Q1. Give the symbol and units used for each of the following:

- **flux**: \( \Phi, \text{[W]} \)
- **irradiance**: \( E, \text{[W/m}^2\text{]} \)
- **radiant intensity**: \( I, \text{[W/}\text{sr]} \)
- **radiance**: \( L, \text{[W/m}^2\text{.sr]} \)
- **radiosity**: \( B, \text{[W/m}^2\text{]} \)

Q2. What are the physical units that correspond to observed brightness, i.e., what a camera sensor or cells in the eye ultimately measure?

\[ \text{[W/m}^2\text{.sr]} \]

Q3. Consider the transfer of light between the following two surfaces:

True or False
- irradiance is invariant with the distance \( r \)
- flux transfer is invariant with the distance \( r \)
- radiance is invariant with the distance \( r \)

Q4. For the above scene, given the radiance, \( L \), develop an expression for the flux transfer between the two surfaces.

\[ \Phi = L \int d\Omega dA \]

(Question 4 continues with more complex expressions and diagrams.)

Q5. A 10 W point light distributes light equally in all directions, as shown below.

- What is the flux received by area \( dA \)?
- What is the irradiance received by a point on area \( dA \)?
- Suppose that the surface has a BRDF defined by \( f = \pi \theta \)
- What is the observed radiance in the given viewing direction \( V \)?
(a) \( d\Phi_A = \Phi_{\text{total}} \cdot dN_A = \Phi_{\text{total}} \left( \frac{dA_A}{r^2} \cdot \left( \frac{1}{4\pi} \right) \right) \cdot N_{\text{total}} \)

\[ d\Phi_A = \Phi_{\text{total}} \cdot \frac{dA_A \cos \theta_i}{4\pi r^2} \]

where \( \Phi_{\text{total}} = 10 \text{ W} \)

(b) \( E_{\text{\theta}} = \frac{d\Phi_A}{dA} = \frac{\Phi_{\text{total}} \cdot \cos \theta_i}{4\pi r^2} \left[ \frac{\text{W}}{\text{m}^2} \right] \)

(c) \( L_r = f_r(\theta_i, \theta_r) \cdot E_i \)

\[ L_r = \Phi_{\text{total}} \cdot \cos \theta_i \left[ \frac{\text{W}}{\text{m}^2 \cdot \text{sr}} \right] \]

Note: observed brightness increases with:

- \( p \): albedo, i.e., overall fraction of energy reflected by a diffuse surface
- \( \Phi_{\text{total}} \): power of light source
- \( \cos \theta_i \): the smaller \( \theta_i \) is, i.e., the more the surface directly faces the light source.

Observed brightness decreases with:

- \( r^2 \): doubling the distance decreases the brightness by a factor of four.