NPTEL online course
Indian Institute of Technology Kharagpur
Classical Mechanics
Assignment 1: Simple kinematics problems and Motion under resistive medium

1. A particle moves in a straight line such that its velocity (v) is given by
   $v^2 = \mu(\frac{a}{x} - 1)$,
   where x is the distance from a fixed point. The acceleration is
   (i) $\propto \frac{1}{x}$ and away from the fixed point,
   (ii) $\propto -\frac{1}{x}$ and towards the fixed point,
   (iii) $\propto \frac{1}{x^2}$ and away from the fixed point,
   (iv) $\propto -\frac{1}{x^2}$ and towards the fixed point.

2. If $x = 30t - 2t^2$, where x is the distance in cm. and t is the time in seconds, then the average velocity from $t = 5sec$ to $t = 5.01sec$ will be
   (i) 8.00 cm/s
   (ii) 9.00 cm/s
   (iii) 9.98 cm/s
   (iv) 0 cm/s.

3. A particle is moving in a straight line subject to a resistance which produces a deceleration of kv^3, where v is the velocity and k is a constant. The velocity v is (in terms of distance x)
   (i) $\frac{mu}{m+kxu}$
   (ii) $\frac{mk}{m+kxu}$
   (iii) $\frac{mx}{m+kxu}$
   (iv) $\frac{1}{1+kxu}$.

4. A particle is moving once around a circle C in the xy-plane. If the circle has centre at origin and radius 3 and if force field is given by

$$\vec{F} = (2x - y + z)\hat{i} + (x + y - z^2)\hat{j} + (3x - 2y + 4z)\hat{k},$$

   The work done by the particle will be
   (i) 0
   (ii) π
   (iii) 18π
   (iv) $\frac{\pi}{2}$

5. If $\vec{F} = (2xy + z^3)\hat{i} + x^2\hat{j} + 3xz^2\hat{k}$ is a conservative force field.
   The potential function $V(x, y, z)$ can be written as

(i) $-x^2y - xz^3 + const.$
(ii) $-x^2y + const.$
(iii) $-xz^3 + const.$
(iv) $-2x^2y - 2xz^3 + const.$

6. A particle of mass 2 moves in the xy-plane under the influence of a force field having potential $V = x^2 + y^2$. The particle starts at a time $t = 0$ from rest at the point (2,1). The values of $x(t)$ and $y(t)$ will be
(i) $cost$ and $2cost$
(ii) $2cost$ and $sint$
(iii) $cost$ and $2sint$
(iv) $2cost$ and $cost$.

7. A particle is attracted towards a fixed point with a force $F(x) \propto \frac{1}{x^3}$, where x is the distance from the fixed point. Find an expression for the work done for a displacement of a to b $(a < b)$. The P.E. gained by the particle is
(i) $-\frac{1}{2}\mu[\frac{1}{a^2} - \frac{1}{b^2}]$
(ii) $-\frac{1}{2}\mu[\frac{1}{b^2} - \frac{1}{a^2}]$
(iii) $-\frac{1}{2}\mu[\frac{1}{a^2} + \frac{1}{b^2}]$
(iv) $\frac{1}{2}\mu[\frac{1}{a^2} + \frac{1}{b^2}]$

8. A particle is thrown upward with speed V. If the air resistance be assumed to vary as the square of the speed and to equal gravitational pool at a speed U (i.e. at the point where the net force on the particle is zero), the particle will rise for a time
(i) $t_f = (\frac{U}{g})tan^{-1}(\frac{V}{U})$
(ii) $t_f = (\frac{V}{g})tan^{-1}(\frac{V}{U})$
(iii) $t_f = (\frac{U}{g})tan^{-1}(\frac{U}{V})$
(iv)$t_f = (\frac{g}{U})tan^{-1}(\frac{V}{U})$

9. A steel ball ($\rho = 7.8 \times 10^3\ kg/m^3$)of radius $r = 2mm$ is falling through glycerine ($\eta = 0.83\ Pa.s$, $\sigma = 1.2 \times 10^3\ kg/m^3$). Its terminal velocity will be
(i) 0.01 m/s
(ii) 0.05 m/s
(iii) 0.07 m/s
(iv) 1.00 m/s

10. A particle is projected vertically upward with initial speed equal to $tan\alpha$ times the terminal speed, the resistance being proportional to the square of the speed. The particle hits the ground with speed
(i) $tan\alpha$ times the terminal speed

(ii) $sin\alpha$ times the terminal speed
(iii) $cos\alpha$ times the terminal speed
(iv) zero.

End