Quiz on Transverse Beam Dynamics

FFA School 2022

Thomas Planche

TRIUMF

Question 1

What is(are) the fundamental assumption(s) that allowed us to use transfer matrices to describe the transverse motion of particles?

1. That particles are not relativistic ($v \ll c$)
2. That particles are hyper relativistic ($v \approx c$)
3. That transverse forces are linear
4. That we worked in a non-inertial frame of reference

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Question 2

Let $\mathbf{M}_{\mathsf{F}}$ be the transfer matrix across an F (focusing) quadrupole, and $\mathbf{M}_{\mathsf{D}}$ be the transfer matrix across a D (defocusing) quadrupole, what is the transfer matrix of an FD doublet?

1. $\mathbf{M}_{\mathsf{F}} + \mathbf{M}_{\mathsf{D}}$
2. $\mathbf{M}_{\mathsf{F}} \cdot \mathbf{M}_{\mathsf{D}}$
3. $\mathbf{M}_{\mathsf{D}} \cdot \mathbf{M}_{\mathsf{F}}$
4. $\mathbf{M}_{\mathsf{F}} \cdot \mathbf{M}_{\mathsf{D}} \cdot \mathbf{M}_{\mathsf{F}}^{\mathsf{T}}$

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3. $\mathrm{M}_\mathsf{D} \cdot \mathrm{M}_\mathsf{F}$
4. $\cancel{\mathrm{M}_\mathsf{F} \cdot \mathrm{M}_\mathsf{D} \cdot \mathrm{M}_\mathsf{F}^T}$

Question 3

Let $\mathrm{M}_{\mathsf{A}\to\mathsf{B}}$ be the transfer matrix from point A to point B, what is the determinant of this matrix equal to:

1. 1
2. $\frac{P_\mathsf{A}}{P_\mathsf{B}}$
3. $\frac{P_\mathsf{B}}{P_\mathsf{A}}$
4. $\sqrt{\frac{P_\mathsf{B}}{P_\mathsf{A}}}$

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Question 4

Let $\mathbf{\Sigma}$ be beam matrix of our beam: how do you calculate its RMS emittance?

1. $\epsilon = \sqrt{|\mathbf{\Sigma}|}$
2. $\sqrt{\epsilon} = |\mathbf{\Sigma}|$
3. $\epsilon = |\mathbf{\Sigma}|$
4. $\epsilon = 4|\mathbf{\Sigma}|$

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Question 5

Under which of the following condition(s) is the normalized RMS emittance **not** conserved?

1. When their is acceleration
2. When transverse forces are linear
3. When transverse forces are **not** linear
4. When the beam distribution does not have elliptical symmetry

Question 5

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6D Phase Space

With s as independent variable the full state vector of a particle is:

$$\mathbf{X} = \begin{pmatrix} x \\ P_x \\ y \\ P_y \\ \Delta t \\ -\Delta E \end{pmatrix}$$

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6D Phase Space

With s as independent variable the full state vector of a particle is:

$$\mathbf{X} = \begin{pmatrix} x \\ x' \\ y \\ y' \\ \Delta t * \beta_0 c \\ \frac{-\Delta E}{P_0} * \frac{1}{\beta_0 c} \end{pmatrix}$$

6D Phase Space

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$$\mathbf{X} = \begin{pmatrix} x \\ x' \\ y \\ y' \\ z \\ z' \end{pmatrix}$$

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there are 15 conserved quantities (15 = n(2n-1), n = 3, symplectic conditions).