

$$g = \begin{bmatrix} 1 & (e_E \cdot e_B) & (e_E \cdot e_k) & 0 \\ (e_E \cdot e_B) & 1 & (e_B \cdot e_k) & 0 \\ (e_E \cdot e_k) & (e_B \cdot e_k) & 1 & 0 \\ 0 & 0 & 0 & -1 \end{bmatrix}$$

$$X = x_E e_E + x_B e_B + x_k e_k + t e_t$$

$$K = k e_k + \omega e_t$$

$$K \cdot X = (e_B \cdot e_k) k x_B + (e_E \cdot e_k) k x_E - \omega t + k x_k$$

$$\begin{aligned} F = & (e_B \cdot e_k) B \sin((e_B \cdot e_k) k x_B + (e_E \cdot e_k) k x_E - \omega t + k x_k) e_E \wedge e_B \\ & - B \sin((e_B \cdot e_k) k x_B + (e_E \cdot e_k) k x_E - \omega t + k x_k) e_E \wedge e_k \\ & + E \sin((e_B \cdot e_k) k x_B + (e_E \cdot e_k) k x_E - \omega t + k x_k) e_E \wedge e_t \\ & + (e_E \cdot e_B) B \sin((e_B \cdot e_k) k x_B + (e_E \cdot e_k) k x_E - \omega t + k x_k) e_B \wedge e_k \end{aligned}$$

$$\begin{aligned} \nabla F = 0 = & \left( -(e_B \cdot e_k)^2 B k + B k + E \omega \right) \cos((e_B \cdot e_k) k x_B + (e_E \cdot e_k) k x_E - \omega t + k x_k) e_E \\ & + B k ((e_B \cdot e_k) (e_E \cdot e_k) - (e_E \cdot e_B)) \cos((e_B \cdot e_k) k x_B + (e_E \cdot e_k) k x_E - \omega t + k x_k) e_B \\ & + B k ((e_B \cdot e_k) (e_E \cdot e_B) - (e_E \cdot e_k)) \cos((e_B \cdot e_k) k x_B + (e_E \cdot e_k) k x_E - \omega t + k x_k) e_k \\ & + (e_E \cdot e_k) E k \cos((e_B \cdot e_k) k x_B + (e_E \cdot e_k) k x_E - \omega t + k x_k) e_t \\ & + (e_B \cdot e_k) B k \cos((e_B \cdot e_k) k x_B + (e_E \cdot e_k) k x_E - \omega t + k x_k) e_E \wedge e_B \wedge e_k \\ & + (e_B \cdot e_k) B \omega \cos((e_B \cdot e_k) k x_B + (e_E \cdot e_k) k x_E - \omega t + k x_k) e_E \wedge e_B \wedge e_t \\ & + (-B \omega - E k) \cos((e_B \cdot e_k) k x_B + (e_E \cdot e_k) k x_E - \omega t + k x_k) e_E \wedge e_k \wedge e_t \\ & + (e_E \cdot e_B) B \omega \cos((e_B \cdot e_k) k x_B + (e_E \cdot e_k) k x_E - \omega t + k x_k) e_B \wedge e_k \wedge e_t \end{aligned}$$

$$\text{Substituting } e_E \cdot e_B = e_E \cdot e_k = e_B \cdot e_k = 0$$

$$\begin{aligned} (\nabla F) / (\cos(K \cdot X)) = 0 = & (B k + E \omega) e_E \\ & + (-B \omega - E k) e_E \wedge e_k \wedge e_t \end{aligned}$$