

```

In[ ]:= (*Define parameters*) k0 = 0; k1 = 432 / 100; k3 = 29 / 50; k2 = 373 / 100;
r1 = 49 / 50; r2 = 224 / 50; r3 = 1 / 10; r4 = 7 / 50;
Km1 = 124 / 50; Km2 = 167 / 50; Km3 = 231 / 25; Km4 = 181 / 25;
Dvalue = 106 / 50; Et = 8 / 5;
ACt = 334 / 50; PDEt = 232 / 50;

(*Define equations*)
dPDEp = r3 * cAMP * ((PDEt - PDEp) / Km3) - r4 * Et * PDEp / (Km4 + PDEp);
dACp = r1 * cAMP * ((ACt - ACp) / Km1) - r2 * Dvalue * ACp / (Km2 + ACp);
dcAMP = k0 + k1 * ACp - (k3 + k2 * PDEp) * cAMP;

(*Equations for fixed points (set derivatives to zero)*)
eq1 = dPDEp == 0;
eq2 = dACp == 0;
eq3 = dcAMP == 0;

(*Solve the equations for fixed points*)
fixedPoints = Solve[{eq1, eq2, eq3}, {ACp, PDEp, cAMP}]

(*Convert the fixed points back to numerical values*)
fixedPointsNumerical = fixedPoints /. x_Rational -> N[x]

(*Print the numerical fixed points*)
fixedPointsNumerical

```

```

Out[ ]:= { {ACp -> 0, PDEp -> 0, cAMP -> 0}, {ACp ->  $\frac{1}{467303743075288459898256161899709399040000}$  ×
7 (2864018173962235991539615685993886231232512  -
411683035407857866220662304716919685075936 ^2 +
411411816621556915966260882408519876606400 ^3 -
217641050696266683384632909183332338052500 ^4 -
226692098271926003706343008047711944486875 ^5),
PDEp -> (60123282097046143491705058783771505363237375083332864  -
86090355171892267281666568572381961823649442219411392 ^2 +
8652461470278556895512708154117454416865796143623300 ^3 -
4386603907083417630430763884788732326034222137983125 ^4 -
4649598517914130424150141445259855641379985323914375 ^5) /
1199504867315836997597987950347286940009331363840000, cAMP ->  },
{ACp ->  $\frac{1}{467303743075288459898256161899709399040000}$  × 7
(2864018173962235991539615685993886231232512  -

```

$$\begin{aligned}
& 4\,116\,830\,354\,078\,578\,662\,206\,623\,047\,169\,196\,850\,759\,936 \left( \sqrt{0.697\dots} \right)^2 + \\
& 411\,411\,816\,621\,556\,915\,966\,260\,882\,408\,519\,876\,606\,400 \left( \sqrt{0.697\dots} \right)^3 - \\
& 217\,641\,050\,696\,266\,683\,384\,632\,909\,183\,332\,338\,052\,500 \left( \sqrt{0.697\dots} \right)^4 - \\
& 226\,692\,098\,271\,926\,003\,706\,343\,008\,047\,711\,944\,486\,875 \left( \sqrt{0.697\dots} \right)^5 \Big), \\
& \text{PDEp} \rightarrow \left( 60\,123\,282\,097\,046\,143\,491\,705\,058\,783\,771\,505\,363\,237\,375\,083\,332\,864 \left( \sqrt{0.697\dots} \right) - \right. \\
& 86\,090\,355\,171\,892\,267\,281\,666\,568\,572\,381\,961\,823\,649\,442\,219\,411\,392 \left( \sqrt{0.697\dots} \right)^2 + \\
& 8\,652\,461\,470\,278\,556\,895\,512\,708\,154\,117\,454\,416\,865\,796\,143\,623\,300 \left( \sqrt{0.697\dots} \right)^3 - \\
& 4\,386\,603\,907\,083\,417\,630\,430\,763\,884\,788\,732\,326\,034\,222\,137\,983\,125 \left( \sqrt{0.697\dots} \right)^4 - \\
& \left. 4\,649\,598\,517\,914\,130\,424\,150\,141\,445\,259\,855\,641\,379\,985\,323\,914\,375 \left( \sqrt{0.697\dots} \right)^5 \right) / \\
& 1\,199\,504\,867\,315\,836\,997\,597\,987\,950\,347\,286\,940\,009\,331\,363\,840\,000, \text{cAMP} \rightarrow \left( \sqrt{0.697\dots} \right) \Big\}, \\
& \left\{ \text{ACp} \rightarrow \frac{1}{467\,303\,743\,075\,288\,459\,898\,256\,161\,899\,709\,399\,040\,000} \times 7 \right. \\
& \left( 2\,864\,018\,173\,962\,235\,991\,539\,615\,685\,993\,886\,231\,232\,512 \left( \sqrt{1.02\dots} \right) - \right. \\
& 4\,116\,830\,354\,078\,578\,662\,206\,623\,047\,169\,196\,850\,759\,936 \left( \sqrt{1.02\dots} \right)^2 + \\
& 411\,411\,816\,621\,556\,915\,966\,260\,882\,408\,519\,876\,606\,400 \left( \sqrt{1.02\dots} \right)^3 - \\
& 217\,641\,050\,696\,266\,683\,384\,632\,909\,183\,332\,338\,052\,500 \left( \sqrt{1.02\dots} \right)^4 - \\
& \left. 226\,692\,098\,271\,926\,003\,706\,343\,008\,047\,711\,944\,486\,875 \left( \sqrt{1.02\dots} \right)^5 \right) \Big\}, \\
& \text{PDEp} \rightarrow \left( 60\,123\,282\,097\,046\,143\,491\,705\,058\,783\,771\,505\,363\,237\,375\,083\,332\,864 \left( \sqrt{1.02\dots} \right) - \right. \\
& 86\,090\,355\,171\,892\,267\,281\,666\,568\,572\,381\,961\,823\,649\,442\,219\,411\,392 \left( \sqrt{1.02\dots} \right)^2 + \\
& 8\,652\,461\,470\,278\,556\,895\,512\,708\,154\,117\,454\,416\,865\,796\,143\,623\,300 \left( \sqrt{1.02\dots} \right)^3 - \\
& 4\,386\,603\,907\,083\,417\,630\,430\,763\,884\,788\,732\,326\,034\,222\,137\,983\,125 \left( \sqrt{1.02\dots} \right)^4 - \\
& \left. 4\,649\,598\,517\,914\,130\,424\,150\,141\,445\,259\,855\,641\,379\,985\,323\,914\,375 \left( \sqrt{1.02\dots} \right)^5 \right) / \\
& 1\,199\,504\,867\,315\,836\,997\,597\,987\,950\,347\,286\,940\,009\,331\,363\,840\,000, \text{cAMP} \rightarrow \left( \sqrt{1.02\dots} \right) \Big\}, \\
& \left\{ \text{ACp} \rightarrow \frac{1}{467\,303\,743\,075\,288\,459\,898\,256\,161\,899\,709\,399\,040\,000} \times 7 \right. \\
& \left( 2\,864\,018\,173\,962\,235\,991\,539\,615\,685\,993\,886\,231\,232\,512 \left( \sqrt{0.879\dots - 2.12\dots i} \right) - \right. \\
& 4\,116\,830\,354\,078\,578\,662\,206\,623\,047\,169\,196\,850\,759\,936 \left( \sqrt{0.879\dots - 2.12\dots i} \right)^2 + \\
& 411\,411\,816\,621\,556\,915\,966\,260\,882\,408\,519\,876\,606\,400 \left( \sqrt{0.879\dots - 2.12\dots i} \right)^3 - \\
& 217\,641\,050\,696\,266\,683\,384\,632\,909\,183\,332\,338\,052\,500 \left( \sqrt{0.879\dots - 2.12\dots i} \right)^4 - \\
& \left. 226\,692\,098\,271\,926\,003\,706\,343\,008\,047\,711\,944\,486\,875 \left( \sqrt{0.879\dots - 2.12\dots i} \right)^5 \right) \Big\}, \text{PDEp} \rightarrow \\
& \left( 60\,123\,282\,097\,046\,143\,491\,705\,058\,783\,771\,505\,363\,237\,375\,083\,332\,864 \left( \sqrt{0.879\dots - 2.12\dots i} \right) - \right.
\end{aligned}$$

$$\begin{aligned}
& 86\,090\,355\,171\,892\,267\,281\,666\,568\,572\,381\,961\,823\,649\,442\,219\,411\,392 \left( \sqrt[5]{0.879\dots - 2.12\dots i} \right)^2 + \\
& 8\,652\,461\,470\,278\,556\,895\,512\,708\,154\,117\,454\,416\,865\,796\,143\,623\,300 \left( \sqrt[5]{0.879\dots - 2.12\dots i} \right)^3 - \\
& 4\,386\,603\,907\,083\,417\,630\,430\,763\,884\,788\,732\,326\,034\,222\,137\,983\,125 \left( \sqrt[5]{0.879\dots - 2.12\dots i} \right)^4 - \\
& 4\,649\,598\,517\,914\,130\,424\,150\,141\,445\,259\,855\,641\,379\,985\,323\,914\,375 \\
& \left( \sqrt[5]{0.879\dots - 2.12\dots i} \right)^5 \Bigg) / \\
& 1\,199\,504\,867\,315\,836\,997\,597\,987\,950\,347\,286\,940\,009\,331\,363\,840\,000, \\
& \text{cAMP} \rightarrow \left( \sqrt[5]{0.879\dots - 2.12\dots i} \right), \\
& \left\{ \text{ACp} \rightarrow \frac{1}{467\,303\,743\,075\,288\,459\,898\,256\,161\,899\,709\,399\,040\,000} \times 7 \right. \\
& \left( 2\,864\,018\,173\,962\,235\,991\,539\,615\,685\,993\,886\,231\,232\,512 \left( \sqrt[5]{0.879\dots + 2.12\dots i} \right) - \right. \\
& 4\,116\,830\,354\,078\,578\,662\,206\,623\,047\,169\,196\,850\,759\,936 \left( \sqrt[5]{0.879\dots + 2.12\dots i} \right)^2 + \\
& 411\,411\,816\,621\,556\,915\,966\,260\,882\,408\,519\,876\,606\,400 \left( \sqrt[5]{0.879\dots + 2.12\dots i} \right)^3 - \\
& 217\,641\,050\,696\,266\,683\,384\,632\,909\,183\,332\,338\,052\,500 \left( \sqrt[5]{0.879\dots + 2.12\dots i} \right)^4 - \\
& 226\,692\,098\,271\,926\,003\,706\,343\,008\,047\,711\,944\,486\,875 \left( \sqrt[5]{0.879\dots + 2.12\dots i} \right)^5 \Bigg), \text{PDEp} \rightarrow \\
& \left( 60\,123\,282\,097\,046\,143\,491\,705\,058\,783\,771\,505\,363\,237\,375\,083\,332\,864 \left( \sqrt[5]{0.879\dots + 2.12\dots i} \right) - \right. \\
& 86\,090\,355\,171\,892\,267\,281\,666\,568\,572\,381\,961\,823\,649\,442\,219\,411\,392 \left( \sqrt[5]{0.879\dots + 2.12\dots i} \right)^2 + \\
& 8\,652\,461\,470\,278\,556\,895\,512\,708\,154\,117\,454\,416\,865\,796\,143\,623\,300 \left( \sqrt[5]{0.879\dots + 2.12\dots i} \right)^3 - \\
& 4\,386\,603\,907\,083\,417\,630\,430\,763\,884\,788\,732\,326\,034\,222\,137\,983\,125 \left( \sqrt[5]{0.879\dots + 2.12\dots i} \right)^4 - \\
& 4\,649\,598\,517\,914\,130\,424\,150\,141\,445\,259\,855\,641\,379\,985\,323\,914\,375 \\
& \left. \left( \sqrt[5]{0.879\dots + 2.12\dots i} \right)^5 \right) / \\
& 1\,199\,504\,867\,315\,836\,997\,597\,987\,950\,347\,286\,940\,009\,331\,363\,840\,000, \\
& \left. \text{cAMP} \rightarrow \left( \sqrt[5]{0.879\dots + 2.12\dots i} \right) \right\} \\
& \text{Out}[*]= \left\{ \left\{ \text{ACp} \rightarrow 0, \text{PDEp} \rightarrow 0, \text{cAMP} \rightarrow 0 \right\}, \left\{ \text{ACp} \rightarrow 12.2229, \text{PDEp} \rightarrow -4.31238, \text{cAMP} \rightarrow \left( \sqrt[5]{-3.41\dots} \right) \right\}, \right. \\
& \left\{ \text{ACp} \rightarrow 0.700684, \text{PDEp} \rightarrow 1.00874, \text{cAMP} \rightarrow \left( \sqrt[5]{0.697\dots} \right) \right\}, \\
& \left\{ \text{ACp} \rightarrow -21.2473, \text{PDEp} \rightarrow -24.2542, \text{cAMP} \rightarrow \left( \sqrt[5]{1.02\dots} \right) \right\}, \\
& \left\{ \text{ACp} \rightarrow -1.43359 - 6.30562 i, \text{PDEp} \rightarrow 2.50584 - 1.88607 i, \text{cAMP} \rightarrow \left( \sqrt[5]{0.879\dots - 2.12\dots i} \right) \right\}, \\
& \left. \left\{ \text{ACp} \rightarrow -1.43359 + 6.30562 i, \text{PDEp} \rightarrow 2.50584 + 1.88607 i, \text{cAMP} \rightarrow \left( \sqrt[5]{0.879\dots + 2.12\dots i} \right) \right\} \right\} \\
& \text{Out}[*]= \left\{ \left\{ \text{ACp} \rightarrow 0, \text{PDEp} \rightarrow 0, \text{cAMP} \rightarrow 0 \right\}, \left\{ \text{ACp} \rightarrow 12.2229, \text{PDEp} \rightarrow -4.31238, \text{cAMP} \rightarrow \left( \sqrt[5]{-3.41\dots} \right) \right\}, \right. \\
& \left\{ \text{ACp} \rightarrow 0.700684, \text{PDEp} \rightarrow 1.00874, \text{cAMP} \rightarrow \left( \sqrt[5]{0.697\dots} \right) \right\}, \\
& \left\{ \text{ACp} \rightarrow -21.2473, \text{PDEp} \rightarrow -24.2542, \text{cAMP} \rightarrow \left( \sqrt[5]{1.02\dots} \right) \right\}, \\
& \left\{ \text{ACp} \rightarrow -1.43359 - 6.30562 i, \text{PDEp} \rightarrow 2.50584 - 1.88607 i, \text{cAMP} \rightarrow \left( \sqrt[5]{0.879\dots - 2.12\dots i} \right) \right\}, \\
& \left. \left\{ \text{ACp} \rightarrow -1.43359 + 6.30562 i, \text{PDEp} \rightarrow 2.50584 + 1.88607 i, \text{cAMP} \rightarrow \left( \sqrt[5]{0.879\dots + 2.12\dots i} \right) \right\} \right\}
\end{aligned}$$