Introduction

Consider the canonical commutation relation in one dimension.

$$XP - PX = i\hbar$$

Let

$$X = x, \quad P = -i\hbar\frac{\partial}{\partial x}$$

Show that

$$(XP - PX)\psi(x,t) = i\hbar\psi(x,t)$$

Eigenmath code:

```
X(f) = x f
P(f) = -i hbar d(f,x)
X(P(psi(x,t))) - P(X(psi(x,t)))
```

Result:

$i\hbar\psi(x,t)$

Another example: Let

$$H = \frac{P^2}{2m}$$

Show that

$$XH - HX = \frac{i\hbar P}{m}$$

Eigenmath code:

```
X(f) = x f
P(f) = -i hbar d(f,x)
H(f) = P(P(f)) / (2 m)
A = X(H(psi(x,t))) - H(X(psi(x,t)))
B = i hbar P(psi(x,t)) / m
check(A == B) -- continue if A equals B
"ok"
```

Result:

ok

In three dimensions:

$$X = (x, y, z), \quad P = -i\hbar\nabla, \quad H = -\frac{\hbar^2}{2m}\nabla^2$$

Eigenmath code:

```
X(f) = (x,y,z) f
P(f) = -i hbar d(f,(x,y,z))
H(f) = -hbar^2 (d(f,x,x) + d(f,y,y) + d(f,z,z)) / (2 m)
A = X(H(psi(x,y,z,t))) - H(X(psi(x,y,z,t)))
B = i hbar P(psi(x,y,z,t)) / m
check(A == B) -- continue if A equals B
"ok"
```

Result:

ok