Opaque Projector

a) Imaging: Match 11" on paper to 2m on screen:

$$m = -\frac{2m}{11"} = -\frac{200cm}{27.9cm} = -7.16$$

$$m = z'/z = 3m/z = -7.16$$

$$z = -.419\,m$$

$$\frac{1}{z'} = \frac{1}{z} + \frac{1}{f} \Rightarrow \frac{1}{300} = \frac{1}{-41.9} + \frac{1}{f}$$

$$f = 36.7\,cm = 14.4"$$

Maximum lens diameter = 8"

$$f/\# = 14.4"/8" = f/1.8$$

Fold mirror required for image parity

H size ~ 8"

V size ~ $\sqrt{2}$ 8" = 11.3"

b) Radiometry:

E_v per bulb on paper:

$$E_v = 1000\ ft\ cdo = 1000\ lm/ft^2$$

Assume the paper is Lambertian with $\rho = 1$

$$L_v = E_v/\pi = 318\ lm/ft^2\,sr = 318\ cd/ft^2$$

Use the camera equation to get E_v' on the screen:

$$E_v' = \frac{\pi L_v}{4(f/\#)^2(1-m)^2}$$

$m = -7.16$

$f/\# = 1.8$

$$E_v' = \frac{\pi\,(318\ cd/ft^2)}{4\,(1.8)^2\,(8.16)^2}$$

$$E_v' = 1.15\ lm/ft^2 = 1.15\ ft\text{-}cd$$

Assume the screen is Lambertian with $\rho = 1$

$$L_v' = E_v'/\pi = 0.368\ cd/ft^2 \leftarrow \underline{\text{per bulb}}$$

Required:

$$L_v^T = 2.0\ cd/ft^2$$

$$L_v^T = N\,L_v' = N\,(.368\ cd/ft^2) = 2.0\ cd/ft^2$$

$$N = 5.4$$

Use $\underline{\underline{6}}$ light bulbs