

25. (a) We take the wave to be a plane wave and consider a region formed by the surface of a rectangular solid, with two plane faces of area  $A$  perpendicular to the direction of travel and separated by a distance  $d$ , along the direction of travel. The energy contained in this region is  $U = uAd$ . If the wave speed is  $v$  then all the energy passes through one end of the region in time  $t = d/v$ . The energy passing through per unit time is  $U/t = uAdv/d = uvA$ . The intensity is the energy passing through per unit time, per unit area, or  $I = U/tA = uv$ .
- (b) The power output  $P$  of the source equals the rate at which energy crosses the surface of any sphere centered at the source. It is related to the intensity  $I$  a distance  $r$  away by  $P = AI = 4\pi r^2 I$ , where  $A (= 4\pi r^2)$  is the surface area of a sphere of radius  $r$ . Substitute  $I = uv$  to obtain  $P = 4\pi r^2 uv$ , then solve for  $u$ :

$$u = \frac{P}{4\pi r^2 v} = \frac{50,000 \text{ W}}{4\pi(480 \times 10^3 \text{ m})^2(3.00 \times 10^8 \text{ m/s})} = 5.76 \times 10^{-17} \text{ J/m}^3 .$$