2.1 *Alternative definition of a tensor*

Show that a two-dimensional matrix, $\mathbf{T}$, is qualified to be called a second-order tensor if $\mathbf{u}(\mathbf{x}) = \mathbf{T}(\mathbf{x}) \cdot \mathbf{x}$ transforms like a vector.

2.2 *Spiral path*

A particle is moving in the xy plane on a spiral path described in plane polar coordinates (r, θ) by the equation $r = a\mathrm{e}^{\theta}$, where a is a constant and $\theta = \Theta(t)$. Compute the particle acceleration in terms of the function $\Theta(t)$.

2.3 *Fluid parcel properties*

Show that for a general scalar, vectorial, or tensorial intensive variable, $\mathcal{F}$,

$$\frac{\mathrm{d}}{\mathrm{d}t} \iiint_{Parcel} \mathcal{F}\rho \, \mathrm{d}V(\mathbf{X}) = \frac{\mathrm{d}}{\mathrm{d}t} \iiint_{\boldsymbol{\mathcal{A}}} \mathcal{F}\rho\mathcal{J} \, \mathrm{d}V(\mathbf{a}) = \iiint_{Parcel} \rho \frac{\mathrm{D}\mathcal{F}}{\mathrm{D}t} \, \mathrm{d}V(\mathbf{X}).$$

2.4 *Evolution of the unit vector normal to a material surface*

Derive an evolution equation for the rate of change of the unit normal vector following a point particle on a material surface.