Department of Mechanical, Materials and Manufacturing Engineering

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MACHINE DYNAMICS

SHEET 1: REVISION OF PARTICLE KINEMATICS

1. A projectile is fired at a target 200 m away horizontally at an angle of 30° to the horizontal. Calculate the initial velocity required to hit the target and the time taken to reach the target.

Answer: [47.57 m/s, 4.855 s]

2. A particle moves on a circular path at a constant radius *R* about a fixed point O with a fixed angular velocity ω. Using a polar coordinate system, find the expressions for the velocity and acceleration of the particle. What is the magnitude of velocity and acceleration if *R*=10 m, and ω=2 rad/s?

Answer: [$\underline{v} = R\omega \underline{e}_\theta$; $\underline{a} = -R\omega^2 \underline{e}_r$; *v*=20 m/s; *a*=40 m/s^2]

3. The position vector of a particle at time *t* is r=(3*t*+1)*i*+2t^2*j* (*r* measured in metres) with *i* and *j* the unit vectors in the horizontal and vertical directions. Find the initial position vector and show that the acceleration is constant.

4. A particle moves such that at time *t:*

$$\dot{r} = 4ti + 5t^2 j$$

At time t=0 the particle has a position vector r=5*i* – 6***j*.** Find the position vector at the general case of time *t.*

Answer: $$r = (2t^2 + 5)i + \left(\frac{5}{3}t^3 - 6\right)j$$

5. A remote control car is being tested in a horizontal playground. At time t seconds, the position vector, r (in metres), of the car relative to a fixed point O is given by

$$r = \frac{9}{2}t^2 i + \frac{8}{5}t^{\frac{5}{2}} j$$

At the instant when t = 4s,

a) Show that the car is moving with velocity $(36i + 32j)\,\mathrm{ms}^{-1}$.

b) Find the magnitude of the acceleration of the car.

Answer: [b) 15 ms^{-2}]

6. A motorist is traveling on a curved section of highway of radius r=750m with the speed of 90 km/h. The motorist suddenly applies the brakes, causing the automobile to slow down at a constant rate. Knowing that after t=8s the speed has been reduced to 72 km/h, determine the magnitude of the acceleration of the automobile immediately after the brakes have been applied. Tip: Work in polar coordinates.

Answer: [1.041 $\mathrm{m/s}^2$]