Equation of fluid statics

$$\frac{\partial}{\partial t} = 0, \quad \mathbf{u} = \mathbf{0} \text{ so } \boldsymbol{\nabla} p = \rho \mathbf{F}.$$

z comp.

$$\frac{dp}{dz} = -\rho g \text{ (body force)}$$

Modelling atmospheres, fluids in tanks, canals etc.

Acoustic wave equation

Euler (Navier–Stokes for inviscid, compressible fluid) + continuity + expansions in p and ρ

$\Longrightarrow \dfrac{\partial^2 u}{\partial x^2} = \dfrac{1}{c^2}\dfrac{\partial^2 u}{\partial t^2}$,

where $c^2 = \left(\dfrac{\partial p}{\partial \rho}\right)$.

Modelling waves in a gas – sound waves.

Other possible answers could examine the Navier–Stokes equation term by term, for example,

steady flow	$\dfrac{\partial \mathbf{u}}{\partial t}$ terms zero,
linear flow	$(\mathbf{u} \cdot \boldsymbol{\nabla})\, \mathbf{u}$ terms zero,
no body forces	$\rho \mathbf{F}$ terms zero,
inviscid	$\nabla^2 \mathbf{u}$ terms zero,

and explain that, in general, the equation is the expression of linear momentum balance (Newton's Second Law) for fluids.

Other answers may indicate that equations can be made dimensionless and consider high and low Re flow.
$Re >> 1$ – inviscid flow – except in boundary layers. (Handbook, page 24)
$Re << 1$ – creeping motion.

[20]

Question 8

(i) $\mathbf{v} = (2xz + y + 2x)\mathbf{i} + (x + 2y)\mathbf{j} + x^2\mathbf{k}$, so

$$\oint_C \mathbf{v} \cdot d\mathbf{r} = \int_{\substack{C_1:\ x=\alpha \\ 0\le\alpha\le1 \\ y=z=0}} \mathbf{v} \cdot d\mathbf{r} + \int_{\substack{C_2:\ x=1 \\ y=z=\beta \\ 0\le\beta\le1}} \mathbf{v} \cdot d\mathbf{r} + \int_{\substack{C_3:\ x=y=z=\gamma \\ 0\le\gamma\le1}} \mathbf{v} \cdot d\mathbf{r}, \qquad 1$$

noting that the third integral will be taken in the direction from B to O.

For the first integral,

$$x = \alpha,\ y = z = 0, \qquad \mathbf{r} = \alpha\mathbf{i}, \quad 0 \le \alpha \le 1,$$

and

$$\begin{aligned}\int_{C_1} \mathbf{v} \cdot d\mathbf{r} &= \int_0^1 \mathbf{v} \cdot \frac{d\mathbf{r}}{d\alpha}\, d\alpha \\ &= \int_0^1 (2\alpha\mathbf{i} + \alpha\mathbf{j} + \alpha^2\mathbf{k}) \cdot \mathbf{i}\, d\alpha \\ &= \int_0^1 2\alpha\, d\alpha = 1.\end{aligned}$$