THEORY OF MACHINE AND MECHANISM II

TUTORIAL NO: 3

GYROSCOPIC EFFECT

1. A flywheel of mass 10 kg and radius of gyration 200 mm is spinning about its axis, which is horizontal and is suspended at a point distant 150 mm from the plane of rotation of the flywheel. Determine the angular velocity of precession of the flywheel. The spin speed of flywheel is 900 r.p.m.

2. A horizontal axle *AB*, 1 m long, is pivoted at the midpoint *C*. It carries a weight of 20 N at *A* and a wheel weighing 50 N at *B*. The wheel is made to spin at a speed of 600 r.p.m in a clockwise direction looking from its front. Assuming that the weight of the flywheel is uniformly distributed around the rim whose mean diameter is 0.6 m, calculate the angular velocity of precession of the system around the vertical axis through *C*.

3. A flywheel is carried on a shaft mounted in two bearings A and B 900 mm apart. The flywheel which has a mass of 5 kg and radius of gyration of 300 mm is fixed 300 mm from A and 600 mm from B. Viewed from bearing A the flywheel is revolving in a clockwise direction at 3000 rpm about its own axis. The two bearings are in the same horizontal plane and are supported by thin flexible cords. If the cord supporting bearing A is cut. Describe the motion of the flywheel and the shaft, in magnitude and direction that follows immediately after cutting the cord.

4. An aeroplane makes a complete half circle of 60 metres radius, towards left, when flying at 250 km per hr. The rotary engine and the propeller of the plane has a mass of 450 kg and a radius of gyration of 0.3 m. The engine rotates at 2400 r.p.m. clockwise when viewed from the rear. Find the gyroscopic couple on the aircraft.

5. A four-wheeled trolley car of mass 2500 kg runs on rails, which are 1.5 m apart and travels around a curve of 30 m radius at 24 km / hr. The rails are at the same level. Each wheel of the trolley is 0.75 m in diameter and each of the two axles is driven by a motor running in a direction opposite to that of the wheels at a speed of five times the speed of rotation of the wheels. The moment of inertia of each axle with gear and wheels is 18 kg-m^2. Each motor with shaft and gear pinion has a moment of inertia of 12 kg-m^2. The centre of gravity of the car is 0.9 m above the rail level. Determine the vertical force exerted by each wheel on the rails taking into consideration the centrifugal and gyroscopic effects. State the centrifugal and gyroscopic effects on the trolley.

6. A rail car has a total mass of 4000 kg. The moment of inertia of each wheel together with gearing is 20 kg m^2. The center distance between two wheels on an axle is 1.5 m and each wheel has 400 mm radius. Each axle is driven by a motor, the speed ratio between the two being 3.Each motor with its gear has a moment of inertia of 15 kg m^2 and runs in a direction opposite to that of the axle. The center of gravity of the car is 1 m above the rails. Determine the limiting speed for the car when moving on a curve of 250 m radius such that no wheel leaves the rails.

7. The moment of inertia of each wheel of a motorcycle is 1.5 kg m^2. The rotating parts of the engine of the motor cycle have a moment of inertia of 0.28 kg m^2. The speed of the engine is six times the speed of the wheels and is in the same direction. The mass of the motor cycle is 250

kg and its center of gravity is 0.6 m above the ground level. Find the angle of heel if the motor cycle is travelling at 45 km/h and is taking a turn of 30 m radius. The wheel diameter is 0.6 m.

8. A two wheeler motor vehicle and its rider weigh 225 kg and their combined center of gravity is 600 mm above the ground level, when the vehicle is upright. Each road wheel is of 600 mm diameter and has a moment of inertia of 1 kg m^2. The rotating parts of the engine have a moment of inertia of 0.175 kg m^2. The engine rotates at 5.5 times the speed of the road wheels and in the same sense. Determine the angle of heel necessary, when the vehicle is rounding a curve of 30 m radius at a speed of 55 km/h.

Programming Assignments

9. Develop the program to solve Problem No 5. Then Study the effect of velocity of the vehicle on the reactions.
10. Develop the program to solve Problem No 6. Then Study the effect of radius on the limiting velocity of the vehicle.

ANSWERS

1.	0.39033 rad/s	**2.**	0.5204 rad/s	**3.**	0.2082 rad/s
4.	11780.972 Nm	**5.**	7131.74 kN, 5130.76 kN	**6.**	113.3 km/h
7.	30.38^0	**8.**	40.402^0		