D1. (10 points) An infinite conducting plane with a hemispherical indentation of radius $R$ is kept at zero potential. A charge $Q$ is placed a distance $D (D > R)$ directly below the indentation, as shown in the sketch. Find the force on $Q$ using the method of images.

D2. (10 points) Find an upper limit for the ground state energy of a spin zero particle of mass $m$ in the potential $V(x)$, where $k > 0$ and

$$V(x) = \infty \quad \text{for} \quad x < 0,$$

$$V(x) = kx \quad \text{for} \quad x > 0.$$  

You might wish to recall that

$$\int_0^\infty x^n e^{-ax} \, dx = \frac{n!}{a^{n+1}}.$$
D3. A laser emits a light beam of power $W$ towards a 100% reflecting mirror $M$ at an incident angle close to 90°. The reflected light is absorbed by a non-reflecting object $O$. In one case, the mirror $M$ is stationary. In the second case, the mirror $M$ is moving with a constant velocity $v$ towards the laser. You can use $c$ as the speed of light.

(a) (3 points) Find the force $F_1$ experienced by the mirror $M$ when it is stationary.
(b) (2 points) Find the force $F_2$ experienced by the object $O$ when the mirror $M$ is stationary.
(c) (3 points) Find the force $F_3$ experienced by the mirror $M$ when it is moving.
(d) (2 points) Find the force $F_4$ experienced by the object $O$ when the mirror $M$ is moving.