Dejan Brkić and Pavel Praks: Colebrook's flow friction explicit approximations based on fixed-point iterative cycles and symbolic regression. Computation

Eq. 3: An explicit approximation with one internal iterative cycle and with a fixed starting point

MS Excel:

$\frac{1}{\sqrt{f}}$: C10 = C154+0.8686*(C176*(C176+4)-5)/(4*C176+2)

a: C176 = C132/(($A176/3.71)+(2.51*C154/C175)) where Re: C175 and ε: A176

b: C154 = -2*LOG10(C132)

c: C132: 16.9/C131+$A132/3.71 where Re: C131 and ε: A132

Matlab code:

```
x=16.9/2.51;
y0= 2.51*x./R+K./3.71;
x1 = -2*log10(y0);
z = y0./((K/3.71)+(2.51*x1./R));
ln11 = @(z) (z.*(z+4)-5)./(4*z+2);
x = x1+0.8686*ln11(z);
f=1./x.^2;
```

In the Matlab codes, the Reynolds number Re is noted as R, while the relative roughness of inner pipe surface ε as K.

Eq. 4: An explicit approximation with one internal iterative cycle and with a rational starting point given by Eq. 2

MS Excel:

$\frac{1}{\sqrt{f}}$: C10 = C154+0.8686*(C176*(C176+4)-5)/(4*C176+2)

a: C176 = C132/(($A176/3.71)+(2.51*C154/C175)) where Re: C175 and ε: A176

b: C154 = -2*LOG10(C132)

c: C132: C199/C131+$A132/3.71 where Re: C131 and ε: A132

p_0: C199: 2.51*((2600*C198)/(657.7*C198 + 214600*C198*$A199 + 12970000) - 13.58*$A199 + (0.0001165*C198)/(0.00002536*C198 +C198 *$A199 + 105.5) + 4.227)
where Re: C198 and ε: A199

Matlab code:

Note: for the rational starting point, x is given by Eq.2, i.e.

```
x=(2600*R)./(657.7*R + 214600*R.*K + 12970000) - 13.58*K + (0.0001165*R)./(0.00002536*R + R.*K + 105.5) + 4.227;
```

The rest of the Matlab code is unchanged.

Eq. 5: An explicit approximation with two internal iterative cycles and with a fixed starting point

MS Excel:

$\frac{1}{\sqrt{f}}$: C10: C154+0.8686*(C221*(C221+4)-5)/(4*C221+2)

a: C176 = C132/(($A176/3.71)+(2.51*C154/C175)) where Re: C175 and ε: A176

b: C154 = -2*LOG10(C132)

c: C132 = 18.15/C131+$A132/3.71 where Re: C131 and ε: A132

d: C221 = C132/($A221/3.71+2.51*C198/C220)
where Re: C220, ε: A221 and C198: C154+0.8686*(C176*(C176+4)-5)/(4*C176+2)

Matlab code:

```
x=16.9/2.51;
y0= 2.51*x./R+K./3.71;
x1 = -2*log10(y0);
z = y0./((K/3.71)+(2.51*x1./R));
ln11 = @(z) (z.*(z+4)-5)./(4*z+2);
x = x1+0.8686*ln11(z);
z = y0./((K/3.71)+(2.51*x./R));
x = x1+0.8686*ln11(z);
f=1./x.^2;
```

Eq. 6: An explicit approximation with two internal iterative cycles and with a rational starting point given by Eq. 2

MS Excel:

$\frac{1}{\sqrt{f}}$: C10: C154+0.8686·(C221*(C221+4)-5)/(4*C221+2)

a: C176 = C132/(($A176/3.71)+(2.51*C154/C175)) where Re: C175 and ε: A176

b: C154 = -2*LOG10(C132)

c: C132 = C244/C131+$A132/3.71 where Re: C131 and ε: A132

d: C221 = C132/($A221/3.71+2.51*C198/C220)
where Re: C220, ε: A221 and C198: C154+0.8686·(C176*(C176+4)-5)/(4*C176+2)

p_0: C244: 2.51*((2600*C243)/(657.7*C243 + 214600*C243*$A244 + 12970000) - 13.58*$A244 + (0.0001165*C243)/(0.00002536*C243 +C243 *$A244 + 105.5) + 4.227)
where Re: C243 and ε: A244

Matlab code:

Note: for the rational starting point, x is given by Eq. (2). The rest of the Matlab code is unchanged.