| Universidad Rey Juan Carlos | **Physics**<br>**Biomedical Engineering**<br>**Course 2020 - 2021** | **Problem Sheet 3**<br>**Particle Dynamics** |
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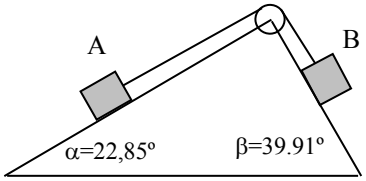
**1.** A body starts to move upwards on an inclined plane (ramp with angle α) with initial velocity $v_0$. If the friction coefficient is $\mu$, determine the distance covered before stopping. What will be the speed of the body when it returns (if it does) to the base of the plane?

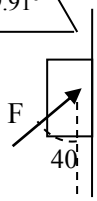
**Ans:** $s = \dfrac{v_0^2}{2(\mu\cos\alpha + sen\alpha)g}$ ; $v^2 = v_0^2 \dfrac{tg\alpha - \mu}{tg\alpha + \mu}$

**2.** A sled on the snow carrying two children is pulled by a rope forming an angle of 40º with respect horizontal. The mass of the two children (together) is 45 kg, and the mass of the sled is 5 kg. The static and kinetic friction coefficients are $\mu_s = 0{,}2$ and $\mu_k = 0{,}15$, respectively. Determine the friction force on the sled and the acceleration of the whole system when the tension of the rope is: a) 100 N, b) 140 N. **Ans**.: a) $F_f$ = 76,6 N; at rest; b) $F_f$ = 60,1 N; a = 0,94 m/s$^2$.

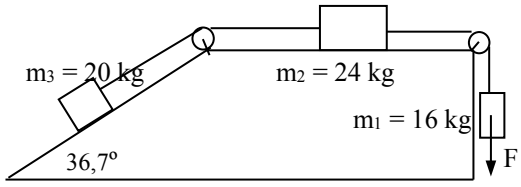
**3.** The bodies A and B have equal mass, m = 1 kg, and equal kinetic friction coefficient μ. They are tied together with a rope (negligible mass), and move from left to right at constant speed. Taking g = 9,84 m/s2. (a) Calculate the tension of the rope and the friction coefficient μ. (b) If we cut the rope, what is the acceleration of each body? (c) If A stops *after* 0,61 s we have cut the rope, what is the distance that B has covered during that time interval? **Ans**.: a) 5,2 N, μ = 0,15; b) –5,2 m/s$^2$ and 5,2 m/s$^2$; c) 2,9 m




**4**. The weight of the body of the figure is 88,9 N. The static friction coefficient between the body and the wall is 0,560. (a) What is the minimum force F required for keeping the body at rest? (b) What is the minimum force F required for moving it upwards? **Ans**.: a) 78,95 N;
b) 218,97 N




**5.** The two bodies in the figure are tied together with ropes and pulleys of negligible mass. The friction coefficient for bodies 2 and 3 is 0,2. The bodies were at rest, but once we pull body 1 with force F, the body 1 goes downwards with an acceleration a=1,5 m/s$^2$. a) Determine the value of F and tension T. b) If the force F only pulls for 1s, calculate the speed of the bodies 1,5 s once after the force is not pulling anymore. **Ans**: a) F = 90 N; $T_{1\text{-}2}$ = 266 N; $T_{2\text{-}3}$ = 1825 N; b) v = 0,5 m/s




**6.** A bucket containing water rotates in a vertical plane within a circle of Radius 1 m. Mass of water is 2 kg, mass of bucket is negligible. The speed of the bucket in the upper part of the circular trajectory is $v_a$. Determine the minimum value of $v_a$ for avoiding the water to fall down. **Ans**: $v_{a\,min}$ = 3,130 *m/s*

**7**. A particle of mass *m* is suspended from a rope of length L, moving at constant speed *v,* following a horizontal circle of radius *r*. The rope forms an angle $\theta$, with sen$\theta$ = r/L. Calculate the tension of the rope and the particle speed. **Ans.**: T = mg/cosθ ; v$^2$ = g r tgθ

**8.** A section of a road has a superelevation that allows a car moving at 30 km/h turning around a curve with radius 400 m without sliding (friction is neglected). Determine the interval of speeds that allow driving without sliding when the static friction coefficient is 1. **Ans**: $v_{min}$ = 0; $v_{max}$ = 230 km/h

**9.** A mass *m* hangs from the roof of a car with a rope of length 30 cm. Determine the angle of the rope with the vertical, and the direction of displacement of the rope, when: a) the car moves straight forward with speed 110 km/h; b) turns around a curve 500 m radius, at 90 km/h; c) moves at 90 km/h straight forward, brakes and stops once it has covered 125 m. **Ans**.: a) 0º; b) 7,27º pointing outside the curve; c) 17,7º pointing ahead.

**10.** A parachutist with mass=70 kg jumps from a plane at an altitude of 2000 m. When the parachute opens, a braking friction force appears, $F_r = kv^2$ , k averaged to be 0,31 (it depends on air density and parachute area). Calculate the terminal speed and the altitude at which the parachute must be opened for having a speed profile like the one showed in the figure. **Ans**.: $v_{limite}$ = 47,04 m/s; h = 1887 m