"You are a Star!"

Do this in small groups. Estimate the "luminosity" of one member of the group: the total energy they are radiating *per second*. Which of the following values – (a), (b), (c), or (d) – is it closest to?

L = Surface Area (m^2) x Energy per unit area (W/m^2)

Hint: Assume that the energy per unit area (second term) = 500 Watts (this corresponds to T = 92° F = 306.5 K), so you just have to estimate surface area in square meters; show your calculations!

(a) 15 Watts
(b) 150 Watts
(c) 1500 Watts = 1.5 kW
(d) 15,000 Watts = 15 kW

The luminosity of a thermal emitter

The total power radiated by a thermal emitter is:

(Surface Area) x (Energy emitted per unit area)

If the object is a sphere, for example a star, then

Surface Area = $4\pi R^2$, where R is the radius.

If the whole surface is at one temperature T,

Energy per unit area = σT^4

The luminosity of a person

I had already chosen T = 92° F = 306.5 K, and calculated the second term, σT^4 = 500 Watts.

That leaves the job of estimating the surface area of a person. How to do this?

-Most groups chose a value by comparing with the 1 m^2 box drawn on the board, or worked backwards from the listed choices.

-You can approximate a person as a cylinder, of height about 1.8 m and cross-section 1.5 m (allowing for arms and legs, etc.).

Responses: Statistics

Surface Area x Energy per unit area = Total Power

_________ m^2 x 500 Watts/m^2 = choices (a) – (d)

Surface Area	Power, choice from list	# groups choosing this value (%)
3 m^2	1500 W (c)	23 (49%)
2.5 m^2	1250 W (c)	7 (15%)
1.8 – 2 m^2	≈ 1000 W (c)	11 (23%)
0.5 – 1 m^2	250 – 500 (b)	3 (6%)
No value given	15,000 (d)	3 (6%)

Responses: Reasoning and Comments

- Several groups failed to choose any of the options.
- Some groups did not explain their reasoning, but just said the surface area was "around 2 – 3 m^2."
- A few groups mixed up this question with the previous example: "(d) because the surface area of a star is very large…" , I didn't ask about a star!
- Others explicitly wrote a number x 10^{26} Watts in their calculations, which is *not relevant*!!
- One group wrote: Surface area = 1 yard x 1.5 yds. A yard is not a meter, although they are close, but you can't mix different units in the same equation!

Errors and Misunderstandings

- Some sloppy math: 3 x 500 = 150
- Substituting 92 for T: $(\sigma T^4) \neq (500 \times 92^4)$!!
  T must be in ***Kelvins***, and σ is not 500 W!
- Treating a person as a (too large!) sphere:
  $4\pi R^2 = 4\pi(2)^2$; claimed to be 3, is actually ≈ 50!
  (scientists' joke, the "spherical cow" realized)
- Random substitutions:
  $4\pi R^2 \times 500 = 4\pi(1500)^2 \times 500 = 3.9 \times 10^{26}$??
- Inverting the ratio:
  Surface area = 500 W/m 2 ÷ 150 W