

PHYSICS 515B
ELECTROMAGNETIC THEORY
Prof. Fulvio Melia
Fall 2025

Homework 1 (due Wednesday, September 17)

Problem 1: Consider the *stress-energy tensor* for an electromagnetic field

$$T^{\mu\nu} \equiv \frac{1}{4\pi} \left(F^{\mu\alpha} F^{\nu}{}_{\alpha} - \frac{1}{4} g^{\mu\nu} F^{\alpha\beta} F_{\alpha\beta} \right) ,$$

where $F^{\alpha\beta}$ and $g^{\mu\nu}$ are the electromagnetic field tensor and the metric, respectively.

(a) Show that $T^{\mu\nu}$ is traceless: $T^{\mu}{}_{\mu} = 0$.

(b) Show that in free space $T^{\mu\nu}$ is divergenceless: $\partial_{\nu} T^{\mu\nu} = 0$.

Problem 2: Jackson 12.1

Problem 3: Jackson 12.2

Problem 4: Jackson 12.14