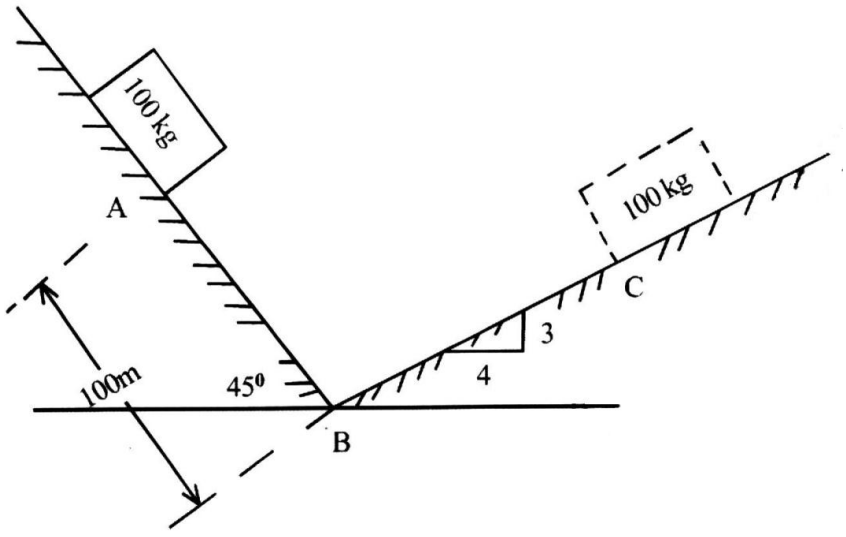

Fig. Q.6

7) A 600 N bock slides down an incline having slope 4 vertical to 3 horizontal. It starts from rest and after moving 1.8 m, strikes a spring. If $\mu = 0.20$, then determine the:

i. Velocity of block with which it strikes the spring.

ii. Maximum deformation of the spring.

iii. Maximum velocity of the block.

(Consider modulus of spring – 4000 N/m).

8) A bullet weighing 0.5 N and moving at 660 m/s penetrates the 10 N body shown in figure and emerges with a velocity of 180 m/s. How far and how long does the body then move?

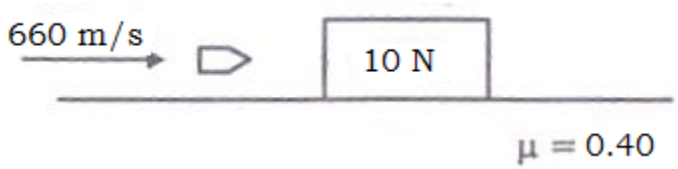

Fig. Q.8

9) The 10 N and 20 N bodies shown in figure are approaching each other with the velocity shown. If e = 0.6 determine velocity of each body directly after impact. [6]

Fig. Q.9

10**)** Define :

i. Direct impact **ii.** Newton's law of Collision

iii. Coefficient of restitution.

11**)** Direct central impact occurs between a 30 N body moving to the right at 1.8 m/s and a body of weight W moving to the left at 1.2 m/s. The coefficient of restitution is e = 0.4. After impact the 30 N body has a leftward velocity of 0.9 m/s. Find the value of W and its velocity after impact.

12) The system shown in fig is moving leftward at a velocity of 4.5m/s when a constant force P is applied. Determine the value of P that will give the system a rightward velocity of 9m/s in a time interval of 10 sec.

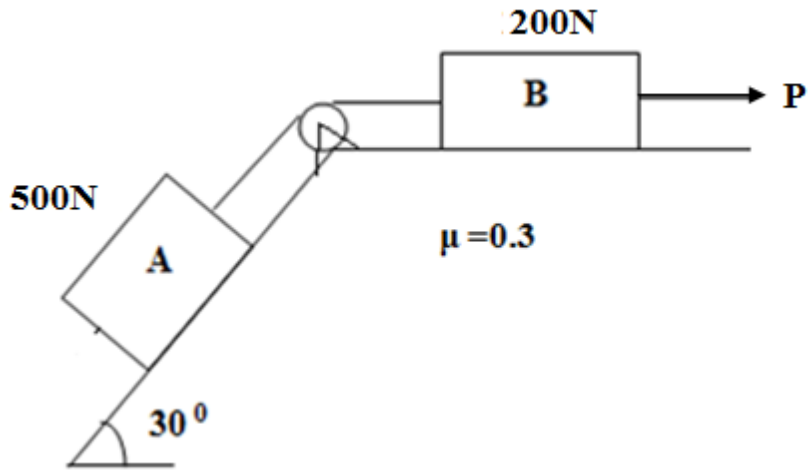

Fig. Q.12

13) Determine the velocity of body A after it has moved 8m starting from rest. Use work energy principle. Assume the pulley to be frictionless.

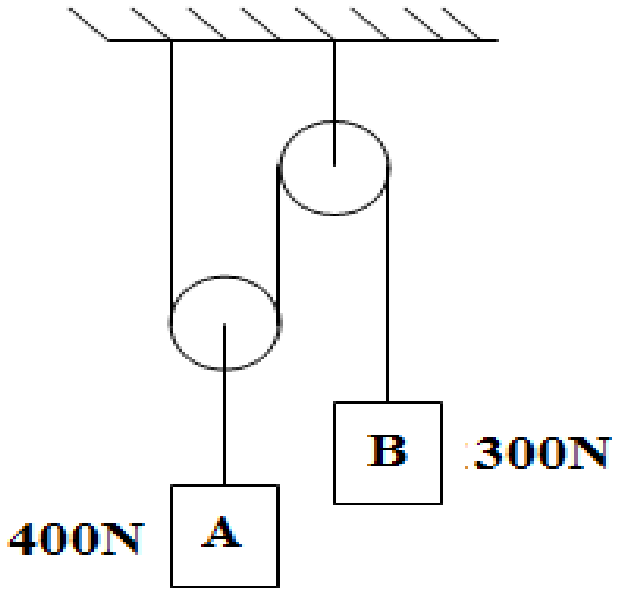

Fig. Q.13

14) Determine the velocity of body A after it has moved 6m starting from rest. Use work energy principle. Assume the pulley to be frictionless.

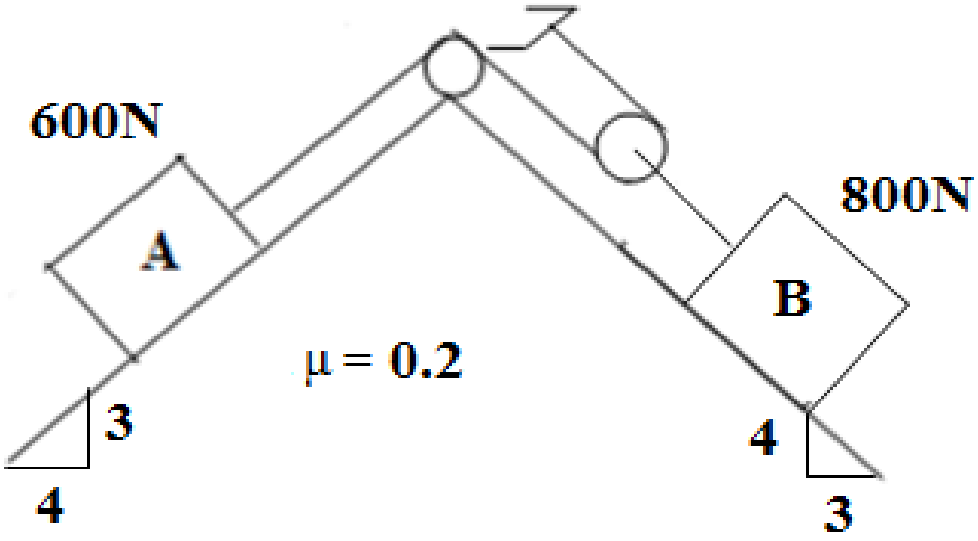

Fig. Q.14

15) A direct central impact occur between 400N body moving to the right with a velocity of 8m/s and a 300N body moving to the left with a velocity of 11m/s . Find the velocities of both bodies after impact if the coefficient of restitution is 0.6. Also determine the average impact force if the impact last for 0.03sec.

16) Determine the constant force P that will give the system of bodies shown in fig a velocity of 3m/s after moving 4.5m from rest.

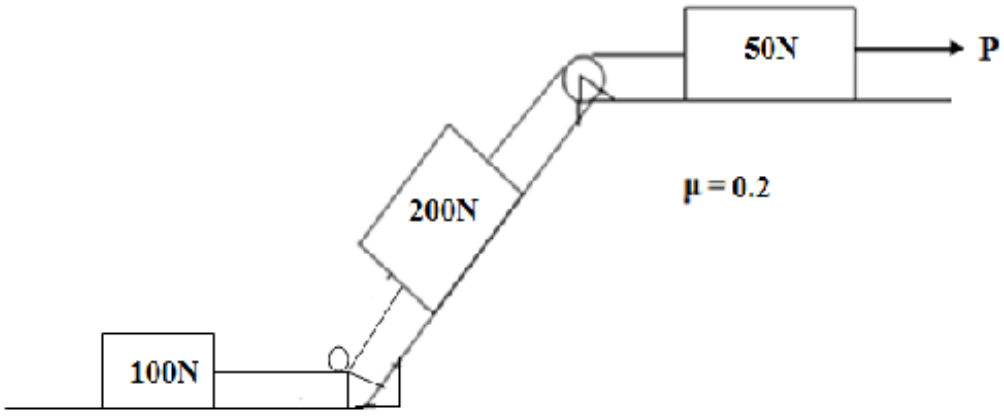

Fig. Q.16

17) A ball is dropped from a height of height of 'h_0' meters on a floor. Show that after first bounce it will rise to height 'h_1' given by $h1 = e^2h_0$, where **e** is coefficient of restitution. Determine the height the ball will rise after 3 bounces, if dropped from the height of 2 m, if the coefficient of restitution is 0.8.

18) Derive Impulse Momentum Equation.

19) State and prove Law of Conservation of Momentum.

20) State and Explain Law of Conservation of energy.