sigma[u_, t_] = ((u + p[t]) * (1 − u − p[t]))^(1/2) * (2 * T[t] * a)^(1/2)

$$\sqrt{2}\sqrt{(1-u-p[t])(u+p[t])}\sqrt{aT[t]}$$

psi[u_, t_] = Integrate[1/sigma[u, t], u]

$$-\frac{\sqrt{2}\text{ArcSin}\left[\sqrt{1-u-p[t]}\right]}{\sqrt{aT[t]}}$$

F[e_, v_, t_] = psi[v, t] − psi[e, t]

$$\frac{\sqrt{2}\text{ArcSin}\left[\sqrt{1-e-p[t]}\right]}{\sqrt{aT[t]}}-\frac{\sqrt{2}\text{ArcSin}\left[\sqrt{1-v-p[t]}\right]}{\sqrt{aT[t]}}$$

F[e, v, t]

$$\frac{\sqrt{2}\text{ArcSin}\left[\sqrt{1-e-p[t]}\right]}{\sqrt{aT[t]}}-\frac{\sqrt{2}\text{ArcSin}\left[\sqrt{1-v-p[t]}\right]}{\sqrt{aT[t]}}$$

F_v[v_] = D[F[e, v, t], v]

$$\frac{1}{\sqrt{2}\sqrt{1-v-p[t]}\sqrt{v+p[t]}\sqrt{aT[t]}}$$

F_vv[v_] = D[F[e, v, t], {v, 2}]

$$-\frac{\sqrt{2}\left(\frac{1}{4\sqrt{1-v-p[t]}(v+p[t])^{3/2}}-\frac{1}{4(1-v-p[t])^{3/2}\sqrt{v+p[t]}}\right)}{\sqrt{aT[t]}}$$

sigma_v[v_] = D[sigma[v, t], v]

$$\frac{(1-2v-2p[t])\sqrt{aT[t]}}{\sqrt{2}\sqrt{(1-v-p[t])(v+p[t])}}$$

D[F[1, v, t], t]

$$-\frac{p'[t]}{\sqrt{2}\sqrt{-p[t]}\sqrt{1+p[t]}\sqrt{aT[t]}}+\frac{p'[t]}{\sqrt{2}\sqrt{1-v-p[t]}\sqrt{v+p[t]}\sqrt{aT[t]}}+\frac{a\text{ArcSin}\left[\sqrt{1-v-p[t]}\right]T'[t]}{\sqrt{2}(aT[t])^{3/2}}-\frac{a\text{ArcSin}\left[\sqrt{-p[t]}\right]T'[t]}{\sqrt{2}(aT[t])^{3/2}}$$

D[psi[v, t], v]

$$\frac{1}{\sqrt{2}\sqrt{1-v-p[t]}\sqrt{v+p[t]}\sqrt{aT[t]}}$$

D[psi[v, t], t]

$$\frac{p'[t]}{\sqrt{2}\sqrt{1-v-p[t]}\sqrt{v+p[t]}\sqrt{aT[t]}} + \frac{a\text{ArcSin}\left[\sqrt{1-v-p[t]}\right]T'[t]}{\sqrt{2}(aT[t])^{3/2}}$$