Universidad Rey Juan Carlos	**Physics** **Biomedical Engineering** **Course 2020 - 2021**	**Problem Sheet 2** **Kinematics**

1. The motion of a particle in *XY* plane is **r(t)**=(1+cos 2t, 2+sin2t), SI units. a) Find the velocity **v(t)** and the acceleration **a(t)**. b) Find the value for **v(1)** and **a(1)**. c) Find the intrinsic components of the acceleration, $\vec{a_t}(t)$ and $\vec{a_n}(t)$. d) Determine the trajectory of the particle.

Ans: a) v(t)=(-2sin2t,2cos2t), a(t)=(-4cos2t,-4sin2t); b) $\vec{v}(1)=(-1{,}819,-0{,}832)$ m/s**;** $\vec{a}(1)=(1{,}67;3{,}64)$ m/s^2; c) $\vec{a_t}(t)=0$; $\vec{a_n}(t)=\vec{a}(t)$ (m/s^2); $(x-1)^2+(y-2)^2=1$ ≡A circumference with radius 1 m and center in point (1, 2)

2. The components of the position vector of a body moving in the XY plane are: x = 16t + 2t^2, y = 18t – 1,5t^2, SI units. At t = 1 s, calculate: a) Cartesian coordinates and intrinsic components of the acceleration. b) The unit vectors $\mathbf{u_t}$ and $\mathbf{u_n}$, showing that they are perpendicular to each other. c) The position of the center of curvature.
Ans.: a) a_x = 4 m/s^2; a_y = –3 m/s^2; a_t = 1,4 m/s^2; a_n = 4,8 m/s^2; b) u_t = (0,8, 0,6); u_n = (0,6, –0,8); c) C.C: x = 96,12 m, y = –87,67 m

3. A particle is moving in XY plane with a_x = 0, a_y = 5 *m/s*^{2}. At *t* = 0 the position is *x* = 0, *y* = 8 *m*, and the velocity is v_x = 5, v_y = 0 *m/s*. Determine: a) The law of motion $\vec{r}(t)$; b) the equation of the trajectory; c) the intrinsic components of the acceleration at *t* = 1 s. **Ans.:** $r(t)=(5t,\quad 8+5/2\cdot t^2)$; $y=\ 8+x^2/10$; $a_t(1)=5\big/\sqrt{2}\ \ ms^{-2}$; $a_n(1)=5\big/\sqrt{2}\ \ ms^{-2}$.

4. An iron sphere is dropped and allowed to fall freely from a balcony. It takes to it 0,10 s for going through the last meter. a) What is the initial height? b) What is the final speed? **Ans**.: a) 5,5 m; b) 10,5 m/s

5. A stone is thrown vertically upwards and is 10 s in the air. Neglecting the air resistance and taking g = 10 m/s^2, calculate the initial throwing speed and the maximum height the stone reaches. **Ans**.: 50 m/s; 125 m.

6. A child throws horizontally a ball from a balcony at height y_0 , with an initial speed v_0. At the same instant, another child on the street throws another ball vertically with speed $2v_0$, from a point located at distance *d* from the first building. Find the value of *d* for making the balls to collide to each other. **Ans**.: d = y_0/2

7. When a stone is thrown with speed v_0 at an angle α, it hits the ground at a distance of 50 m (neglecting the air resistance). If the same stone is thrown at the same angle but with speed $2v_0$, which is the range? **Ans**.: 200 m

8. A ball is thrown vertically upwards with an initial speed of 20 *m/s* from the roof of a building 50 *m* tall. The ball is pushed by the wind, with an horizontal acceleration of 2 *m/s*^{2}. Taking *g* = 10 *m/s*^{2}, calculate: a) Horizontal distance between the initial point and the point of impact. b) Maximum height. c) Intrinsic components of the acceleration when the ball reaches 60 *m* above ground the first time. **Ans**: a) 32,97 m; b) 70 m; c) a_t = - 9,02 m/s^2; a_n = 4,32 m/s^2.

9. William Tell aims to the apple atop his son's head, at a distance *d* and 50 *cm* below from shooting position. The initial speed of the arrow is 50 *m/s*, with an angle 30º. The wind produces an horizontal acceleration of 2 *m/s*^{2} , braking the arrow. Taking *g* = 10 *m/s*^{2}, calculate: a) Horizontal distance *d* required for the arrow to go through the apple; b) Maximum height the arrow reaches, as measured from point of shooting. **Ans**: a) 192,4 m; b) 31,3 m

10. See figure. A body is thrown from a point P in the slope (22º) of a hill. The initial speed is v_0 = 150 m/s, forming an angle of 31º with respect to the mountainside (see figure). Calculate the flight time, the distance from P when it hits the ground and the