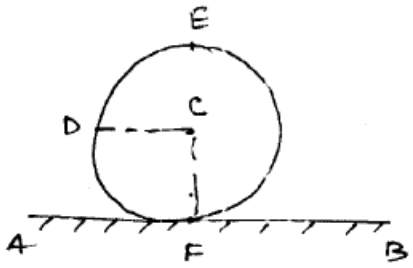
Problems Based on Kinematics of Rigid Body

2006–2007 (Sem. II) (ME202)

1. A cylinder of radius 80 mm rolls without slipping along a horizontal plane *AB*. Its center has a uniform velocity of 15 m/s. Find the velocities of points *D* and *E* on the rim of the cylinder.



2008–2009 (Sem. II) (EME202)

1. What do you understand by the term kinematics? Explain different types of plane motion of rigid bodies with suitable example.

2. A wheel rotates for 5 seconds with constant angular acceleration and describes 100 radians during this time. It then rotates with a constant angular velocity and during the next 5 seconds describes 80 radians. Find the initial angular velocity and the angular acceleration.

2009–2010 (Sem. I) (EME102)

1. A horizontal bar 1.5 m long and of small cross-section rotates about vertical axis through one end. It accelerates uniformly from 1200 rpm to 1500 rpm in an interval of 5 seconds. What is the linear velocity at the beginning and end of the interval? What are the normal and tangential components of acceleration of the mid point of the bar after 5 seconds after the acceleration begins?

2009–2010 (Sem. II) (EME202)

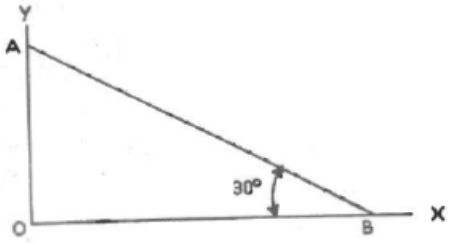
1. The motion of a particle is given by $a = t^3 - 3t^2 + 5$, where a is the acceleration in m/sec^2 and t is the time in seconds. The velocity of the particle at $t = 1$ sec, is 6.25 m/sec, and the displacement is 8.30 meters. Calculate the displacement and the velocity at $t = 2$ sec.

2. A train starts from rest and moves along a curved track of radius 600 m with uniform acceleration until it attains a velocity of 70 km/h at the end of third minute. Determine the tangential, normal and total acceleration of the train at the end of second minute.

2010–2011 (Sem. I) (EME102)

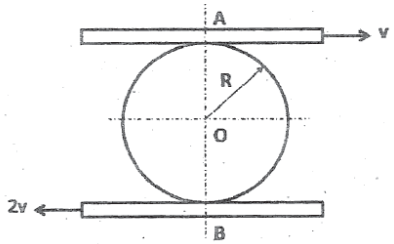
1. The motion of a particle is defined by the relation $x = 6t^4 - 2t^3 - 12t^2 - 3t + 3$. Determine the time, position, velocity and distance travelled when acceleration is zero.

2. A straight rigid link *AB* of length 50 cm is shown in the figure. The end *B* of the link moves along *x*-axis with a velocity of 4 m/s and accelerates with an acceleration of 10 m/s. The end *A* is constrained to move along *y*-axis. Find the velocity and acceleration of the end *A* at the given instant.



2010–2011 (Sem. II) (EME202)

1. A disc of radius R rolls without slipping between two plates A and B. If plates are having velocities V and $2V$ as shown in figure, determine the angular velocity of disc and velocity of center.



2. A passenger train passes a certain station at 60 km/h and covers a distance of 20 km with this speed and then stops at the next station 30 km from the first with uniform deceleration. Another train starting from the first station covers the same distance in double this time and stops at the next station. The second train covers a part of the distance with uniform acceleration and remaining distance with uniform deceleration. Determine the maximum speed of local train.

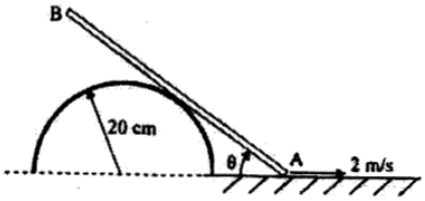
2010–2011 (Sem. II) (EME202) (MTU)

1. What do you understand by the term kinematics? Explain different types of plane motion of rigid bodies with suitable examples.

2011–2012 (Sem. I) (EME102)

1. Explain the relative velocity of a point on the circumference with respect to the center of a wheel rolling without slipping on a horizontal surface.

2. A slender bar AB slides down a circular surface and on a horizontal surface as shown in Fig. At an instant, when $\theta = 45°$, velocity of the end A is 2 m/s. Determine the angular velocity of the bar and the velocity of point of contact on the circular surface.



3. The motion of a particle is defined by the relation $x = 6t^4 - 2t^3 - 12t^2 + 3t + 3$. Determine the time, position and velocity when acceleration is zero.

2011–2012 (Sem. I) (EME102) (MTU)

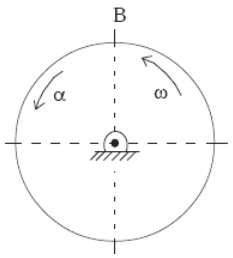
1. Distinguish between relative velocity and resultant velocity.

2. What do you mean by instantaneous centre of rotation? How can it be located for a body moving with combined motion of rotation and translation?

3. A wheel rotating about a fixed axis at 20 rpm is uniformly accelerated for 70 sec. during which it makes 50 revolutions. Find angular velocity at the end of this interval and time required for speed to reach 100 rpm.

2011–2012 (Sem. II) (EME202)

1. The angular acceleration of a circular plate of radius 0.5 m shown in Fig., is defined by $\alpha = \alpha_0 e^{-t}$. At $t = 0$, the plate is at rest and $\alpha_0 = 10$ rad/s^2. Determine magnitude of total acceleration of point B when



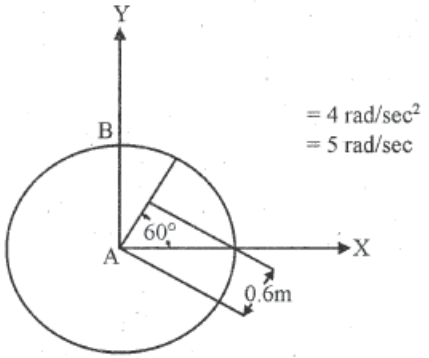
(i) $t = 0$,
(ii) $t = 0.5$ sec,
(iii) $t = \infty$.

2011–2012 (Sem. II) (EME202) (MTU)

1. Define tangential, normal and resultant acceleration of a particle.

2. A grilling wheel is attached to the shaft of an elective motor of rated speed of 1500 rpm. When the power is switched on the unit attains the rated speed in 4 seconds and when power is switched off the unit comes to rest in 75 seconds, assuming uniformly accelerated motion determine the number of revolutions the unit turns to attain the rated speed and to come to rest.

3. A wheel of radius 1.0 m rolls freely with an angular velocity of 5 rad/sec and with an angular acceleration of 4 rad/sec^2, both clockwise as shown in figure determine the velocity and acceleration of points B and D shown in figure.



2012–2013 (Sem. I) (EME102)

1. A particle moves along a path $y = 3x^2$ m. The motion starts at $t = 0$ from origin and projection of the particle on x axis varies as $0.4t^2$. What are the acceleration components in tangential direction and normal to the path at $t = 2$s? What is the velocity of the particle at $t = 2$s?

2012–2013 (Sem. I) (ME101) (MTU)

1. Explain the difference between kinematics and kinetics.

2. What do you mean by general plane motion?

3. A rectilinear motion of motor car starting from rest is governed by the equation $a = 8/1.5\ V + 2$, where a is the acceleration in m/sec^2 and V is velocity in m/sec. at any

instant. Find the distance moved and the time taken by the car to attain a velocity of 8 m/sec.

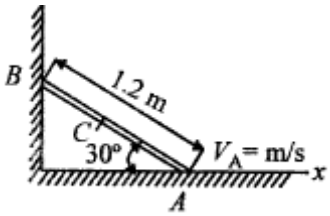
4. Explain plane rectilinear motion of rigid body.
5. Explain plane curvilinear motion of rigid body.

2012–2013 (Sem. I) (EME102) (MTU) [COP]

1. Differentiate between Kinematics and Kinetics.
2. A motorist is driving his car at 90 km/hr. He observes red light 200 m ahead turns red. The traffic light is timed to remain red for 15 sec. If the motorist wishes to pass the light without stopping, find the required minimum acceleration.
3. A wheel rotates for 5 seconds with constant angular acceleration and describes 100 radians during this time. It then rotates with constant angular velocity and during next 5 seconds describes 80 radians. Find initial angular velocity and angular acceleration.

2012–2013 (Sem. II) (ME201) (MTU)

1. A body is moving with a velocity of 4 m/s. After 5 seconds the velocity of the body becomes 10 m/s. Find the acceleration of the body.
2. Write the general equations for curvilinear motion.
3. A car starts from rest and uniformly accelerated to speed of 20 km per hour over a distance of 200 m. Calculate the acceleration and time taken. If further acceleration raises the speed to 50 km per hour in 8 seconds, find the acceleration and the further distance moved.
4. A particle moves along a straight line with variable acceleration. If the displacement is measured in m and given by relations in terms of time taken t, $S = 3t^3 + 2t^2 + 7t + 3$. Determine:
   (i) the velocity of the particle at start and after 3 seconds.
   (ii) the acceleration of the particle at start and after 3 seconds.
5. A bar AB of length 1.2 m slides in xy plane as shown in Fig., the velocity of the point A is 5 m/s towards right. Determine:
   (i) the angular velocity of the bar
   (ii) the velocity of the end B and the velocity of the midpoint of the bar at the instant when the axis of the bar makes an angle of 30° with the horizontal.



6. A train moving at 40 km/hour is hit by a stone thrown at right angles to it with a velocity of 12 km/hr. Find the velocity and the direction with which the stone hit a person travelling in the train.

2013–14 (Sem. I) (NME102)

1. A scooter is travelling on a curved road of radius 25 m at a speed of 45 kmph. Determine the normal and tangential components of acceleration.

2. Acceleration of a particle is defined by $a = 21 - 12s^2$, where a is acceleration in m/s^2 and s is in meters. The particle starts with rest at $s = 0$. Determine (a) velocity when $s = 1.5$ m, (b) the position where velocity is again zero, (c) the position where the velocity is maximum.

2013–14 (Sem. I) (EME102) [COP]

1. Distinguish between relative velocity and resultant velocity.

2. A wheel rotating about a fixed axis at 20 rpm is uniformly accelerated for 70 seconds during which it makes 50 revolutions. Find (i) Angular velocity at the end of this interval and (ii) Time required for the velocity to reach 100 rpm.

2013–14 (Sem. I) (ME101) [COP]

1. What do you understand by relative velocity ?

2. The equation of motion of a particle moving in a straight line is given by:

$$S = 18t + 3t^2 - 2t^3,$$

where S is the total distance covered from the starting point in meters at the end of t seconds. Find out:

(i) velocity and acceleration at the start,

(ii) the time when the particle reaches its maximum velocity.

3. A passenger sitting in a train moving at 54 km/hr is hit by a stone thrown at right angles to it with a velocity of 18 km/hr. Calculate the velocity and the direction with which the stone appears to hit the passenger.

4. A flywheel had an initial angular speed of 3000 rev/min in clockwise direction, when a constant turning moment was applied to the wheel, it got subjected to a uniform anticlockwise angular acceleration of 3 rev/sec^2. Determine the angular velocity of the wheel after 20 seconds, and the total number of revolutions made during this period.

2013–14 (Sem. II) (NME202)

1. A car is travelling at a constant speed of 30 m/s on a curve of 900 m. Determine the tangential and normal components of the acceleration.

2. A stone is dropped in a well and the sound is heard after 10 seconds. If the velocity of the sound is 325 m/s, then find the depth of the well. Take $g = 10$ m/s^2.

3. Acceleration of a ship, moving along a straight course, varies directly as the square of its speed. If the speed drops from 3 m/s to 1.5 m/s in one minute, find the distance moved in this period.

4. A car starts from rest on a curved road of 200 m radius and accelerates at a constant angular acceleration of 0.5 m/s^2. Determine the distance and time which the car will travel before the total acceleration attained by it becomes 0.75 m/s^2.

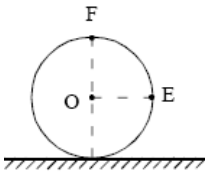
5. An automobile is accelerated at the rate of 0.8 m/s^2 as it travels from station A to station B. If the speed of the automobile is 36 km/h as it passes station A, determine the time required for automobile to reach B and its speed as it passes station B. The distance between A and B is 250 m.

2013–14 (Sem. II) (EME202) [COP]

1. Define instantaneous center of zero velocity.

2. A particle moving along a line has an acceleration given by $a = \sqrt{V}$ where V is the velocity in m/s. At $t = 4$ seconds its velocity is 36 m/s and its displacement is 72 m. Find the displacement and acceleration of particle at $t = 6$ seconds.

3. A cylinder of diameter 1 m rolls without slipping along a horizontal plane AB. Its centre has a uniform velocity of 20 m/sec. Find the velocity of the points E and F on the circumference of the cylinder shown in Figure.

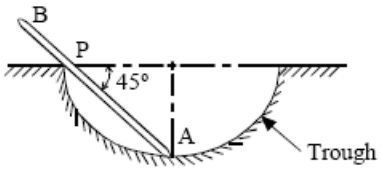


2013–14 (Sem. II) (ME201) [COP]

1. Give two examples of curvilinear motion.

2. If the instantaneous centre of a Rigid body lies at infinity, what will be the relation between velocities at any two points of the body?

3. A bar AB is placed in a semi-circular trough of radius 20 cm and released to slide in it such that at an instant when bar makes an angle 45° with diametral axis, the end A has the velocity of 5 m/s. Determine velocity of sliding of bar at point P.

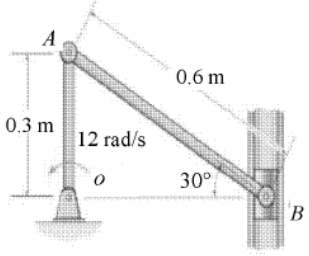


4. A circular disc starts from rest at $\theta = 0$ and accelerates at a rate given by the relation $\alpha = 3t - t^2$, where 'α' is in rad per square seconds and t is time in seconds. Determine the time at which the body comes to a momentary rest before changing the direction of motion. Also determine the angular displacement in this time.

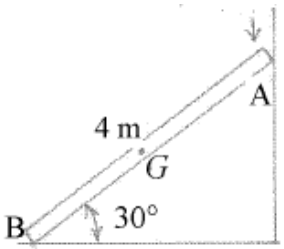
5. A motorist is driving his car at 80 kmph. He observes red light 200 m ahead turn red. The traffic light is timed to remain red for 12 s. If the motorist wishes to pass the light without stopping, find the required minimum acceleration.

2014–15 (Sem. I) (NME102)

1. If crank OA rotates with an angular velocity of $\omega = 12$ rad/s , determine the velocity of piston B and the angular velocity of rod AB at the instant shown in the Fig.



2. At a given instant the 5 kg slender bar has the motion shown in Fig. Determine the angular momentum about point G ($V_A = 2$ m/s).

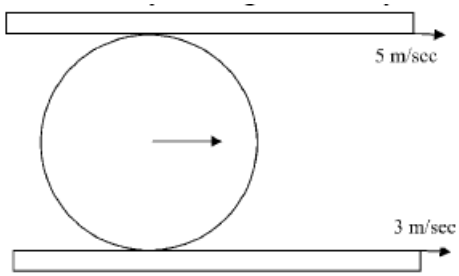


2014–15 (Sem. I) (EME102) [COP]

1. A horizontal bar 1.5 m long and of small cross section rotates about vertical axis through one end. It accelerates uniformly from 1200 rpm to 1500 rpm in an interval of 5 seconds. What is the linear velocity at the beginning and end of the interval? What are normal and tangential components of acceleration of the mid point of the bar after 5 seconds after the acceleration begins?
2. Two ships leave a port at the same time. The first moves in North-West direction at 50 km/hr and second at 35° South of West at 40 km/hr. Find the relative velocity of second ship with respect to first. Also find distance between them after 25 minutes. After what interval of time will they be 40 km apart?
3. A shot is fired at 50°elevation with velocity 100 m/s. Determine the horizontal range, vertical range and radii of curvature at the starting point as well as at highest point.

2014–15 (Sem. I) (ME101) [COP]

1. A car is moving with a velocity of 15 m/sec. The car is brought to rest by applying brakes in 5 seconds. Determine the retardation and distance travelled by the car after applying brakes.
2. What do you mean by instantaneous centre of rotation?
3. A stone is dropped from a height. After falling 5 seconds from rest, the stone breaks the glass pane and in breaking, the stone loses its 20% of its velocity. Find the distance travelled by the stone in the next second. Take $g = 9.81$ m/sec^2.
4. A cylindrical roller, 50 cm in diameter is in contact with two conveyor belts at its top and bottom as shown in figure. If the belts run at the uniform speed of 5 m/sec and 3 m/sec, find linear velocity and angular velocity of roller.



5. Ship *A* is approaching a port in due East direction with a velocity of 15 kmph. When this ship was 50 km from port, ship *B* sails in N45°W direction with a velocity of 25 kmph from the port. After what time the two ships are at minimum distance and how for each has travelled.
6. The initial angular velocity of a rotating body is 2 rad/sec and initial angular acceleration is zero. The rotation of body is according to the relation $\alpha = 3t^2 - 3$. Find (i) the angular velocity and (ii) angular displacement when $t = 5$ seconds. Consider the angular displacements in radians and time in seconds.

2014–15 (Sem. II) (NME202)

1. The equation of motion for motion of a particle is given by $S = 18t + 3t^2 - 2t^3$. Find acceleration and velocity at $t = 2$ sec.
2. A stone is dropped into a well and is heard to strike the water after 4 seconds. Find the depth of the well if the velocity of sound is 350 m/s.

3. Discuss and describe the laws of motion applied to planar translation and rotation.

2014–15 (Sem. II) (EME202) [COP]

1. A particle is moving along a circular path with a constant velocity. What will be its acceleration?

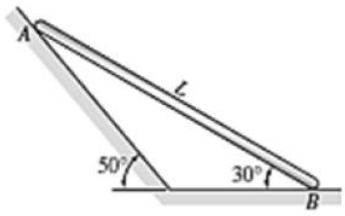
2. The acceleration of a particle is defined by the relation $a = -0.5V$, where a is in mm/s^2 and V in mm/s. If at $t = 0$, the velocity is 25 mm/s, determine (a) the distance the particle will travel before coming to rest, (b) the time required for coming to rest and (c) the time required for the velocity to be reduced to one percent of its initial value.

3. A particle moves along a path $y = 3x^2$ m. The motion starts at $t = 0$ from origin and projection of the particle on x axis varies as $0.4t^2$. What are the acceleration components in tangential direction and normal to the path at $t = 2$s? What is the velocity of the particle at $t = 2$s?

2014–15 (Sem. II) (ME201) [COP]

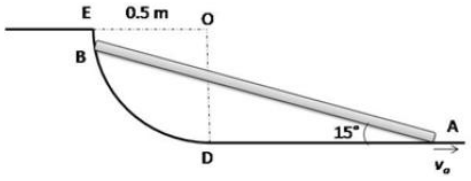
1. Differentiate between kinematics and kinetics.

2. When bar AB is in the position shown, end B is sliding to the right with a velocity 0.8 m/s. If length of the bar is 2 m, determine the velocity of end A in this position.



3. The acceleration of a particle is given by the expression $a = -kx^2$. The particle starts from zero initial velocity at $x = 1$ m and it is observed that its velocity is 5 m/s when $x = 0.5$ m. Find the value of k and the velocity of particle when $x = 0.25$ m.

4. Bar AB shown in figure is 1 meter long. End A moves with a velocity of 5 m/s on horizontal plane. End B follows a quarter circle path ED of radius 0.5 m. Find velocity of B for the given position.



2014–15 (Sem. I) (NME202/NME102/EME202/EME102) [SCOP]

1. What do you mean by types of motion?

2. A flywheel rotates for 5 seconds with constant angular acceleration and describes 90 radians this time. It than rotates with constant angular velocity and during the next 6 seconds describes 80 seconds. Find the initial angular velocity and the angular acceleration.

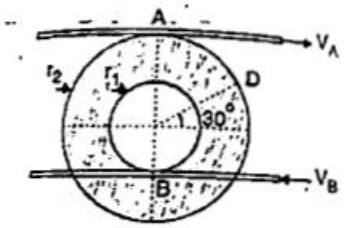
3. The equation of motion of a particle moving in a straight fine is given by: $s = 9t + 7t^2 - 1.5t^3$. where s is the total distance covered from the starting point in meters at the end & time t in seconds. Find the following:

(i) The velocity & acceleration at start.
(ii) The time, when the particle reaches its maximum velocity and
(iii) The maximum velocity of the particle.

2015–16 (Sem. I) (NME102)

1. Write the different types of motion.

2. A compound wheel rolls without slipping between two parallel plates A and B as shown in fig. At the instant A moves to the right with a velocity of 1.2 m/s and B moves to the left with a velocity of 0.6 m/s. Calculate the velocity of center of wheel and the angular velocity of wheel. Take r_1 = 120 mm and r_2 = 360 mm.



3. A wheel that is rotating at 300 rpm attains a speed of 180 rpm after 20 seconds. Determine the acceleration of the flywheel assuming it to be uniform. Also determine the time taken to come to rest from a speed of 300 rpm if the acceleration remains the same and number of revolutions made during this time.

2015–16 (Sem. I) (EME102) [COP]

1. Define General plane motion with suitable example.

2. A sphere, cylinder and hoop is released from the top of a inclined and rolling. What will be the velocity at the end of inclined plane?

2015–16 (Sem. I) (ME101) [COP]

1. A particle moves along a straight line and its motion is represented by the equation $s = 16t + 4t^2 - 3t^3$, where s in meters & t in seconds. Determine: (a) displacement, velocity & acceleration 2 seconds after start, (b) Displacement & acceleration when velocity is zero, (c) Displacement & velocity when acceleration is zero.

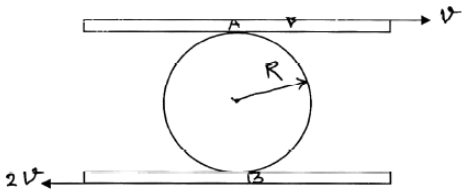
2015–16 (Sem. II) (NME202)

1. The distance covered by a freely falling body in the last 1 second of its motion and that covered in the last but one second are in the ratio of 5 : 4. Calculate the height from which it strikes the ground.

2015–16 (Sem. II) (ME201) [COP]

1. A stone is dropped from the top of a tower 40 m height. At the same instant, another stone is thrown upward from the foot of tower with an initial velocity of 20 m/s. At what distance from the top and after how much time the two stones cross each other? Further proceed to calculate the relative velocity with which the stones cross.

2. A disc of radius R roll without slipping between two plates A and B. If plates are having velocities V and $2V$ as shown in fig. Determine the angular velocity of disc and velocity of centre of disc.



2016–17 (Sem. II) (NME202/EME202/ME201) [COP]

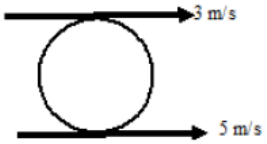
1. A ball is dropped from the top of a tower 30 m high. At the same instant a second ball is thrown upward from the ground with an initial velocity of 15 m/sec. When and where do they cross and with what relative velocity?

2017–18 (Sem. I) (NME102/EME102) [COP]

1. A fly wheel makes 100 rev from a velocity 120 rpm to 160 rpm. Find the acceleration and time taken. Also find the total number of revolution if the fly wheel started from rest.
2. Acceleration of a particle is given by $a = 10 - x$. Particle starts from rest at $x = 0$, $V = 0$. Find the position when velocity is zero and the velocity when acceleration is zero.

2017–18 (Sem. II) (NME202) [COP]

1. A particle starting from rest moves in a straight line whose acceleration is given by relation $a = 10 - 0.006s^2$, where a is in m/ s^2 and s is in m. Determine:
   (i) Velocity of the particle when it has travelled 50 m.
   (ii) Distance travelled by the particle when it comes to rest.
2. A cylinder roller 50 cm in diameter is in contact with two conveyor belts at its top and bottom as shown in figure. If the belts run at uniform speed of 5 m/s and 3 m/s. Find the linear velocity and angular velocity of the roller.



2017–18 (Sem. II) (EME202) [COP]

1. A shaft rotating at 50 rpm about a fixed axis accelerates to 850 rpm in 22 sec. Determine the average angular acceleration.
2. Why does a cyclist tilt inward while negotiating a curved path? A train weighing 4500 kN of weight. Determine the steady pull that the locomotive must exert if the speed of the train is to be increased from 15 km/h to 60 km/h within a period of 3 minutes.

2018–19 (Sem. I) (NME102/EME102) [COP]

1. Differentiate between resultant and relative velocity.
2. A sphere, cylinder and hoop is released from the top of an inclined and rolling. What will be the velocity at the end of inclined plane.
3. A horizontal bar 1.5 m long and of small cross section rotates about vertical axis through one end. It accelerates uniformly from 1200 rpm to 1500 rpm in an interval of 5 seconds. What is the linear velocity at the beginning and the end of interval.

What are the normal and tangential components of acceleration of the mid point of the bar after 5 seconds.

2018–19 (Sem. II) (NME202/EME202) [COP]

1. A particle moves along a straight line and its motion is represented by the equation

$$s = 16t + 4t^2 - 3t^3,$$

where s is in meter and t is in seconds. Determine:

(i) Displacement, velocity and acceleration 2 seconds after start.

(ii) Displacement and acceleration when velocity is zero.

(iii) Displacement and velocity when acceleration is zero.

2. A passenger sitting in a train moving at 54 km/hr is hit by a stone thrown at right angles to it with a velocity of 18 km/hr. calculate the velocity and direction with which the stone appears to hit the passenger.

2019–20 (Sem. I) (NME102/EME102) [COP]

1. A particle moves along a straight line and its motion is represented by the equation

$$s = 16t + 4t^2 - 3t^3,$$

where s is in meter and t is in seconds. Determine:

(i) Displacement, velocity and acceleration 2 seconds after start.

(ii) Displacement and acceleration when velocity is zero.

(iii) Displacement and velocity when acceleration is zero.

2. A passenger sitting in a train moving at 54 km/hr is hit by a stone thrown at right angles to it with a velocity of 18 km/hr. calculate the velocity and direction with which the stone appears to hit the passenger.