SJPO Training
Calculus in Physics

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Differentiation and Differential Equations

1. A nuclear fission reaction occurs when a neutron collides and joins with an atomic nucleus, causing the new nucleus to be energetically unstable. Neutrons, smaller daughter nuclei and energy are released as products of the nuclear reaction. Can a chain reaction be sustained if there are many more daughter nuclei than neutrons? What will happen to the reaction if there are fewer daughter nuclei than neutrons and some some of the neutrons escape the reacting system?

2. Imagine a rocket at rest in space with no forces exerted on it. However, as soon as its engine is started (clock set to 0), the rocket is expelling gas mass at a constant mass flow rate M $\left(\mathrm{kg\,s^{-1}}\right)$ and at exhaust velocity relative to the rocket v_e $\left(\mathrm{m\,s^{-1}}\right)$ Find an equation which relates the velocity of the rocket with mass of the rocket?

Integration

1. For a sphere of density ρ tho and radius R, integrate the infinitesimal mass elements to find the mass of the sphere when:

    (a) ρ is constant

    (b) ρ is proportional to R

    (c) ρ is inversely proportional to R

2. A block of mass M sliding down slope of angle θ and coefficient of friction μ_k is proportional to time. Find the equation describing the velocity of the block as a function of time?

    Some variants: what's the behaviour of the block for different constant coefficient of friction? What if the coefficient of friction is proportional to the slant distance?

3. Calculate the moments of inertia I using $\mathrm{d}I = r^2\,\mathrm{d}m$. The mass is evenly distributed in the objects below:

    (a) A stick of mass M and length L at the centre.

    (b) The same but at one end.

    (c) A flat disc at the centre.

4. A metal sphere of mass M is falling through a viscous fluid and it experiences a drag force, b, which is proportional to its velocity. Find the equation which describes the motion of the sphere.