

Triple Integration with Maple

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Maple is helpful in setting up triple iterated integrals over regions in \mathcal{R}^3 . Just as for double integrals, the key step is determining the limits of integration. That is easier if you imagine an arrow shooting through the region E of integration parallel to the axis of the variable with respect to which the first integration takes place. Plotting the region E reduces the vividness of imagination necessary to see the corresponding limits.

Fubini's theorem for triple integrals states that the value of a triple integral of a continuous function f over a region E in \mathcal{R}^3 is a triple iterated integral. Suppose that E is a "Type 1" region between surfaces with equations $z = h(x, y)$ and $z = k(x, y)$ and has perpendicular projection D on the xy -plane. Then

$$\iiint_E f(x, y, z) \, dz \, dy \, dx = \iint_D \int_{h(x, y)}^{k(x, y)} f(x, y, z) \, dz \, dy \, dx$$

The remaining double integral over the region D in the xy -plane is evaluated by iteration as before.

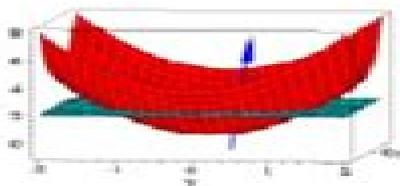
Example 1. Evaluate $\iiint_E z \, dz \, dy \, dx$, where E is the region between the paraboloid $z = x^2 + y^2$ and the plane $z = 2$.

Solution. The following Maple routine plots the region E with an upward-pointing arrow passing through it. The entry point of the arrow occurs on the surface whose equation $z = h(x, y)$ gives the lower limit of the first integration, which will take place with respect to z . The exit point of the arrow is on the surface whose equation $z = k(x, y)$ gives the upper limit of that first integration.

As for two-dimensional arrows, when working with other regions modify the parameters in the `ARROW` command to size the arrow appropriately. The first and second triples within the command specify the starting and end point of the arrow; the third one specifies a normal direction for the plane in which the arrow is seen; note that it does not appear perfectly vertical even though the direction vector \mathbf{k} was specified. Adjust the direction vector to get an image that you like.

```
> with(plots):
with(plottools):
regionbot := plot3d( x^2 + y^2, x = -2..2, y = -2..2, color = red ):
regiontop := plot3d( 2, x = -2..2, y = -2..2, color = cyan ):
regname := textplot3d([0.5, 0.5, 2.5, "E"], font = [TIMES, ITALIC, 14], color = black):
alice := arrow([3, .3, -1], [3, .3, 8.5], [0, 0, 1], 1, 4, .25, color = blue):
display(regionbot, regiontop, alice, regname, axes = boxed);
```

Warning: the name `changeprocs` has been redefined



Maple's real-time rotation feature reveals that the bottom boundary of the region is the paraboloid $z = x^2 + y^2$, and its top boundary is the plane $z = 2$. The lower limit of the first integration, with respect to z , corresponds to the equation of the lower surface, and the upper limit is $z = 2$. Hence,

$$\iiint_E f(x, y, z) \, dz \, dy \, dx = \iint_D \int_{x^2 + y^2}^2 z \, dz \, dy \, dx$$

Triple Integration With Maple Uconn

Emilie Sanchez



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