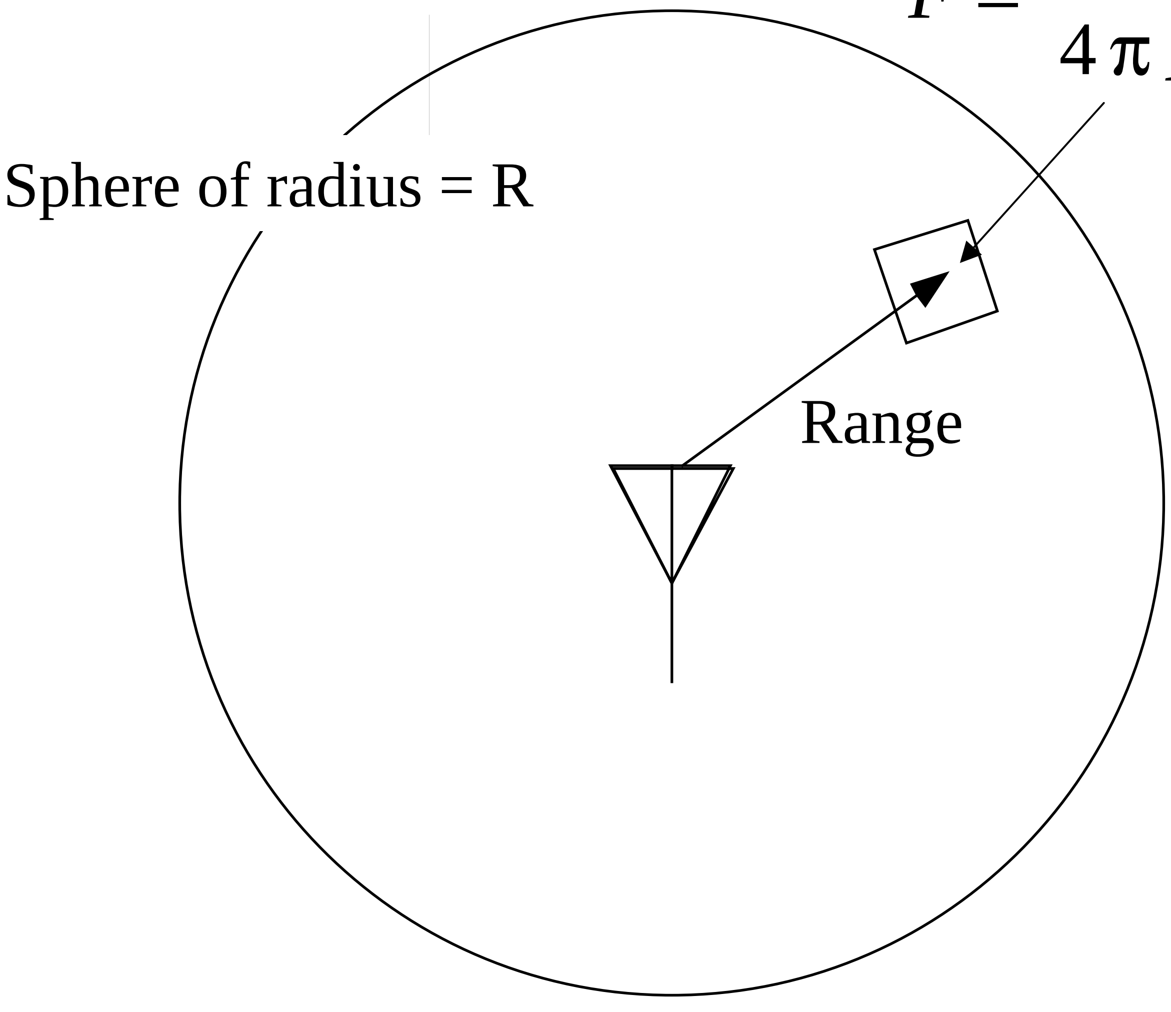
Antennas Tutorial

EEL 5432 Satellite Remote Sensing
Lecture -3a

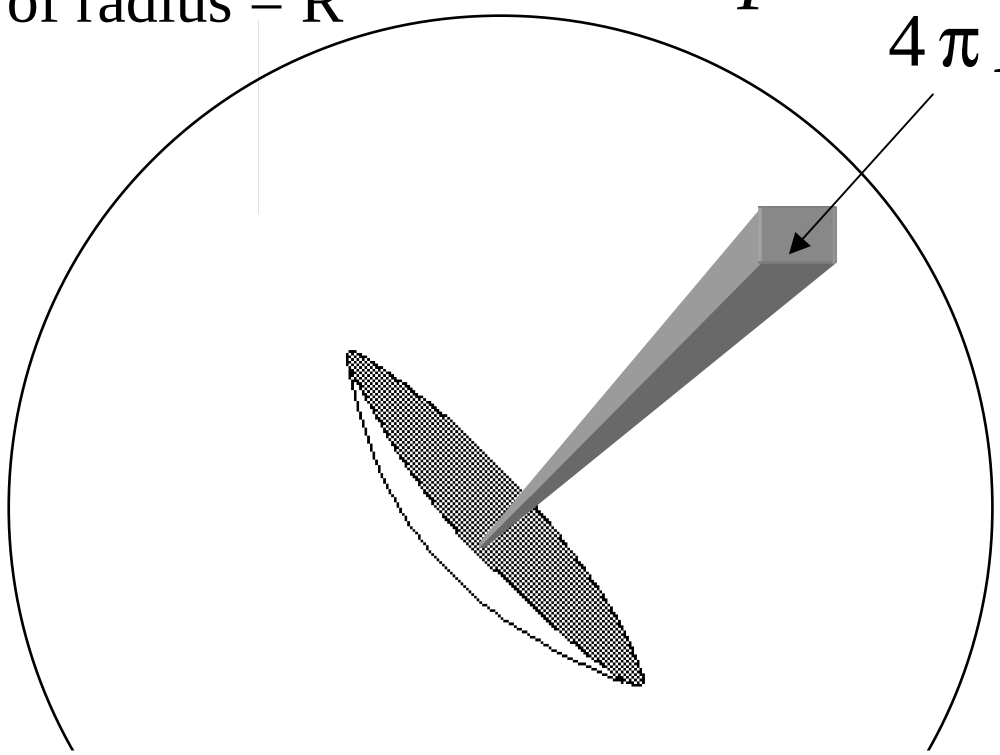
Flux Calculations - Isotropic Transmit Antenna

$$F = \frac{P_t}{4\pi R^2} \;, \quad \text{W/m}^2$$



Flux Calculations - Transmit Antenna with Gain

$$F = \frac{P_t G_t}{4 \pi R^2} \ , \quad W/m^2$$



The antenna gain pattern redirects the radiation in a preferred Direction, thereby increasing the radiated flux density by the antenna gain G_t (power ratio).

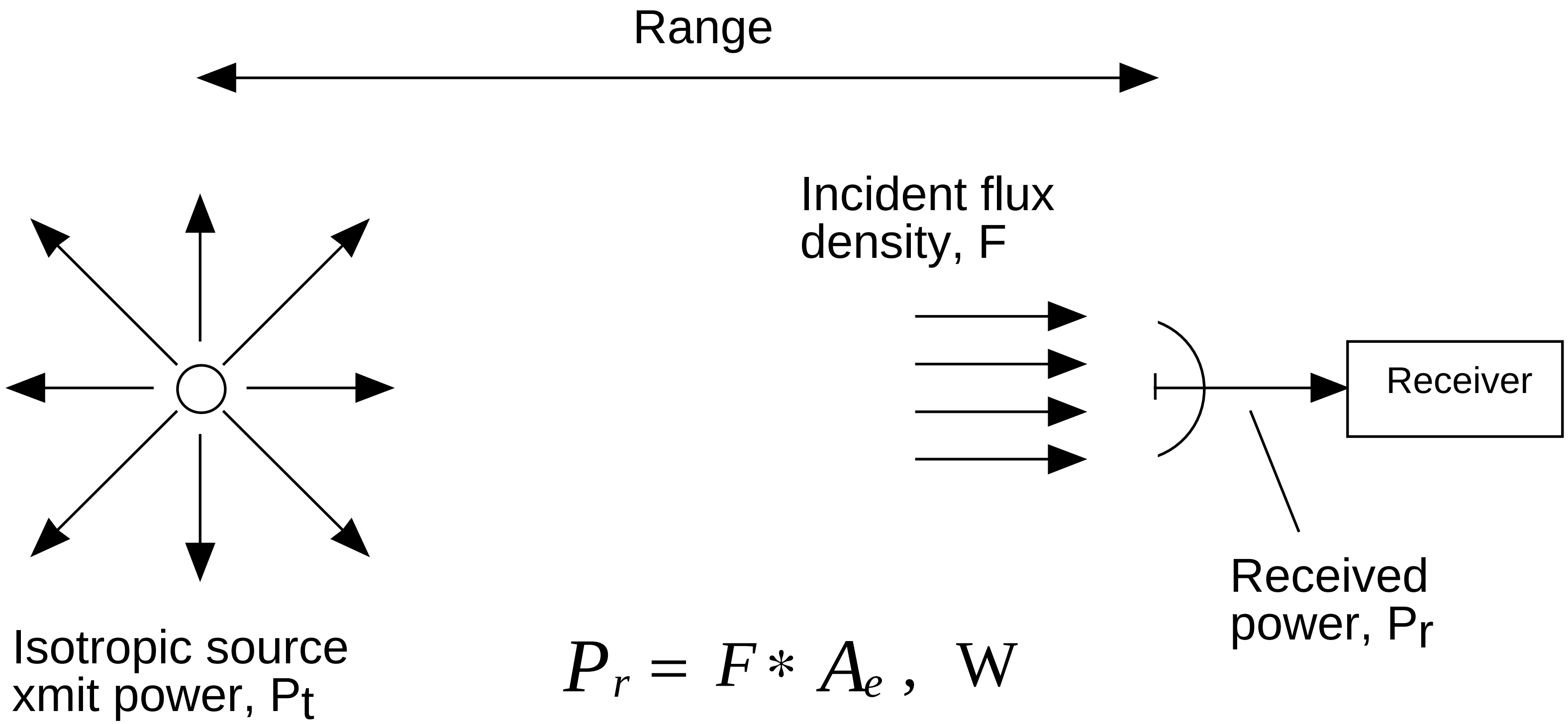
Antenna Gain Definition

- Peak gain is the max value of the antenna radiation pattern (power ratio).

G_{pk} = (max flux density)/ (isotropic flux density)

The direction of the max gain is known as the antenna boresight.

Friis Transmission Formula - Isotropic Source

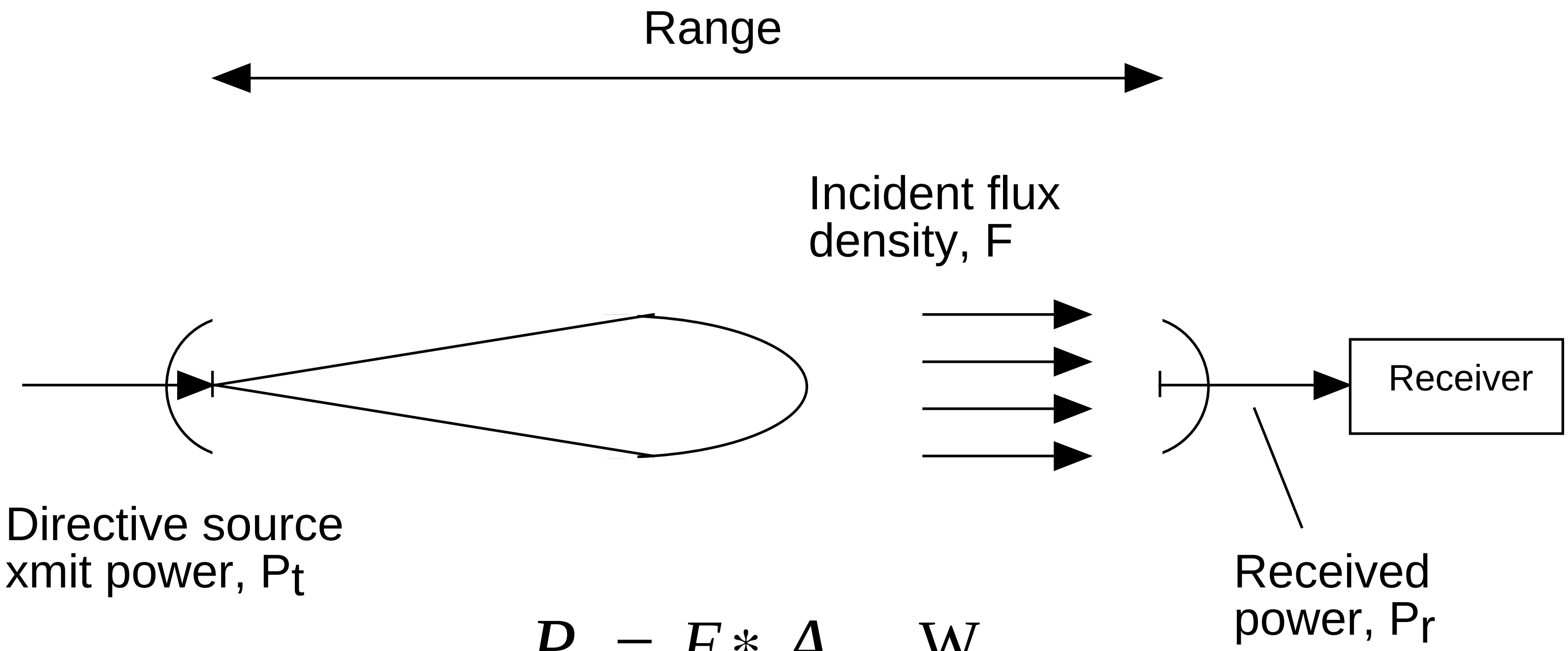


$$P_r = F * A_e \,, \quad \mathrm{W}$$

$$= \frac{P_t}{4\pi R^2} * A_e$$

where A_e is the antenna effective "capture" area

Friis Transmission Formula - Directive Source

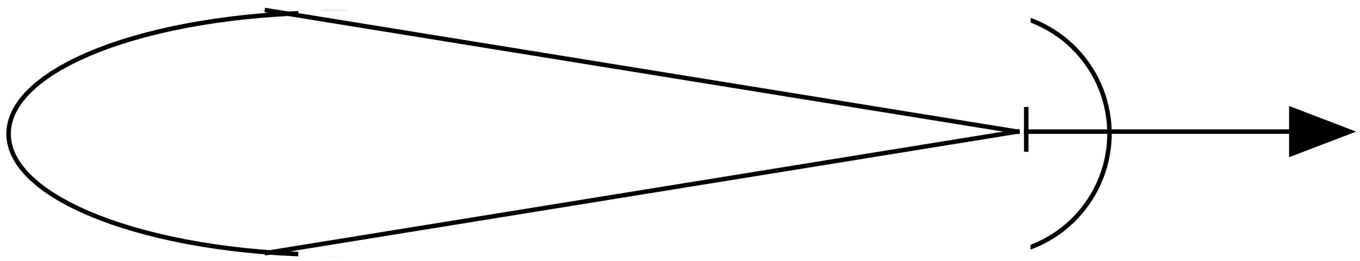


$$P_r = F * A_e \ , \quad \mathrm{W}$$

$$= \frac{P_t * G_t}{4\pi R^2} * A_e$$

where A_e is the antenna effective "capture" area

Relationship between Antenna Aperture and Gain



Antenna directive pattern

$$G_r = \frac{4\pi A_e}{\lambda^2}\ ,\ \text{power ratio}$$

Idealized Received Power - no system losses

$$P_r = P_t * G_t * G_r \left[\frac{1}{4\pi \left(R/\lambda \right)} \right]^2$$

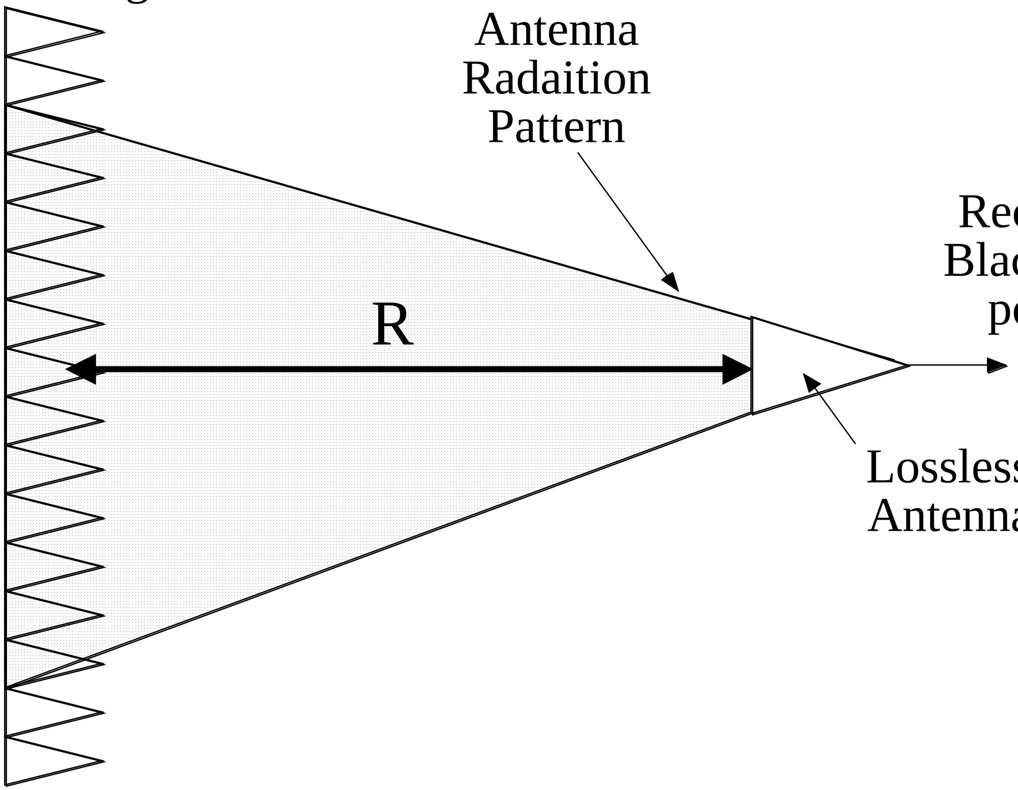
Power Received = EIRP * Recv Ant Gain * Path Loss

EIRP = Effective Isotropic Radiated Power = $P_t * G_t$

$$\text{Path Loss} = \left[\frac{1}{4\pi \left(R/\lambda \right)} \right]^2$$

Radiometer Antenna and Power Measurements

Radiometer Antenna Noise



Recv Pwr = Sur Emission * Isotropic Loss * A_e

Recv Pwr = Sur Emission * Isotropic Loss * A_e

- Surface Emission
  - Blackbody emission = $(4/\lambda)^2 kT$, $W/m^2/Hz$
  - Ant. IFOV area = $\pi R^2 \beta^2 / 4$, m^2
- Isotropic Loss
  - = $1/(4 \pi R^2)$, m^{-2}
- Antenna Effective Aperture
  - $A_e = \lambda^2 / \beta^2$, m^2

$$P_r = kT \text{ , W/Hz}$$

If the receiver bandwidth = B, then

$$P_r = kTB \text{ , W}$$

Radiometric Received Power

- Pr = kTB
  - K = Boltzmann's constant = 1.38 e -23
  - T = radiometric brightness temperature

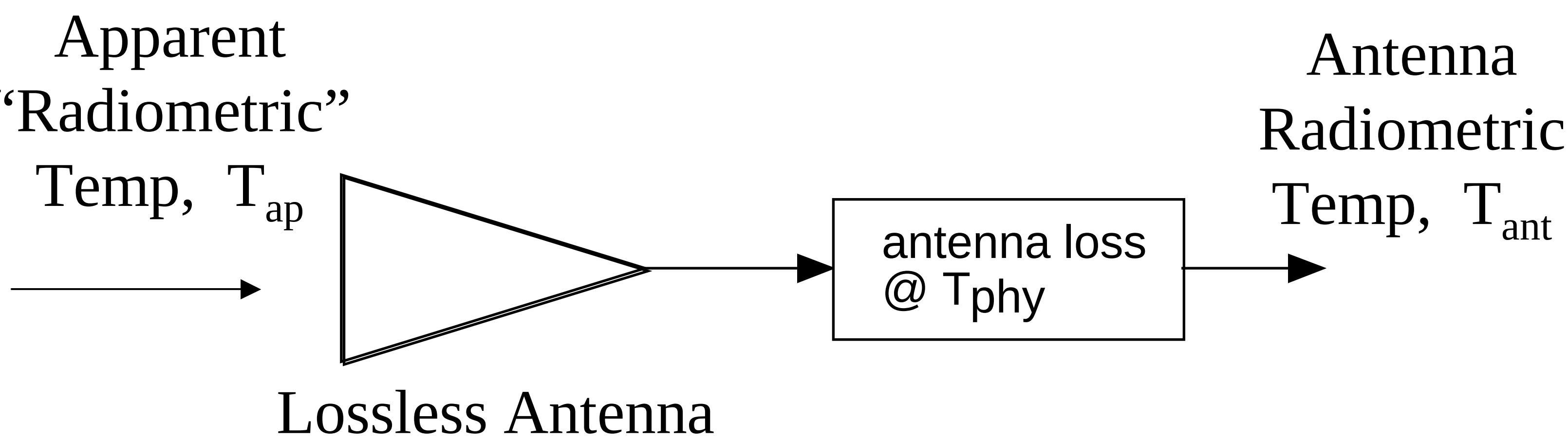
    = ε T_{phys} = (emissivity * physical temperature)
  - Receiver bandwidth, Hz
- The received power is independent of the antenna gain and is independent of the range to the surface
- The surface area from which emission is captured is the antenna IFOV
  - IFOV depends on both the range and the antenna gain (beamwidth)

Antenna Radiometric “Noise” Temperature

- All bodies above absolute zero degrees (0 Kelvin) will emit non-coherent electromagnetic energy continuously at frequencies from RF to Light.
- Antennas viewing natural surfaces will receive this “black-body emission”
  - In the RF & microwave freq region, the emitted power = Boltzmann’s constant * noise temp. * bandwidth
- We define the noise temperature ($T_{antenna}$) as:

$$T_{ant} = \frac{surface\ \ emission\ \ captured\ by\ antenna}{Boltzman's\ constant * receiver\ \ bandwidth}$$

Antenna Noise Temperature, T_{ant}



$$T_{ant} = T_{ap} * (l_{ant}) + (1 - l_{ant}) * T_{phy}$$

T_{phy} = antenna physical temperature, Kelvin
L_{ant} = antenna loss (gain < 1), power ratio