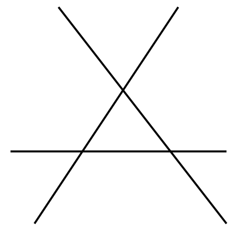
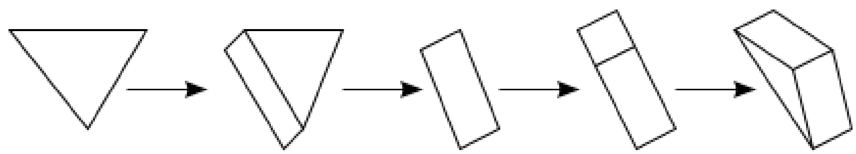
1. (a) From above, the extended plane partitioning looks like



There are 7 cells above the object. The layer of cells between the top and bottom extended planes looks the same, but the middle cell is the object itself so there are only 6 cells that count there. Then below, it looks just like above, 7 cells, for 7+6+7=20 aspects.

(b) Each edge connects aspects in which only one face appears or disappears.



top   top and one side   one side   two sides   two sides and bottom

There are other paths, such as replacing the two-sides aspect above with one side and bottom. The shortest paths all have five aspects: the original, three at which a required side appears, one at which the top disappears.

2. (a) $\partial E/\partial x = 2 (\cos x) (-\sin x)$ so at $x=\pi/4$ this is $\partial E/\partial x = -1$. Also, $\partial E/\partial y = 0$ everywhere. Now estimate $\partial E/\partial t$ at $(x,y)=(\pi/4,1)$ by the forward difference

$$(E(t+\Delta t)-E(t))/(\Delta t)= (1/4 - \cos^2(\pi/4))/(1) = -1/4$$

So the normal component is

$$v' = \frac{-E_t}{\|\nabla E\|^2} \nabla E = \frac{-1/4}{1}\begin{bmatrix}-1\\0\end{bmatrix} = \begin{bmatrix}1/4\\0\end{bmatrix} mm/s$$

(b) The component of the optical flow orthogonal to the image gradient is missing when the normal component is calculated. But in our case, since the car is driving in the x direction and the scene is still, there is no y-component of optical flow, and $v=v'$.

3. The brightness is proportional to $\cos \theta i$, where θi is the angle between the direction of the irradiance and the surface normal. Looking at the cylinder from above, in the case of points p1 and p2 the light ray and the normal are collinear, so $\theta i = 0$ and the brightness at

p2 is the same as at p1, 128 (see left diagram). For p3 the angle is θi = 30^o, as can be seen on the right diagram. So cos θi = $\sqrt{3}/2$ and the brightness there would be $64\sqrt{3}$.