# 机械原理

## 平面机构结构分析

### 自由度计算

#### 计算公式



其中为自由度，为低副个数，为高副个数，为活动构件个数

#### 低副

常见的低副为移动副与转动副

|  |  |
| --- | --- |
| 移动副 |  |
| 转动副 |  |

#### 固定构件

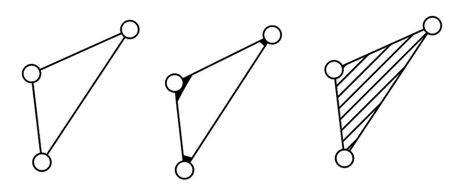
构件分为活动构件和固定构件（机架）。图片包含 图示

AI 生成的内容可能不正确。常见的机架：

手机屏幕截图

AI 生成的内容可能不正确。\*该图与上图定块十分类似，但是下面的图滑块是可以运动的，而上面图的定块是固定构建不可运动。

#### 活动构件

形状

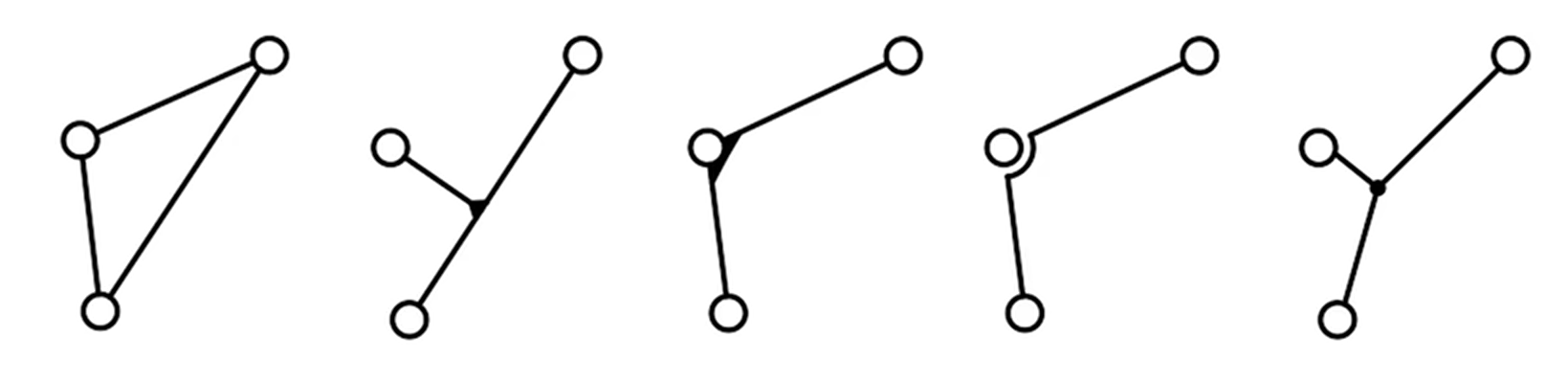
AI 生成的内容可能不正确。图表, 箱线图

AI 生成的内容可能不正确。常见的活动构件：

形状, 矩形

AI 生成的内容可能不正确。图片包含 图标

AI 生成的内容可能不正确。



线条连续即为同一构件。

上图所有三角形等价。其中拐角的阴影代表焊接，实心的阴影代表桁架。

#### 高副

常见的高副为齿轮副，凸轮副，圆弧高副和滚子高副

##### 齿轮

图示, 工程绘图

AI 生成的内容可能不正确。图示, 工程绘图

AI 生成的内容可能不正确。

图示, 工程绘图

AI 生成的内容可能不正确。

两齿轮接触点为高副。

##### 凸轮

形状, 圆圈

AI 生成的内容可能不正确。图示

AI 生成的内容可能不正确。

左图1虽然线条连续但是明显是分开的（否则转起来断掉了）所以不能认为是一个构件。

##### 图示 AI 生成的内容可能不正确。圆弧和滚子

#### 基础机构

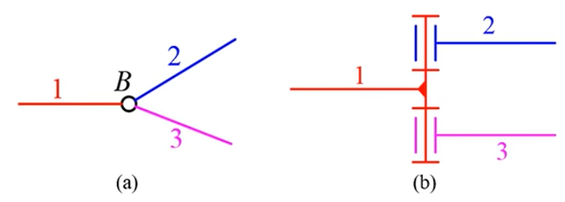
#### 图示 AI 生成的内容可能不正确。机构的运动

机构原动件数目等于机构的自由度数目且自由度大于0时具有确定运动。

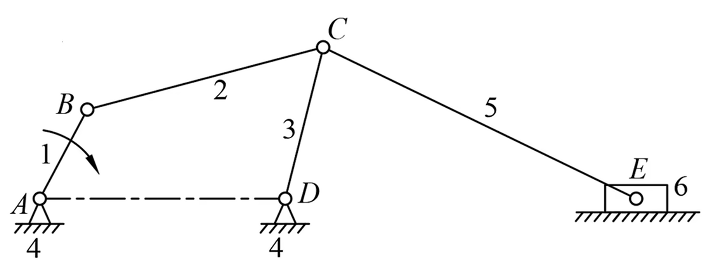
如果机构的原动件数小于机构的自由度，机构的运动将不确定；如果原动件数大于机构的自由度，将导致机构中最薄弱环节的损坏。

因此题目中**自由度大部分为1或2**。

#### 复合铰链



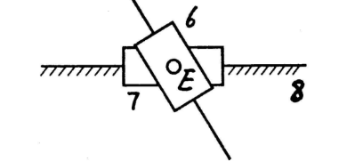
*C*



图中的C点看似是一个转动副，实际上画成俯视图为两个转动副。

当构件在同一点形成转动副时，转动副的数目应为。注意，这里的是包括机架（固定构件）的

注意：右图不是复合铰链，因为转动副只连接了两个构件



#### 局部自由度

图示

AI 生成的内容可能不正确。不影响其他构件运动，仅与其自身的局部运动有关的自由度称为局部自由度。

局部自由度的表现形式一般为滚子构件。在计算机构自由度时应将局部自由度去除，即将滚子和与其通过转动副连接的一个构件焊在一起再进行计算。

#### 虚约束

在机构中不起独立限制作用的重复约束称为虚约束。

##### 距离不变虚约束

图示

AI 生成的内容可能不正确。

##### 移动副导路平行虚约束

手机屏幕截图

AI 生成的内容可能不正确。

此类虚约束计算自由度时需要去掉一个移动副。

##### 构件重复虚约束

图示

AI 生成的内容可能不正确。图示, 工程绘图

AI 生成的内容可能不正确。

##### 图示 AI 生成的内容可能不正确。对称虚约束

图中红色部分可以去除，效果不变。

##### 高副公法线重合虚约束

图示

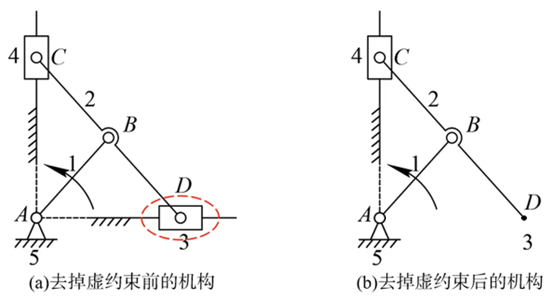
AI 生成的内容可能不正确。

形状

AI 生成的内容可能不正确。

若高副公法线重合，保留两处高副中的一处即可。

##### 轨迹重合虚约束



去掉移动副之后仍与先前轨迹重合，故为轨迹重合虚约束。

图表, 折线图

AI 生成的内容可能不正确。

![图表, 折线图

AI 生成的内容可能不正确。](data:image/png;base64,iVBORw0KGgoAAAANSUhEUgAAAXEAAAKTCAYAAADv4ziwAAAAAXNSR0IArs4c6QAAAARnQU1BAACxjwv8YQUAAAAJcEhZcwAADsMAAA7DAcdvqGQAAFwYSURBVHhe7d2Hd1X1uj76399zGfeOe8/ZSiCNJKQTQhqL3hKQDuk9lFCCFKWTuvrsc60ki6YUC7oEFUWXYu9b3batIgRs+7njO+dayWIBbguwcft8xnhHCAQy8Zzz8J53fsv/+T9ERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERERET032Do8MEFQ0cOXhw6fBDDRw5i6Mg+mMO7oA9uhxrsgmxusT4OH9uDU2dcOHXGefHkE84FiX8OERHdZYOH9xcOhg6G/Oom+NVO+JQNcEttGPA1wulvgluyy6M0w6e1Qw10WuGuDW4PqYPbCxP/PCIiuktEgKvB9pBX7oBXboFqroOst8ErN8KrNELSWyAbrVACbVaJz/1aC5y+RrildgY5EdF/imq2FypGS8jtb4ZPaYEWbIdqtkIxmiHrzfBrTZBFiEdLMVqtn7d/vQVeuRmy1gmv0h6S1HYGORHR3WIHeHPIK7daXbcIaMVogU9tsEr8nNvfCJevEQOeBvS76+DyNcCrNEAxm6AF26CabZD1DivIJY1BTkR0V+h62ziXd63c766HTxVddZMV4mJM4pVF990O1WiNeOWGsCiXz/4oSgu2RdSA6MqbYX9sh09ph0/eBEntCHmlTQxyIqI7STHXJanGunCfe+3oeESMU/zqOgwffQjDR3eFho885Bg6ujPJ6W0YLa/SkCSrrQ5JawlZ4xSlHorRBsXogNvXDlndBq/UKUt617jE70lERLeJanQ4NKMj4vJVQ9LsLtwjtcIc3GGNRQaP7frFblpSWwoVoz3kkeohaaKTb4WkroNqdEGS14UVsysp8fcQEdFtIEYpbl+9rJnr4JPrIavNkJQWKNomqwP/dwEeI6tNDllvj/jkRsjiBajaBkleD8XoYogTEd0psVGKX2mBpNTDLzfC52+BMbgjIkYoiV9/K16lJUlSm8OK1gpJaYCstsLnFy9HGeJERHdMLMQ9/gZISp0V4pIiuuiWsJiBJ379rYgQl9XGsBFYB79cD0lpgl9u4TiFiOhOEiFuBFutEJc1O3xVfR0kuTEsgjnx62/l6NGuJEluCKtGG/yy+MegAX6xskVpY4gTEd0pdie+PuyVGqEajVD05ug8+7eF+JHjOxyy1hJRdDGWqYuOZhogqW0RWW761WMZIiL6DWIh7ldaYQZbIatiDNIUDfGGXxXix45tLzx67MGQGKWIebik1kHWxHhGvChth19qDElSy696QUpERL+Brm8cpxrrZc3cACNgh7gYqWh6Z0SsAU/8+kR2gG8PDQ5vgsdfawe3Fleq6MzbISnNDHIiojtBNdY7NGNDRIw/xDjFHom0QVJaQ7La4ZD0tptu1okF+NHjD0Y7eLsDF+Gt6OLPEh/FcsMW+CXx5zHIiYhuu9hIpd+5ForWYgW5pLRCNzZB1tojsrpeFmGuKC1JR4/utErMwO0A3wHxMlOMUezgjpUI8Lroj0V3L2btHVaQixm5mLfr3MlJRPTHiZGKT6qX3V7RTYuwbYKitUPR1lul6hugGxsjit4RlpXWsCS3ho8e2xExgxutLtv6enHeyk1DXHwUoxWxdFGEeRsktT0iK41hSW2VDWObwzS7kiR9IwOdiOj3Us0NhZLUHpLkDnh8jVC0DujGBmu5oSpOJhQrVhSxkUeMWpqtl5/WC1BFhHczVCMxxGNBfn1HLgLfJzXC42uyRiyqtjFiGNvCqr5BVlUelkVE9LuZ5qZCv9Qc8ksdEGFumJ1WxYe5boozUdogdmbGRi923SzExzpy1WiIlljGKD7as3fxj4Oqi+/zIFRtQ0hVNzDIiYh+LxHkhtEZ8ksb4JfEKGUTFK0TirYBiiaCXPxcB1RdnFIoRi/R8ctokNshHR/iqiFKBHl8iZ+zu3PxD4Kqb4RhbrOCfHBwP4OciOj3EkGuaptCTtd6DDg74PNtgqxshiSLYF8H0an75VZrfh4bq4jt+tbmHnEc7a1C3Ky5saxAFxuNRHe/Hqq2FYOD+0LB4B7H0NA+zsmJiH4PSdpQ6JPWyz5pfdgnrQtL8vqwLG+ySvxY0deFZaU5Wo1hv9wQsQ+/EqcYivCOdeT2OEXWqqHoa6GaiVUN1ai1xyxWR77B+gdjcHBvRNU3yezKiYh+J0naOM7rXZckSlE2JXkV+6NV5roksUzQroYksWxQkhtlzWiL6Gab/RLT2vAjArzWCnFZWw3FWAPFWDVaqrnGCnNFr4nOysWMfAMUdQsGh/ZB/H8EDHIiortAkhrGiXPFFa0xJMLY7sjF5p9bh7hdK60uXdFrrQ4+FuSqvhnDw3aQm+Z2BjkR0d0gqQ2FmtEaEksJ3b4a+KQaSGpNNMjXWGEeH+iyvgKytgqKLkYrsRm5WP3Sbr1YHRzabQU5lyASEd0lktRQKKn1spiVm8H11o5OvyyC3O7KJVWEuQjxNZD1lZB10ZGL0UpsRi5GK+JYXHvTkRl4EIODu0PB4EOOoaHd3BxERHSn6UMbx8lqvUOS62UjuD4idneK9eH2rFyEuQj1tVYXbof42IxcD9RCD9RDN5usrlwsaxTLHFWtM6IbXWFV75AlriknIrrzRJgbwfUOI7g+JEYk9tpysYoltpuzOtqF26UHRIhXR6sOutkI3WyGeGFqbzraBN0Qa8rbQ7K63sGunIjoLjDF1n61OSR2gIo7OO1LmUWI10bXjYslh7EQj5UI8loYwQaYg83Wcbn2gVvtkJWN0I0HI7K6QTbNrezKiYjuNEltKZTUJlmsL5fUhoi9iiW6NT8a5NeHuB3kRlAEeT2MoHjpKeblLdERi9iyvx2K2hkaHhbz8l3syomI7iSxFNEc2pQUDHY6goObrBuBxLpy3Wywxyejo5SxIDeCNVaQ64Eae15ujVhaoBvroGhiy/6DGBraHTGMLTLDnIjoLjEHNxVqRksoOLTJDmWz0Rqd2C82bwxz+3MR5GJWHj1IK3psrmFuxfDwbivMdWOrPDi4hyMWIqI7zTTbC3WjRQ4OdkZ3ezZYAW0ERVcuAjsxxKvtpYjW2St2kNsbhNZZF1noRheCg3sQHNwdMhnkRER33tCQuOuz1RqvmEFx3G2TvcTwJh15bBni2JpysRRRrF4RSxFFV74OstIJXd/OICciupvs8UpzKDi00QpmIyjCPDYLF9332FLE0SAfPQ0xukHIWlculiJ2WpuErHPKjfUOXgdHRHQXiPGKHeSbrFUo8XNy67As67wVsW0/unXfOh0xdrStOPZWrGARG4varAstDHMLjMC2iKqvl3npBBHRXaCaLYW60WTNycUNQH5Z7PAUB2TZG4PEDk+xXX80yGMlft06ETF2JZx48WkfcSu6ckXtCKnWBqE2duVERHeSmJOLZYi60ShLWk1ErF4RB2lJ6mpIanyIx1cszGPH24rgF+vQxS5RMS/faHXlsiq27bezKyciutNEmMtqjUNSa0Pi5aVfiR2gtco+/XA0wOOPtx0btdinI4oxi72Kxb5mbjMktTXEICciuksktbZQUqtDYhmiT1prdeRjR9vGOvP4EF8d9wJUzMvt0xGtCyuiFzSLIJfVDr70JCK6G0SQ+5W1IUVrgdu3Gj5ZjFbs88ljnbl9ImJ8iI+tZhmbmTda57eIkxF1oysicbxCRHR3iJeeXmmNdRWcuD1IBLlfWW0F9I2XTowFefzM3F6S2GS99BSHaRlml/XSk0FORHQX6HrbOJ9c4/BKa0NWkEsiwGPXwIkzyscunUi8Dk41RbCPXdAs1pXLagd0YyuDnIjobpKk2kIR5D6pAW5ftbUU0b4KLnbhxOq4Wbn4aNforHz0Ojj7hSeDnIjoLhNB7pdqQz5/C8TtQT6pLtqZXx/k1l2e+nIoxopokN+8Ixdb9g1jq7WeXDE38So4IqI7zWt15PWyV6oN+/x1EZ9UjwHXSrh9q6yZ+Y1BfuuOXMzIJXkDNL1LrCcPq/oG7vQkIrrTxDnlXm9Dkk+ud0hqi+yV6sPiomZxSbOkinl5fFceC3H7xWfsTs/Y2SuK1gFVF+eUb7WugtOMrpCsdjp0neeUExHdcZLUNs7rrbYC3SutCnmlZrh99tG19hJDcQZL7FLm2Bnl4rIJcQyuuKBCnL0SOxXRvkEo2pnL4l5PhjkR0V0iRi2S0hCyxiRKk3WmirWDM3polh3gsbI7cjvM7QuaxU5P+05QsdNTHKa1IyKr62XV3MQRCxHR3SBJDYWS2hLSAp2QxNpwrRGKuBnIjB1zmxjk4kIKO8zt88rFaYr2WeViXm4GdkAzNoVUo5NXwRER3Q32Jc0tIWNwK/xaGxSjBVqgMRraiWEe+7loWZ256Mrts8rFTk8zsA3BwZ0R3dgkm4Pb2ZUTEd1pYv23pHfI+uDWiKx3jJ5XPnaLUK11IbNddXFXxNl3etrz8rEbhHRjswhyUaFgcAe7ciKiO00f6hpnBLc4jMGtIb/SDo9fbBCKhnSgfjS8x8I8visXoxUxK7dffIpLmu3dnlaYWxdPsCsnIroLzMGthWr0gmYjuN463VCsFbeDXFR8iMfGLLFZuQjy2CoWsclI7Pi0L56wroPjunIiojsvdkGzojVGr4NrtYPc6soT5+Txs/L4F5+iWqwRi7hBSFE3wTAfZJATEd0t4mRE1Wi1unJZbYasiRl5bE6eGOQ1cfPyWJjbXbluijXl66wgF2ewiA1CvAqOiOguiF0HpxotITO4Hj7ZvkRCC9RDs8J6bBXL9S8/xeilEUYgNl6xD9MSQS7JW6JXwXFNORHRXWEObipUjYaQmJNLWhP8qrijM9aZx0I7/sVn7OdiG4RaYATEMsR18PnFgVpboKidIQY5EdFdIsYrktYeMoe2QBbLCY1WaGYzNLPR7rpvGeQixO0gF5uDdGODtWXfp26BVxUnI25xSLwKjojozpPMlkLZaJVlozUcGNwUXcEiNvyIsYn94nMsyOO68bhliCLIVV109J3waVtFRVR9i3z4MLtyIqI7TqwpN4c2JcliBYvREgoMbbbOLBe3CYkgH+vIY8sSYzU2WhEXO6umCPKNcEkb0D3QAVXbHBo+ssUxdIxdORHRXSFm5bLeJIuuXBczb+sgrWjnPbq2PLZRyA722C5PzWyDZq6DZm6EpG6wDtIaPmK/9OROTyKiu8RawTLc6RgMbQoFBtdbJxyKl57WIVnXBXn8Tk97CaL4WrEOPXRkCwaHN9srWLRO6IYI83aGORHR3TJ4WKxgaQ4NhjZBUuqtSyfGtu3HB3lsaeLY8bZGQKxeEUsRm6FoLdbWfcPcYm3bl+T18uDgLs7LiYjuNBHkdke+AX5ZBLm44k3MyRtgDoqPiR25vdPTvgrO3iRk7/Zsss8rVzYgOLhLVOj48T2OY8f2sSsnIrqTRJAHhzvlweHOiNVVW+eviAC/fhnijdv247bvW1v3RVcuDtOyNwnpRlckOLRLZpgTEd1hsTl5cHBDKDi0MTont1ev2Nvyx3Z63ljRX7tubfl6KJq433Mbjh3fEzl+fI987NgejliIiO4k0ZWL1SvBwY0Rv9xgn79ibQ6KLUVM3CAUH+yx88qbrfPKxRksuiGCfAsGh3bh2CO7rRHL0Ud3J4kylU2j5Y0r09yZxJejRES/k33+ynqHrNfLmtEesY6pjYa5ORg/YolVLMjjV7LErS/XO2AGN+P4I3usrtwwNocNvTWsq53WR1VtDUtyp1WK2mF99EqdXOlCRPRHxMLcHOwMWScb6mKXZ2zL/vWd+fXjlbHzyu0jcVshljIODW/G8HAXhga7YJpboGuboGuboWlboGibIcmd8EmiNkNRtyMY3BlR1Q7ZNLnShYjod7OPuG0JBQY7R7fsx84rj4X5TWfk1nglblmi2QxDb4auNUNVm6BrLTD0NmhaKxRxdK7SZJWitkLVxChmC4LBXaJCpsl5OhHR76aa7YWqIXZ6boxYSwlV+1agWFd+qxefRqB6tEyzGqYxVrq+FrpWDU1bDVVdYZWmrYSqrYaiVUNRG6EoHdD1BxnkRER/lG6tYFnvEGEeHN4YCQyKLfj2ckR7zfj1YxU7vNfADKyCGViJQGA5goGlCAaWQFMXQJbmQJZmQZFnQlVnQpFnwO93QJLmQFUrYRiroWn1ULV10LQHETR3hw4P7meQExH9EWJWfvzEDsexR7eHgqGNMIfa7cskRm8RsjtyI7AWRmA1zMAKBAIPIBhYhMHgHAwGZ8AwimEGinD4SAlOnpyO06cqcOJEBY4dK8fRo7MxNDQXgUAVdHMVNK0BirIOhrETqtrJICciuh2OPbq9UAT58RM7EDrSCXOw5brr4MZCfCkCgUoEAjMRDBTjyJEinDhZiGfOluLVi7PxzjsL8P57C/DW2wvx1luL8frrK/HUUwsxNDwHqr4Imi46cjFH70QwsAfDw/vloSFuHiIi+sMePb2r8OSph0InTz9sBbm9tLAehhkf4ktgBubBNKchNJyDxx7Lw6uvleHzLxbgm2/n49Kl+bj03Tx8991iXLmyEl99tRavvrYYxx+ZAVWbAd14AJpeC1Vtg6E/iOGhfZHh4f2OxGchIqLfQQT5iVMPySdPPRQ5+shmDA63wjBroRtiHr7aGosY5gwEg/k4eTIbL708BZ9/6cD3P8zFDz9W4Nr3pRi5Ng1Xr83A9z8sxMjVFfjiq9V4KbIER4/PhW4shKqJsYpY2bIJoeH9MPRt7MaJiG6XU6d2jTtx+iGH6MpPnOxCMNhorToxjVXWLNwwyhAK5eDcs3n48KMSXLo8Dde+n4KRaxkYuTYJV0bScXkkB5evFOHylTkYubYaH39ajaeeqYIZnAdFXW7Nxg1jI4aHdosQDw8NHUhKfA4iIvoDRFf+6MmtocNHN0LVxBLCFQiY82EaxTh6NAsvXsjD51+U4PJIAUauZuLKyP0YuZpklQjyKyPZ+O5KGa6MVOHTz1bg3POLEByaDUVdClWthWGsx/DQLgTNTQxxIqI7QXTkJ052RawVK9pKBM15CBhTcPxYBiIv5+KLL4oxcrUAV69mYOTK/bg6koRrIxNwdSQNIyNZGBkpwbXvF+Hrb8RIZTFCh+dAVhZD1aphGB0YGhTLDUWI72aIExHdbidObHEcProxIgfaIKurYRjzETCKcOxoBl66kIMvPi/B1ZEiXL06GSNXJuDayER8P5KMayOTcPVKNq5cKcW1a5X47nINXr24DIePzIWsVEGx/qxWBAObMTS4MxI0Ovlyk4jodtpvbi/cb2wP7Te3o1tpg0+vg2ZUwTRKMDyUiefO5eKLz2fg+2sO/HCtCFdH0q0O/NpIKq5eycLIlQJcuTITI1eX4vMv1uL8i0sxFJoX7cTXIBBoQTCwAQFxi5C5IWSam7hmnIjodqj17iqs9uwK1fRtQ3P/Jjwkb4TLbINkroBhzoShZ+Px0zn44P2ZuPLdPPz4/QxcG8m3uu+rYoxyRYxYKjAysgj//Ho53njzAZw8Pc96salqy6AbaxEINCEY7EAwINaMbxUzcgY5EdEfleuUCit694Uch/Zg/sHtqPE8hG36LvQENsNrbQCqgqZPQ2goF8+enYaPPpiFkcuL8NMPs/H9tXJcuzoV167NxA/fV+HKldX4+ONVeOqpOTAD02GYC6GbK2GY1TDMeqsbD5gd1kvOYGALTHNryDA6HbrexSWHRES/RYZLGpfjVh25TilU2NOH3AP7Mb13H5a496Nd3YvdgZ3oD66DHFgN1ZgHQy9GaCgPZ54oxLtvz8I3/1yAb7+Zg0vfzsClS5X46qsH8MH7S3H++UU4dnQmdH02DHOxdQaLHeK1MMTpieJERKPVetFpmp0IBLoihrFeNs0N7MqJiH6N1D6pMK3fJ+e41EiWS0JGnxvZTg+mDvRhpvMQVvn2Y6O2B3uNLfCYzVACq6Dp86GpJRg0C/DYqWK8eL4cr7xSgYuvluLixdl44YU5ePLJ2Tgmzk8ZnIdBsdvTWB4N8Jpo1UWDvNHqyk1x1rnSIYI8Ol5hkBMR3VKRpI9LHfA50vr8oVynjLR+PyYMSEhxSkhzych1eVDs7Mdc5wGs9e7FFnUHuvUN8JhNUIxVMM0qBI2ZGAyUYnhoCo4dLcLx4wU4dqwEhw9XYHhoFgaDC63TDoPmSgRM0YXHAlyU6MZFie39DfbLzqA4IGs9zOicfJi3AhERXW+GpI/LGpAdyb1eOc8pR3LcKlL6JSQ7FUxwa5jo0ZHs0THJLSHX7UXJQDcWuvahVdmDh/Xt6DU2wm80QzOrETSXIWAugmnMgWnMRCDgQCAwx1qOaIrxibkMhrEShti6f10XnhjmsSBvhhloh2GsQyCwxVqCaBgb5MHB7ezKiYjKJbMwY0CSp/q0SL5LQUqfDxP7/Zjo1jDBrWO8R0eS17QqxaMiwyOjwDmAioFDWOndh07lYew3d8JtboZfF7PsOuj6Guj6cuj6UujGEvujvgK6LsYua6Hp1dD0GuvjWPcdqxs7ckNcUmHNyUVXLrbn78Tw4M4Qg5yI/rJE950zIDsq/EaosM+H5AMDdoA7Favrnug1rAC/P1rjvSYmenWkejVku32Y6hrAAtdB1Lp3o9O7A/v8W+FUN0HR1kG1rmdrgGnWwzRrYZp11o91ox6qLqrBKkWrg2qtNxdXvYkSl0/EnVueEOSBQBt0vQ2q0m7d5SmC3B6v7EziiIWI/jJE950zIMkVfiNS7NOR6RSjExkT3aoV1BO8BiZEu+9YiCd5jWiI65jskVDo8mC2sxdLe3ejvvtB7PTsgG/oAIKhPRgK7cThww/i8OEuHD68BYcPb0YotAnDoc0IHdli1fDhzdYly6rRYt3tKa6Es467tZYt2jcJjXXk4oWnCPPofZ5GKwKmPV6RtQ0R3egKB4M75ODwQ5yXE9F/L9F9l/sMq/ue7jeRK15YOv1IcStWcIugFiU68Pgxivg1EeApHg1pbhXZLj8KB9yY0duDygO7UePaHfEO7g8HQ7uvq8OHt4VDoU6rDh/eHA4d2Rw2jPrwo6d2h0+c3BM5cWoPQke6YAY3QDVaoZstcUF+s/HK2OoVK8zNNqh6BxRtA3RDnLC4M6IbmxjmRPTfx5p993ut7nuKU8KkXi9SBvxIcslI8uq432taIxNRdnCbmOgxrErx6Ej1qMj0qMhySsjrc2NarxOVThcWOZ2hHe4dDu/QgSRR5tDuJHu8sTPp6NEuq4aGNiUdPbop6dHHdo/WiRN7HI+e2iPHAj0wuBmK1gpFt7tycUmzHdqJLzyv78x1sxm6CHOtA7qxWQQ5BocfssJ88PAuzsyJ6M+tzOq+VUfGgCdU7teQ2etCco/LWjo40athvNfA/T4D9/nM0SAXIT7RYyLZYyDVoyPNpSDDKSFnwIcipx+zvTJmeaVI5YBLXuR0/u6gPHVq37hYoIcObw0NDndB0cThWo3WJc12UMd35DcL8+iLT9PeIKRFw3wo9DAGQw+FGORE9KdVLqmFGb0uudyvRXL73Mgc8CLV6UeyW8F4jx3gIrxjJT63Zt9W920g3a0h06VCrBkv7PeiwunDfJcUmTLgk2f5ZMcMl3TbRhaPnt5TKKut8uBQV1gzWiO6KcYrIpwboBviNqEa6Eb1DTX28tMesYiXn2IVi25sRDC4g0FORH8+ovsulVVHRp8rVCZpyOxzI7Xfi2SnhInR+fd4b8DqukX3HavYy8s0r1gTrmLygIRCp4wKl4QFbhlrjeHQGmPYsVYfum3hHW/oWNe4oaNdScHhLQ7NaAnJajMUTaxqEUFeZy1JvD7E11o11p3HuvIWaxWLrm+AoW9FMLg9xDk5Ef0plES77zK/Fin2ykjv92BivxcTXLI1PrFfXoquOzga5LGXlyleA2ke0X0ryB6QUNTvwzy/LsIbjYOHQw2Dh+9aR3v48NZCzVgfEnNyv1wPRa2Hqtpry8fCXIT4mmiQ39iVG0abNV5R1U3Qta0RXV8vqyq37hPRPWiGJI3LH3Bbs+9Stw/J+w5Zs2+x8iRZjE48IsBFeIvgFhVEkjdglZh/p3oNZHh0THapyO/3o3TAj0q/jqbBI3c9wGNEkIdCXSHdWA9FbYaqNUIT68r12oQgt8M81pEHAvUIBsW6cnu8omntkKR1IsihaRtCqrqeJyMS0b1jhiQV5g+4ZIfPHyn2+JEhXl4O+DDRJUeXDopxyVh4x2qibxDJ3iDSPSYyXBpynQqKnAqmD0hYKptoHDwSaQoekf8TAR5z7NiuwqPHdoVCh7chOLgBgWC7NTIRG4diuz6v78hrEAjUWUEeCIht+7FNQu3R8cpmBPSuiCp3yKrU/h/7exERWUSATzrUG3L4/ChwipeXHivAx7tUe8elN4D7vUHc5x3E/d5BJPmGMMGqQaR4g0jzBpDlNpAzoKCoz4+5Hh0r5YDVfTcFjzgaho79xzvWRx/dX/joyX2ho8d3IXRkK4aHxUvLduhG4+isXBNb/a0wt89jsYM8Fub2qYi63gJNEzs+1yFgdEFVOkIMciL6jxDjE4dYIeJXQlN6BzCpuxepvU6kOP2Y4FZxn1vDfR6x+kQE+PUhLjpwEeDpHhHgJnL6ZBT1+DDfrWOFFIjMdev/0e77Zk6f7is8depQ6MTJfTh6bAeOHtuG4WGxyccesdirV8ZWsBgBEebVCATFeCVuXbneBFW8MJVboWudMI2tIdPcek/9XYnov1xun7cwp98ll7n9kYyDPUg51IdUpw/JLhHg9vJBsVU+FuKiExclRiixDlyMUCa7NOT3Kyjp9aPSa2KlZN4z3ffNWEH+eF/o1OluPHpiD44/ssPa6CMp4jwWcQaLqBrrNEVNHHMbWItAMHZSor2uXHTuY2HeAkXugKZ2hgxji0PXN96Tf28i+i9hvbzsdTuy+5yhmX4FOf0upPV7rO7bWjroESOU6Aae6Bz8Pp89C5/gDSDZE0Cq27TGJ7lOFUV9Eqb3yVguDWKZNBhaKZn3fEcaC/LTj/fhxMn9GA5tg6q3RzcIiaqHatRCNddCF914ILZy5fowtzvzZuh6q3XxhKptjEhquyyrHQ5FaUnii08iuq3E7Du31y3P9MuRMo+ErD430ge8SHGLtd8ykhICXIS36MTFjyd4xDGy4uWlgRynhqJ+BdMOeTD7kAfL/YORil5J/jMEeIwd5L3yqdPd4dOP9YaPHd8RkdV2SEqztW1f7PYUQa6ZoiuPX72SGOb2iEXTWyB+v6p3QlLbIj5pXdgnrZclicsRiegPinXfeX2e0EyPhNzufkzqcSK5z4uJLglJHrF5RywfFMfFik089sad+zziBEJxGqFhjU6yXDpyevzI3+dE6d5+zDrkjiyTgvIyOehYLt2ZzTt30qlTPeMee6wnSdSJE/sdw8PbZFVri/jlZkiK6MhFmNdDFUEet6bcMMWIpSZuVi7CvBGqJn5fi7XT0y+th6ZtgyK1hiSphUFORL+PPfv2yg6fGnH4VOT1eZDe67FOHhRb55NcY9vnxfkn98dC3CNOIjSss0/S3DomDyjI7/Fh2gE3ZuwdEB146M8a3rcyNNQ1bnh4m0NS14d8/hb4pMbRrjw2K7dXroiXnSLEE196NkHXm6GoLZCkFvj94sXnZivITZOXTxDRbzTDKxXmHRoIzfRKyOsesA6fynTJSHUpSHarSHKLDTzRSxtEcCecfSICfJJbQ9aAgoIeLxw9fji6/ZHi/S55mTT4XxtKg9YGoe0hWV0P3VxnHW9rz8pFkMcfphXtyAP25qD41SsizK1ZudwGn1ecxfJgyDC2cYMQEf17ZbGlgx4pVOGVkNndj/ReFya5Zfvcb7eGpOglDbHxSfzWeXErT5pbQ4ZbRY44+6TXi/KDLszu84eK97sdM3pu36FV96rDh7cXakZHKHRYrF5ZB0Vvjl48IY6ujZ2MGFtPbnfjdkc+dl65tXRRa7ZWsEhSBwx9W0SSOmR25UR0S+LUwTJJlcu9/kiR24tJPf1I6XdbLy+TPWPdt7193g7u2NnfsWNjxcFVWU4ZWd1uFOwfwOx+Pwp7PaGS/b//yNg/IxHkutEhDx/eETECG62zylVDnD0uwtwOcrGufCzIY1362FJEcfCWWMGiqq2QpQ6YxoPiajiOV4joekWSNK5cVh2ZHn+oXFKR0dOH5N5+JLu8mOiVMdEnXlzGXl7GwtteNpjkNpHs0pEuZt9uDdn9fuQcGEBJtxuz+v2Rgl6vXNDn/UuGjji1cHh4h0OMVwKDWyCLMFYboYmdntadn7EjbuPPKh87r1z8uujMA4FWaForJKkNmrrJPhUxuM0h5vCJ35OI/mIKvFLhFK8s5/e7IlO8fmR5/Eh1ezHR48MEr4zxPhXjrcsb7BAXYxT71p2AtWww1aVj0oCCnAEZxS4V090qFri1SIVLlRe41dt65veflejKxVnlgcEtEXu8Yt/rqUWPuI2F+di8PDHM661ZuTgVUVzSrCgbEAw+GFHV9RyvEP1Vie57ik92FHqVUEG/G6nd/UgR5564JUzwSBjvkZDkVTF+tAvXMMErbqHXrbl3qsdAhltDjltDfq8PU7vdWOjRMNWphsrdqmOeS//Lh3e8WFeuaC0hVV8Pv9xkLSsU17vZR9eKEUtsyWFimI/dIBQ7f0VT14uOnF050V+RmH2n9bvkKT45MsWnILXPhaQBD5Jcfoz3iDsvFYz3KRgvQnw0wDXrSNlUj2atOrFu3OnzI2dvL3J37MWcQ04s8KihcqfKzvAXSGpLoQhyw9wMSWmzZuViBYt9mUTsSrhYmI915Hanbq9gMY0W6FqL1ZXrqjiM68GIYYiXntwcRPRfTwT4ZKcnlLHvALKdHqS7xJGxPtzvtgNchLcIcbtUqyZ4VUz0qkjzqNaqk+wBGXk9PpQccmP2IWdkgUcNL3Sr8iIvA/zXEEEuxiu6sSkiq+sgNggpavQiCasrj7/fM+5QrWiXboo5udGEgNEKTRHnr7RZh2kZxtaQYYizynkGC9F/HbHzUry8rJDUUPq+A0gbcCHdKyHJ5cN9Lp/deUdLBPiEaE0UZS0vlKOXFUuY0utDWbcH0w95QmLuPd+rJHF88tuIoBXnpBjGppCibYCitUM3xVnloiuPH7GMjVVix9ya4uIJox4BoxGm3ghDb4FpdCBgbhJBHjGMDezKif6bWBcW97vkfKczkn7oEJL7+jHBI7pvH+5z+3G/9QLzxhAXAZ7sUZDmkqwAz+v3Y0q3B45ogLPz/uMktb1QVttlTd8Y0Y0NUMV545o4e9y+eOJmM3JTLEsUQS66cl1UPUy9CabRDsPYCNPcCk1tDw3yiFuiP7dY950x4AxNl1VM6unFhL5+JLm9uM8r4W8eP/7mlXF/XIDHQlwEeIpHwSSvWPftx+RDTkztdsHR7Y5M6fXKJYf+mssG7wQp2pUrantINzrh8zdDVpqgabHRyvUvPO0Qrx4tU6+BqdfBECtY9FboagcMrRODwS6+9CT6s7K77wG5QlIjBU4XMgZcSPP4MNHrx31uH/7X48d9Xtmq+PCOBbjowNPdCjIGfJh8cADFBwes7rv4kNtR1ONiKNwBoitXrVl5Z9jqzHVxP6e9g1OMVmJLEe0QXxtXNTDFz+t11nhFzMp1tdW6QWgw2BUx1A7ZCnOzK4mBTnSPE+uyy32yo8TpCZW4PMjs7UO604UUjx9JHjE6kawuXIR3YgceG6GkRkcoWf0+5PW6UXLIiRl9ntDUQ3+tXZf/CWJWbpqbklSj02EY7SHD6LCWFYrxiqaJez3Fi00xSol14iLExUd7xGIHuXjx2QxDb4OursdgcJsV5oPBrrCudsimuon/cyS611QNHRtXOXzcUeGV5WlOdyS7ZwAZ/U6kuNyY6PFivEesPpGu67pHf2x9Llu7M1M9Mia5/Mjs86Cwx4UZfV7k9bpCU/f38f/w7zJVbSnUxLpybR1kqQmK0mAFuXU7kFhyaMSCXAS4XXZHboe5CHLRkZtaBwL6RhjaZmhqlzUvV1Xe7Ul0z1g0eKwwq9ctV3jlSEGfG2kHxbZ5J1Lc9vgkySdZHXjii8tYJXtlpHllTHL7kdbjxOTuART3ezGj1xvJ7XXJBezA/2NiQW4YYgnhOshyPRRF7PKsh2HYLzftioV4tRXk1s8Zdkdu6qLsWbnka4cibRGBHlLZkRP9Z8W670XDx0LTvQqye5xWCKe7/EizRiMyknzXrzyJD3FrdOJVkOmRrVvqxe+f2udBeY87UtDjkqf0cv59LxBBrqodsiw3RHR9HXw+EeQN0PVGmGY9Ambd2GoVqzuPdeaiGxdBLubkYl15GwLiHwK/uNdTBLnoyLmunOg/QnTflcPH7e67x4msPg8y3RLSPLK1qkTcuCM278QvH7zuxaVXsb42yyMj3yVZo5OKXg8mdztDDO97jwhaVW11SFKTrOsdEVlqto6qFUfWmmYjAqNhPjZaGevSxZrysQ1CQXM9AmYnDH2LCPOIoW+R2ZUT3UUiwEX3XTl8HFNEcPe4rMuKx8Jb7LQUh1aJs09uXHWS5lWR4VGQ7ZKQ3ePC1IMDcDglq/vm6OTeZod5k0PTNoTEtntVFRdINMcFuR3cwUCs6hAM1CMYaEAw0Iig2Yyg2YagKc4o74CirIMmZuXa+pCqdjokqY3/eBPdKfHjk1IlgELZtC5rSHZJ1rZ4Ed73W9el6bjfJ0qzVqAkrvue7FaQPeDHlD4vHE4ZlZIZqpQNR5XEXZd/FvaIpTmk6xugyKIrF2vE7SC3Q1uE9y8FeYvVlYudnrq+3rqkWda2RiS1QxZLHRO/HxH9QeWSWTh5QJbL/YFIzoAfk5wS0r2aFd72RcWGdVVa7L7L+6zScF80xMXLSxH4k10ycnrcKOp2o0oKoLDPE1r0J7ppnsaoklhX3iQPDnZGAuZ6mCKUox25HdoiwKtvEeRNVpAHzXaYZoe17d+viGNyt0JSO0IMcqLbpEzSx5XLhqNCMkMVUgCZfT6k9ovRiYqkaOdt3XMZLfu2+ejFxdFOXAR4ultCrlvClAE/yno8qPIHrJ2XDPA/t2NDXeOODG9xHA5tDQ0NbUIg0AZTzL5NEdYiuGv+fUdutsEwW6HqHZDUdZC1zZDUdgY50R9V0CcV5vdLcrlTjRT0S8h2ik049kXF4j7L0YuKE8q+sFhc4KBaq1PSPRImO72Y2u/FPI/C8cl/ocOHtxaKID9yuAvB4DoEAi0IBBqtuzt/ebQiXnaKc1ea7UsntDbIaoc1XhHHABzj+StEv4+40iyj1xMqd6nI2D+A1G4PUp3ixaRuBfh9Hn20RsNb3H/piZ37rVq7LlP6XZh0sBcFB/uxyKeJJYQcn/yXigV5KLQNgeB6mIFWaz25WIZoh3d8xQV5QAS5OKdcBHkrxHZ/RW2Dqm9EyNgQeiK4w3FmaGfSmaFd/Eef6N8pc0nj8nt9jnKnGpo2IGHSQbH224s0l4qJ0YuKRWD/zTtWdoBrmOhWkeJSrBMHJ/d7kdPjRP6BXhTv68YDPg1LvCoD/L/csWPbC48c3iofPfpg5PDhrdZ4xXrhKY6uNWPhXWd16IFAPQIBcYenXeKccvtyipbRrlxRO3A8sDVy1FgXPh7YIj8xuOs/8r8//3rxzLh/PX8mSXxM/DWie0bWIWfh5B6XXO6WxAXDyOz1IK3fj9S4AI913yK8Yz+2A1yMWmRkOSXk9roxtceFuW4JS3xa5AGvGl7iVeXFPDr2L+HYsa5xR45scxw9uj107Oh2DAbWWTs37U0/DRgMNmIwKAI8FuR22eeXxw7carZelIpTEUPmRjwS2Ionh3bhicFdoWeMbY6zZlfSoz3VVg1tmp/0aMvs0Xp+VdFovVSUnlDJ0bI/vxirkriK+/zN6qqk12sqHXjhDGIlPhc/f93X36xKJlvf40xJXtKZeWUMf7pzxJGxOb1uh9hoU+6RrbXb6b1epDklpIj5d0IHHj9GGQtwcWCVF3k9LhQf7Lc676ndztASn+pY6lWSOP/+6xFd+bEjD8qHD28NDwY6IvbW+3oMmk04PNSCoWADBkWQX3cx81iYBwJiBUszQkYbjhnr8JixCWcD23Baao080lMdNrsWhEOdC8KPts4ZredXFVr10tTUcGRqevijspTwF9MnWT+2S/y8Xa9MnRR+tXhS+PWSjBvqtal2vV5TFX6jenHkjZrFGK3qxRHx87GvuVV94CgMv1I82apwWa78xPxyNjF0+5V7pcK0fq/VfRc5fZjU40JqnxfJTtkajyTFBXhieE9wiw5dQYZYOtjvRe6BPhQ8vB+Let3W6ISdN4mu/OjRnUlPnX7Iceb07tCZx3bj1LEtOB5sw7FAM46a9RiOnYoYiJ1ZXjvanYu5echswjGzFSf1Njwmt+KRnmoEuhZCWzcboc4FONE2F0cemILBihQcnnI/HiuagOempeGF4jS8PDUNkeJ0RMTH0UpFZGqK/bEoHa9OnYSL0zLwekkmXivOiCvxuV0Xp17/+XW/Ni0Tr06zP9pfa9cr0ybjpeJMnCrOwtD0KXhifkWIQU63jXVhg092VHiVUH5PP9K7+5HWHxfeYtNO9GXldStPPJq1tFCEd6pLnDgoIavHjfyD/XB0O7GwxxUpPtjP0Qnd4InTewrPP34wdP7xgzihteGYvw6PKjV4NFCPI8E6DAZEN25fAWePWuyXoMNmPY4EGnBMb8AJrQFP6s04q7fgWa0VkeAGvCu34/WdS3B+9RQ8N2MiIqXj8ffyVHw5fRIuTc/A5YoMXKnIwEhCXS3PxLXyLKt+qJiMHysm4+fp2fh5eg5+rsjFzxV5Vv1Unouf40p8/mNC/VCRi+/LcvBDWQ5+FB9LsnGtNBsj5bn4cMYUhMvzMDR7GkRHztEK/WG5fVJhTr9XrvDJkZx+F1K6B6xt82JViQhpO7DF5h17A0/8yhPr5aVbRrpLLBv0I6fXg4J9vZjV48KiXpc1PuHohG7ludP7rSB/0teGw/uW4sShpXjMvxanzTocM6oxaETPJw+KbtxeljgYqLW69cNGLY4ZtThh1OExvQ6Pa3V4UqtDRGnA++4afPLwEnzUVIb3FmXg0xnJ+OeMVFyenoqRilRcq0jF9+Wp+DGufi5Px89laUBpGlASq0lASUa0MoFpWb9cJXFVnHljTcvEN+W5eLU8D08uqEC4LC98Zv70pMT/LkS/Sq5LGpcz4HPkDvhD030KcgbE3NtnhfLE6NJBO7jNaBm4z63hfreK8S7VWh8u1olnDviR0+dFUa8HU/f2ig48kn+wX57Bc0/oV3jC1+p40tcWObx+Fh5pL8fpXQvwlGsVnlBrcVyvRUh04kExXhEd+fVBHjJrcSQa5kf1GhzVanBGrsZLUo0V5F8cWoVPN87B+8ty8fbcVLw/cyI+mjERnzgm4nNHMr50JOOr6XZ9PT0F31akYKQ8BT+XpdphPi3druJoTcuwqzj2cdIv19SEKp6Ey2XZeLMsG0/NL7VC/CxDnH4Pu/v2Wd13sZhji5UnVvetYqK1MScW3IHREL/PreN+t4YJYoOPU9w2L2bfPuR2u1Dc7USVV0elRwtViu6bt83Tr3TG25L0pLc1fLppBk6vLsCJxql4fNtsPN2/Ame0Opw06zAUiF44Ebi+Ix8SZdqBPmR17tV4RKvGU0o1XpZr8aHciH/0rcWHW+YisiYPLy2ehFcWpeO1hel4bV4q3hQ1NxVvzU3Fu3NS8d7sZCvgv56ejKsVqfiX6MxFRx4f5FNvUbf69aJoRT+/WjYZb5dm45n5ZXiFIU4xuT2ucXk9ziRRk3u8v1hZvbIjrU8KFbtk5IpzT/r8SOkXR8bqmGjtvIzvvu0QFz833iUCXEWqU8akPp81OinqdWNmvw9VXi0ypdct88Z5+q1EiJ9tmB0+1zAHzy7Nx5lV+Xi6tQzP7FyAswMrcUapwXGzBiFTnLsiglyMV+wfDyaU+LnDZjUe1atxRqnGebkGb0h1eLtvFV7dtRCRzbPwaudMvCZq/XS8sW463lw3HW91TMe7HdPxQft0fFpfik8fyMUns1LxRWkSLpdMjI5WfiGob1WxAB8N8knWbPyd0hycW1CBN0qzGeJ/deKc7az9hxz5PS65sHsgLCq/xxnO7vWGs/t94cxebzizV3wUJYVzBuTwVKcUyRW7LQ+5kdovIc1tINljYmI0rBM78CS3gQluHclOEeCiaxdLBz1wuBVr1yW7b/ojzjbMtkL8QvVsXJg3GReWFeCVxjKcXzcd57bPQ7h3KZ5Q1uKEXm0FuejK7YO0xioW7KJEmIuve0SvxmNaNcJyNc77qxHx24H+llSHd/11eM9Xhw+i9aGvDp946vClrxHf9lbjs865eHd5Lt6ZNRGflE/Ad2VixBIdrfyarvy6EE+LVizEc/CuCPH55XhmTmn47OwShvhfVdb+Q4Vp+3vk4t6ByJTuAeT3uJDT50N2vx9ZfT5k9YmPoiRk9YruWUaa6LhFOVUkO8WLSRHQovsWAR7rvq/vwCe6devrJw0oyOr1I2t3Lxx9Eop6XJEpvS523/SHvNfSkPTxstnhV1bMwIVpE/DqnEl4d0UhXqmeghfbSvH8jrk417cMT/nX4JRhd+XDph3WIrTNuLJn53awiyA/athd+WmtGk9qNXhGq8U5rRbPqXY9r9bivGLXS3ItXpVq8Y67Gn/vXolPt1fik5YKfLIsH5/PycC3Isinpfy2jnw0xFOBqWnWz4lOXIT42blleHZeefjR6haG+F9R1qG+wsz9h0JF3X1IfWgP0g/0ILPPjYwBLyZZ5YsrCZOc4iWkGIdEy61jgieACd4g7neJF5aiAxfBfWMHLn5fRr+C7G4f8va5UHHAgzXaI6HW4acca/Vj7L7pD4mF+NvLZuC1gvvxZvF4/H1uBt6uzMTFFTm40DgVL3TNxvnupQhLa/GE9SKzGkNi5UrADm8jPsSjFRu3iDA/YlZbv0cE+knNDnVRolN/XLXrSXktzvjX4Dn3KrzurcFnvkZ801uNkV3LcbllNr5ZmIuRsjQ7yGPdeGJoX1citEWJAE+JfoyFeC6enVfBEP+rEh345O6+0LS+AaQf6EZmnxM5Xj8yXS6k9vcgtfeQVWm93Ujr7UFKTy+SewYwsd9rzbRFMCdZZWC8O2CFuFVxIW534AZSXToy+hQUDmhYoBzBGv0RtAw/FWoZfJrdN90WIsTfaW0Mf7xsNj4pmIBPC8fjm/IUfDYjBR/OTsUbVRm4WDMFFzodeHZfJZ7xrsJjut2RDwXF0bYJnXh8RYNcjGDErNwKcqMGp81aqx4P1OEJsw5PmnXWPw6P6zV4UlqDc/61uCjV4mO5CSP+Vvx4qBbft87FyLwcXClJBoqjQX5DcCeGeCzAk0dDfKQkG++W5OH5BTNxcm0LQ/yvJjoDl6d29yNLBPiAE0WyF9NUJ4r9e1AiPYhS32aU+Tai3LcJ5d4tKPHtwBT3w8hyHUSyy4kJLi/GuxTrReV4l3hhaYe4CHRRE9wmUlwGMpwGsno15Oz1wtFjiPBGy/CZ91qGnuqMPc+6nqGk+Uu7orUzqeoOlPhzE+tWP/9rKvHPv12V+D0Sv+9vrcQ//3ZX4vdK/P6/thL/3H9Xq5Z2JbUs3ZTUVdWQZAV4W2PVu22NkX8smY1vi9JxeUoyfpqWgqulybhUNhGfzUzFRwszcHFlLp5tnopnd87Fs55VeFqtwQmjxhqZiPGKCOr4F5yxEj8fm5GLjvtppdoK6ed9a/GCdy1ejNZzvrU4K1db3f6TvlV42rUC592r8IGvAV+7m/Djw6twbXUpvi5PwQ9TJgDF9njk1hUf4hNHQ/xqaS7eLSnE8wvmihCPnFzbUiWCvGXVgaSlsVq6+6ZVxbqu7P8mO5MO9BxNWr78T3KqZUmPM6m4dyA8cdd+TO7pQ/ZADwr7t6PcvR4rBtvQ9XQHDlzYgJ4XW3DohTb0XNiI7lf2YPvzB7D80QMoUPYjxXkQSU43xjv9uN9pB7kV4i7RfQcwyRVAjjOAol4TpQd1lO3wYHaXGyseUtHRHUJ793CkozsUnr98R3jBsu3hBUu3hxc+sGO0KpftCFct2xlX+xM+v7HE74mv+D8vsRYs/f0V/z0WLz9gP+vSm1fs139N3a7nS3zGxP9OVt3kWW/4mrivS3zW2/G8iX/eLZ81WouXj9Wy5TvCK5dvC7ct6wyLDlwE+LttTfj7ghm4UpyJn0UAioC0ut1k/FSajCvlyfh4ViouLkrH+TW5eHZjBc7tWYiwawWe0mpw0qzFcaMax8waHAnYM/NYHdHXWmH/vNGAN5UGvNG9HK9tm4s3O2fhnXUOvNlWjlcai/FceynObpuFF/qW44LegPNanRXoF7zVeNffiO96ajHSNhdfzcnElSlJdjiLebd43utWoPxyiF8rK8CHFeV4du5CEeJWkLeu3BeuX90TXrZyX3jZyv031NLle8IPLNt9XS3+S9WeW9bSpQ+HFy/dEV7ywA55/6HD9/6EQIR4gas//D879qLQ3Y+C/odQuHctFruX4cC5Rpz+tA0XLm/Aq5eb8NK3LXj50jq8OLIHT383AM9HEtY+5UKu9yHcd2gfJvS7kTSgYYLTwASnidQBE5kDQeT3BVHcHUD5Xh3lXV6Ut/WgbO3DmL5yJ+as2IH5K3ZiwfLtmL90GxYs7cLCpduwcOmDWLh0OxY9sGO0KpftRNXyXb9Y4mviK/73J9ZCUUt/uRbEVeKvid8f/2yVS3ei6hdK/HrsmRKf82bP+1ufL7ESnzP++1j/rW7yjIm1eNmuG57/dj9v/HMm/vmiFi/fZT3HjbUTS1bswvIVO7FyxYNoX96JB5c0wb9gOc7Mm4f3Z5bjh9Ice2fj6MtAUclWmF8pnYh/TJ+I12ZPxPOL03G2Lh/hzdNx9tBiK2xFmIvRSKw7F4Eu6pRWjbN6Hd5Vm6w142+1VyBSmY7X56Xi/TmpeHd2Mt6aOQHPz52AJ5ek4el1pTjftxwvKrUIqzU461uLC75afDZQh5Hty/DPpYX4ZqoI8eTfFeI/lBfhY8dMPDOrCv4Zy7F1Vi2qF3VizfKdWLZqL5at3IelK8TH/dbHB5bvua6WLNv9Fy3xd98bV3vwgPj5pTuwqHITlq1Yh4OHjsj7eu7x93RT3AOOrO7eyP17DqDIuRfl/RuwxLkU+x9bibP/aMOH12rx+c9r8dWPD+CLH5bhH9eW4+8/tOFDPIRzPyo48LaMmdp23Le7C6l9TqQ4DaQOBJDmHEJu/xCmdg+idK+JWQ8HMH+HgYWbFSxsc2NhfS8qq7uxeM1BLF59AFUr96NyxV6rFq/ch8Ur92PJygNYsuIgFi/fP1ri81g9sOrQDRX/6/+2Vh7E4n9TVXGV+Gvi98c/y1JRKw9h2erum5b49Vs9401//ibfM7Hiny+xEp8z/r9T4rP9Uom/0wMrDo4+/y3/e9/k+RIr8Rn/3XPGnnX5mp4bniv286tWH8TaNQexftVO7HxgA7TKGjwzvxIfzXLgp9J8oDgrGoipY0FenAqUpOKnslR8VTER7ziScGHuRDyzdBKeaS3Gc3sW4QX3KmscckarsZYjipUsp/UanFNr8YpUi4+6V+KT9bPwxsJ0vDXtf/BR8f/i86l/w5cl4/FlaRLerRiP8xX/izNL0vDMFgdedK7EWaUGz/jF+KUG7ztr8d3+tbjU4MC3jnT8WBwNcbEz81eH+CRcK5uKjx2z8eycZTDm12NPVSdaV+5D/ZperKn2YPVaN1avFR/tWrXGjZWrndbH2I//muWKlvhv4In+eAArV3Vj6dKHsWptFw50HwmL0Upibt4zilw94zJcvXLKoT7rhWX+oU7MddZjx6PVOPdhC778uR2XfliEb644cPnKNFy6XIJvvivDZ98txD+u1eLlq3ug/30Aa4/twuTu7cjo7UVqv46MgUFkDgxjWu9hLOg9hhV9J9HY/wTa+86gs/cpdPU8jV09z+Dhnmewt+cs9nQ/c9Pa2/0M9h06e8dqb7f43r+/xO9P/DNvZ/3R54vVHX/O6LP+0ef9vc+5/+DT6D74FJR9j+DRvUN4ZfsAPmjswGfz5+OHablAkejERTBGu/HEMC9NxWUxXnFMxKuzJuDZqjQ811KMF3fNt7py8eLzjF5rLSkUgf6KUoe3B9bgg01z8MHiyfioIgnflU3ETxVpgHVWSipQZp+r8vH0CXhxfjLONU/FSweX4DmpGueUWjwl1eANVw3+2VuLq5sqMVKZj2slYpwiAvrXduLi8wxcLS3ChxWz8Py81XiyfhdOPxyC3nsWvfufwZ59z1m1d//zVu07cN6q/QdfZI3WBew/+JL144PdL+DAoXPYt+8JHOw+cu+HeLqzJynlYG846cAhZLp6kX+gGZWuFfA8U40P/tmIq/9aix++r8C1y4X48XI2vv8uB9e+y8e3l8rw1eUFeGtkI85824/eN/yoOuxEdt8hpPQqyOwPIKtnCDN6jmJj8CWoz3+L4y//iKGnv8HhJ7/B8ae+w8mnrlh1+umRW9ZjT4/g8aeuWvVE+NpNS/zaY2eujH5dYolfi6/TT14erVNPXsbJM7+/xO+P//NEnXziu1tW/NclPtfNnvGPPl+sEp8z8bl+TSX+PePrTj3nr33W0098i9Onv8Jzx97DB4++hR+Gn8G1XYfw9eIluFqUg38ViACPhviU5OtLhLkI8mnJuFqWjM/EeGVGEl6oSsezDVPwxMYynOtZiufNRms9+LNqLd701eLjnlX4asMcfDU/E19NG4+fp00ExOad0YOu0oDyNIyUJ+Pi9PsRXjoJz2+dhedcK/GcWoczSi1e8dTgc3cjfnhoJX5cVYqrFSK0o3Px+BAfDfObhHixHeIflM/E+flr8NKmAbwbjODlM9/iyRP/xLFHvsXR49/i+KOXrXr0xBWcODli1clTV1lWXcPJU9/bH09fxanTl3Dq1Bc4/fg7OP3YO2Gv98y9H+LjD+5HlqcbhQfrUeWsgu/ppfjo85W4MrIIP40U4afLOfjXd5Pw06UM/HgpC1cuTcE3l6bjgyuNuHD1EIKfGah/UkZe/wGk9srI6gsg+9AgFvQ+ikOPvo/TrwPn3gTOXPgZT7/wM8Ln/4WzL8Cqcy8Cz74EPHvhxnpOfHwReP7CrUv8+m+tc+L7Rr//M7+iYs+aWLE/J7HOnv/lzxOf52b1W57v9zxn4jPdqn7N1/3W57zV8yb+ufHP8Ev13Pl/4bnnfsDFJ7/A52c+xr+OPo+ruw7hy8oqjEzJxs+F0cOiRkM8xa7CFKAg+lGE57QUfF+Wgk8rJuKiYzzOVabi8do8PL+vEheMRnsTj1xj7cb88sBKfN1YgW9npOFy0f12qIp/DKwXqNGywjwZ75T+DWcXTMRz68vxXP9yPK/U4UmlFi/7avGJpxE/7F2LH2umY2S6eMboSCUxwG8IcbHE0A7xkdIivF82A+cXrEFksxMfH30D7134CS89+yPOngPCZ8dKfH7uWfsj61b1M849ew3nnvvMCvHHHnvv3g3xyd6epAxnTzjp4F5kOPdham8TFvYvhPOJxfjw81W4MlKJn64U4afvcvGv7zLw06VMK8SvfjcFl76rwIdXahG5uhvBT32of8KDfOc+pPZJmNwXQF5PCIu6j2O7dB7dgdfQr1/EgHoRbuU1uOSLcMdKeQ0e5XV4lDduKK/8y+VT37yhEr/ml0p8D/evqMTnSny+xGf4I/VbniuxEp/vTj6nKK/65g3P8FvqZs+Z+D1i5dfeumXJ6htQlIs44jmHp12P4429Et5r6sDHc2bjalE2MCUDmBLdqh4L8cJUuwqiH0WJgJyWipHyVHxcPgEXZk3A2TW5eHXfErxqNOGCVIML/mprO/0/dy/D5yun4Otp43G14G/Rl5LRzt4K2rEO//1p/4vn5k/E+Y4y+wWn2mB14iLEP/U14ft9a/F9zXRccfybELdeesZCXNRYiH9QMQvPzluJJ+t34KkDR/CI9jICyiuQlNchKW9CUt6GpLwTrXfhl96F1/8Oyyrx3+K96I/fgk96DV7vBfikJ+GVnry3O3ER4pme7nDyob3IdO5DUW8L5vUvRv9TK/HBN424+tNq/HS1HN9fysdPl7Lw46Vs/HgpF1e+K8G3V+bgvSvNOPvNw3C+1Ytlx3tQ4DqA9F4/8vpMTO0ZwoI9g1i9WcPKdh/WtPpQ0yahpkVCTZMfNY0+VI+W+PzXVW2TPFp1zcoNFf/rohJ/f3yJ7/trK/H3JladeJ4mGfXNyi+W+JrEZ0x83sTv/Vsq8blu9oy/5jkTnzm+Rp+1Sb7h+/+WSny+X3rGhhb1ltXYIqO5xYdtjb3ornsYQyva8MzCxXhverk9E5+aFRfiogsXoZ1mV0G0xI+jc+efS9LwTWky3piVgpeqC/HW/mV43Wy2jqN90V+Nv7tr8cXDS/H56iJ8XTYBI1PuB8RLydENOGMvTv9Vkoy3S/+Gc4tS8fyGCrzgXIkLWiPCah1e9dbic28Tvt9trxe3OvHYMsMbAjwa4vH/SFhLJzMwUjYVH82YjbNzl2Kwqgl9ax7ElsYetDX0obbRhdpGN+qa/KhvklDfKEdLiZbKatSiJf57yKhvcKO6phsNTQ/f+yGeIV5sDuyXJ3UfQKbzAPK62zDLuRo7T6/Csx/X46sf6zFybTaufDcN177Nw7VvC3Dt2yJc+m42vr66Eq9d2Qb9/b2oOboJuX2bkdO33zpjpbhXxeyeAJY8rGN+3T5ULN6KmVVdmLNkO+Yt3oF5i3di/uJdo7VgycP3dC1c8jAWLb59Jf68xO9xO+p2P+et6o8+v/j9C2/y5/7uqhJLwrpQPb8d62ZXo3f6IpyscOCd8hI7xIsnx41TUq8P8fiKBeW0NGsX5TszU/DymgK8uWcJXjOa8IJUY72YfMdbi7/vX45/NJXjm3mZuFQ6wZ6Jl9idvFUlqfihPBXfVCRbSw/P10/Bhd2L8IJcgxf1RpxV6vCmuxZf9tXiyqZKXKkqwFXxUjS24eeGAI+FeHyQR0O8vAgfzpiJZ+YthjxvFR6cV4fVC9qxeOF6zK3sxPyqLViwuAsLFm/DwqoHsbBqOxYt2YHKxTtRtXgXa7TEf48dqKzainkL1qFySTMaGh8ONzTsvndDXMhyH3JkOvdHUrt3o9DZhXJXE1ZIlegPL8PL/2zFlz/U4JsfVuDbkYX4dqQK315dii+vNeKzn7rw4vceDLznwzxtM5J2r0dO30EUDvhRdtCLsm09KK57EJkVazEhbzEmFS5DVtFKZBWuQFbBCmTlrcDk/JXILlg1WuJzUeLX7rWaHKvcm1dO/spfrFzxdxQ/voN/z1/zfOI5RCU+3y+V9fXR5xffI/H7/tb6d88Z/4yxH8cqr3D1jVWwHPkFD2BGzlxUphWjMzUHwfx8vFEy5foQFyU68lglhnisWy9Oww8lqfhwRipefiAbF7fNw0WpDi8r9XhWqcWrYrNO/xr848FFVjf+0cwUfF6WhG9KJ2KkNBmXy5KtH38sXpJW3I+zlal4duN0RPpX4bxWj/NKPc7LddYSw6/2rMQ3jQ5cmp2J78XqlOihVjcGeEKYx4X4lfIp+HDWTDw9dyEGHAtRXzgbFbnzUJS/ENmFVcguXIzswiXIKXwAOfkPILdgKfIKl9kfC5ZdV/mFy6+rxF//o5V/T9dS5OYvRm5+JTKzZiEn34HKxc33fojneXcn5XseDv/toS4UeB5GoasTxQeXYrm/Ev3PNeH819vx1vcP4fVLG/DapU144/KDuHj1EM5fccP8VEXrWRdKfNuRfmgXCgb6UOr0Y9YhD4rbd2DizBX4v9PL8X8lTcX/pJTib6nl+FtyGf53Yin+NrEU9yeXjZb4XNT/JpXc1vqf8dNuS/1vtP52i7ovqQT3Tyi9ZY2fWGaV+LveN+H2/z1F/S2pxHqOW1Xis1jPc5NnTSzxdeKZRYnvkfh9f2v9mueMPd+E5PIbamJqxXWVnFyKlAlTkX9fNsr/nwlo/dtEmDnZeK24AN8Xi80+k+2bc+JDvDD9xpoSDcnidPw8LQ3/mJ6KV+anI9Jahou9q3BRbsBzaj1e8NfiFW8tPuxbi0+3L8a7dSV4beEkvD47xere35qVgtdnJuOFeSkIV6bhqaYinNtbiRe91dbvf1GqQ8Rfh0/6avDtg0vw9epp+G56unU0wO8J8ZGKInwwawaenD0Xh0pmYGlaAXIm5CE9ZQqS0qZhQnopklJLkZRSggnRGp88DUkTRZX8Yo2fUHxbK+meq6lxVYTxSQW4f3we/t//bxLGT8iyQryq6h4/iyYW4kkPb0NW30PIce5AQV87SnqrsVyrRe+FHdDf2Qv51a2QX9sO5fWHoLzTj76LTjQ/0YO8/i1IP9CFPFcvivr74RjwYoVXx8IeZ2Rq7bZwRvna0cosWjla2fmrblmT81dalZm3/D9ek29VOXZl54u/y60rJ3/VDXW7/543PNtNni/xGcae5cZn/qXfYz/7Sut7JD7Hv6sbnjHhORO/V3zlFfxyObLnWNWZkh0O5uVFnp4/F29XFGNkShYw1b6LcizERWhPurGmRMu69iwN/yxPtQL5ldUFeG1npTX+eFkTY5U6PO+vxev+enwqt+DDg6vw6joHXqgpxEtrCvDy2kK8uLYAz9QV4txGB148uMwK/ud8NXhOrsMr/jq87anDVwfX4vKGBfh2SYF1mqEY44yeZHhDcN86xC+XF+K9WRV4at5cyAuqMOBYEKkvmB0uz5kXLspfYFV2wQPhnPyl4byCZTdW/rJwfsEvl/iaP1L5f4paOlo5+ZVW3Z+U2VNV1XBv79jMde0aN3n/Q/Lk/Q8hq/thTOp9GHnuh1Hk3YlS90bMlzqwSG7DIn8TFviaMc/bgjn+jXD4ujDFtROT+vcgq+8Acvv7MLW7F9MP9mKFV4us8GpVVT3OpKLqLqvSp1eP1uSiVWOV92tq6T1Yic94feX9ikr8PTd+jz9Sv/45Ep8l8dduVrfvmW/8s39PTZ8826oz82cnPTV3ruOzRXNCn1fOwbf5afhJrEARW+9/U4hPwkhZOj6enozXF2XijXYHPuhejbeVZryiNuGsJM4Mr0dEa8JrciMuDqzFKweX47UDy/H6wRV44+AKXDi0HOedq/G8rwZn5Vo866+xuvB3/I34xFmHS7uW40q9A5fmZeNHMUqJPwDrhuC+SYhH7+j8piwXr5cX4bkli3B+WWXkhaWVVcr8qqSGvNlWTc+bn5SXt5T1G0p033bd4wEek3VoV2HmoYdCeQd3I+3AQ5g8cAA5nm5k9z+EyYe2IPPARmQe2ICMA51I378Jafu3IWX/TqR278ckpxM5Ay7k9/Sjoqcfi3qdcPR75eW8lYf+gz6vnOX4vHJ25KucifghVxz1Gtu1GR2bJAZ4fIiLr5s6CT+XpFsXN3wwKw1vL8/HOxvn4O1DK/GW1IgLWhOeVetxRq7B01INnlXqrFC/oDZaJcL9Bb0J5/RGPKPU4Sl/Nc77avCavx4fu+vx1YHV+G79fFxeUojvykUoR9d9/9sATwjxkkz8szQbr5bm44VllThbNTss/iFL/O9BfwGxIC/sPYDkPTsx4YBYdtiLLFcfMl39yHD2W4Gd7nQj3elF+oAfGU4JGQN+TO52ovBgH6o8flR094WW8WYe+g/7R9XspM8rZ4e/zJ6AH/PERh5xfkrsTJKbBPjNgrw4Hf8qSbOOiv1odjreXJqL11or8Nb+5XhDabKCXFy8fMq/FieltTil1OC0Js4Qr8MTWh0e18SZ4vXWckIR8CLA33fV4tO9K/DZ+rn4cnkRrszIwA/WmSm/tLQwsa7vxEWIv1aWj+cemC+CPPz80vkM8b8qEeQZB/fLBT37I5kH9yPf48FklwcZAx7rdp+0fh/S+iWk99tXs2X3SSgckFDS68Z8pztS6fbJi7wSA5z+40SIf5k9ISw68RtC/Fad+GiQx15y2rfS/1SaZl0qYQX54my80VKBN/c8gNddNXhRFitW6qyzUJ6Ua/CEWmvtxhSbecJihKLU4RWlEe9KTdYI5e+7luDvLQ78fWk+vpiRjmvTohdCjC4fTAzsm1VciBdPGg3xc1VzoiFexRD/Kytz9YwrHeh1lA70hcoG+pC5Zw/SHt6NtL37kb73ANL3HkTmnkPIfOgACnYfwHynB5Uef6jS7XNUuSSOUOieMBbiohMXR89GQ/yXZuLXhXg0VMV4Q9y4U5qOyxXp+HzWJLy9IAMXVxfgjY2zra78fXcd3pOa8Ja/EW9IjXjDV4+3fPX4wNeIj72N+GKgDp/vXo5POmbjw5WF+GheBj6fnoLvYjf6iFn4LQM84URDUdbYJfoStHgSvinLwesixCtn45mFMxjiZCvp67O68owD+8Ppe0QdGK2M3QfD8wc8Vk2zLjZm9033li8nJyddzksJf5mdhB/zfyHEY+OT6yoW4rHQHAvya+Xp+EdFCt6ekYLXKjPxRm0xPtw4Fx89WIkPHqzEu9sr8X70xx9vXYRPN87Dp80OfLSiEB/Nz8QnjhR8WToRV4on4l9iSaH1MvNWIS4CPOPGII+9/BRH1kZD/I3yApxdOAuvlhcwxGmM6MpLnD1J6bsPjNZ8p3e0qrzeJHbfdC/6R15y0pfZSeEvsifgh3wRltEXm/EhfkN4x4d4LETHVqtg2iSgdBK+L5+Er8vT8HF5Mt6fkYIP5mXgg6ocfLAkF+8tzsH7i3Oszz+uzMEn8zLxyYw0fFo2Ef8sS8ZIaYo1nrGXE8YFeOKqFOtz8b3F+vboGvfEEmvfiyfha9GJVxTg7KKZeGV6UfhsFV9sEtGfnAjxz3JSwp/lpuCKmInHQtzanfkLIW51vnEl1piLEr9frDUvyQRKM/FTWSZGyibh27I0fFWWis/LU/FZeSo+LUvBP8pS8FlZivXz4tevlIsr1NLxU5n9j8ANN9tHO+rrAzoa0rHvH1/iWaznybKe6cvyXFysKER40Uw8P31q+CxXpxDRn91HeelJH+Snhz/MT8dX+aLzFVvvM28M7VgwFolNQVnR3Z1xNS1nrEqygZLJQOlk/FyShR9LsvB9aSaulmRgpCQDV0ozcLnU/ig+v1aSge9LMvBjSSZ+KsnEzyWZ+Jf4hyBWsTAeLdFZx0p8LkJaPENiZUefSawvz8Fn5YWiA8dTlbPsEGcnTkR/dm8WTbZC/M2pOfhgSha+LsnFpZIcfFc8ebQuF0/GlWnZVo2U5Fp1pSQXV0vzcS1a35cVWBcR25WPa+V5GCnNtassF1fi6rKo8jxcEV8jPpbZX5NY4nb6azdUTrSy436ci+/L8kbrh9HKxw9lBRgpLcDlskJ8OL0Y56cX4/GqOVaIP8YQJ6I/OxHib0zNDj9ZkIUzk1PwUmEGIgWTcLEwA6+JKsjA6wUZeCNabxZmWvVWYSbenpL1q+qtKVl4s+jflPiahBK/7/o/S3zPDLwzJQPvXleZeHdK1lgVZuG9wiy8H633CrPx/pQ8nC/KwyNT8hCaNwOPV86WT1XN43sqIvpze6sod9ybRdk9T+ZnhmN1oWBS+LWCSeHX88fqjYIMq94syAi/XZj5u+rNwszwG0X/pqJfl/h7Rb1TOCmhMsLvWD9/83q3IDv8fmFe+IPpU8Oi8xYVmucIiwA/vWg2V4oR0X+HM7kZ487kTU56KS/9uroYV2/+UhVNvsMlvodd7/27ypt8Q300vcgqMT4RxQ6ciIiIiIiIiIiIiIiIiIiIiIiIiIiIiIiIiIiIiIiIiIiIiIiIiIiIiIiI6K76/wHeE4h4nu6VpwAAAABJRU5ErkJggg==)

如上二图所示。

### 高副低代

在含有高副的机构中，将高副虚拟地用低副替代称为高副低代。机构中常见的

几类高副低代方法分述如下。

#### 曲面高副接触

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 代换后杆1、杆2分别为原来的构件1与构件2，增加一个杆4替换原来的高副 | | |

#### 凸轮

##### 尖底凸轮

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 代换后杆1为原来的凸轮1，增加一个杆4替换原来的高副 | | |

##### 滚子凸轮

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 代换后杆1为原来的凸轮1，杆4为原来的滚子 | | |

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 代换后杆1为原来的凸轮1，杆2为原来的滚子 | | |

##### 平底凸轮

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 代换后杆1为原来的凸轮1，杆4为原来的滚子 | | |

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 代换后杆1为原来的凸轮1，杆2为原来的滚子 | | |

#### 滚子

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 代换后构件3为原来的滚子3 | | |

图示

AI 生成的内容可能不正确。滚子在曲面上运动时类似曲面高副接触的情况。

#### 齿轮

图示

AI 生成的内容可能不正确。

雷达图

AI 生成的内容可能不正确。

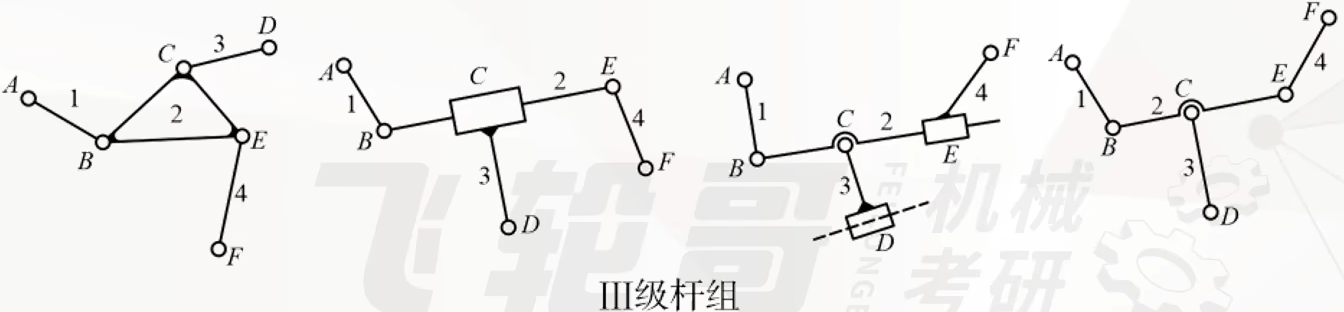
此处两个红色角都为直角

### 杆组拆分

#### 基本杆组

自由度为零且不能再拆分的构件系统称为基本杆组。最简单的基本杆组由两个构件和三个运动副组成，称为Ⅱ级杆组。图示

AI 生成的内容可能不正确。

四个构件和六个运动副构成的基本杆组为III级组

机构的级别即为机构中基本杆组的最高级别。

#### 三角架拆分

#### 基本步骤

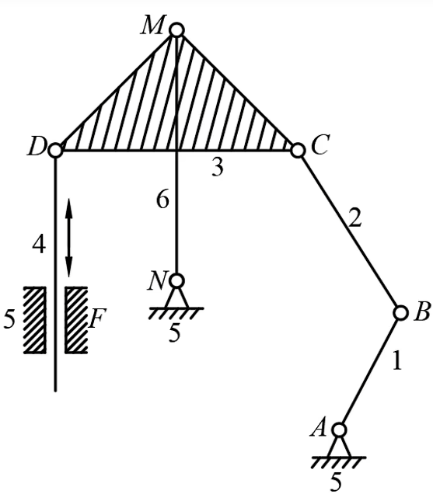
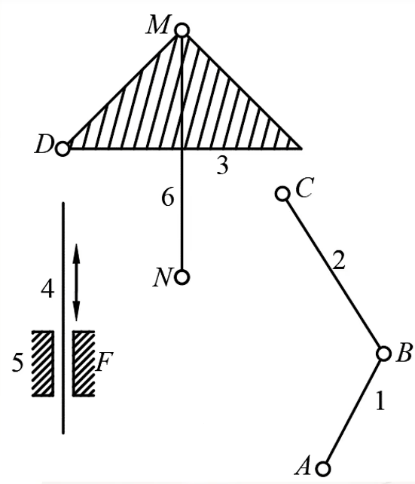
(1) 首先去除机构中的虚约束并对局部自由度进行处理

(2) 计算机构的自由度并确定原动件;

(3) 然后对机构进行高副低代;

(4) 拆分时先将原动件拆下，之后从原动件部分开始试拆杆组，首先考虑II级组，拆下的杆组是自由度为零的基本杆组。

注：机构中仅原动件的机架需要保留。



图示, 示意图

AI 生成的内容可能不正确。图示

AI 生成的内容可能不正确。

注意：该题中E点为复合铰链，拆分时要记为两个转动副

### 机构运动简图绘制

#### 基本步骤

1. 找出图中的机架
2. 找到与机架直接相连的构件1、2，判定其与机架通过转动副还是移动副连接
3. 抽象、简化构建1、2，画出相应的运动副
4. 找到跟构件1、2直接相连的构件3、4，并重复上述步骤2。

#### 例题：唧筒机构

如图1，先找到机架为4，其与1通过转动副连接，与3通过移动副连接且始终与3 的方向位于同一直线，可抽象为图2。最后再来看与1、3相连的构件2.可知2与1、3都通过转动副连接，最终抽象为图3。

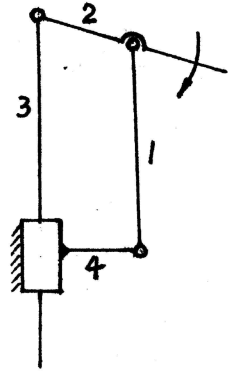


图3

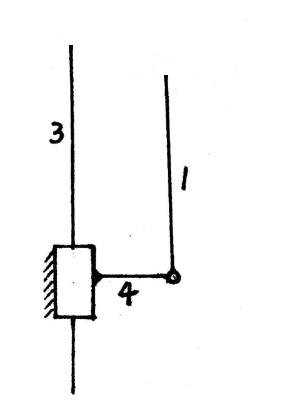


图2

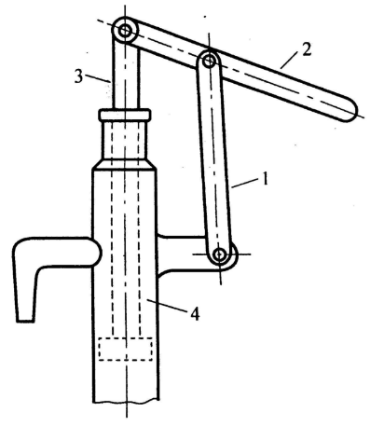


图1

#### 图示, 工程绘图 AI 生成的内容可能不正确。例题：偏心油泵

右图偏心油泵中间部分的运动形式与下图机构相同

（当A点是机架而C点不是）

1. 圆球球心绕A运动
2. 直杆所在直线上固定一点为球心

A点为机架，圆AC（原图的AB）可以简化为杆，通过转动副与直杆相连，直杆通过移动副与构件3相连，3通过转动副与机架相连。

得到最终答案（右图）。图示

AI 生成的内容可能不正确。

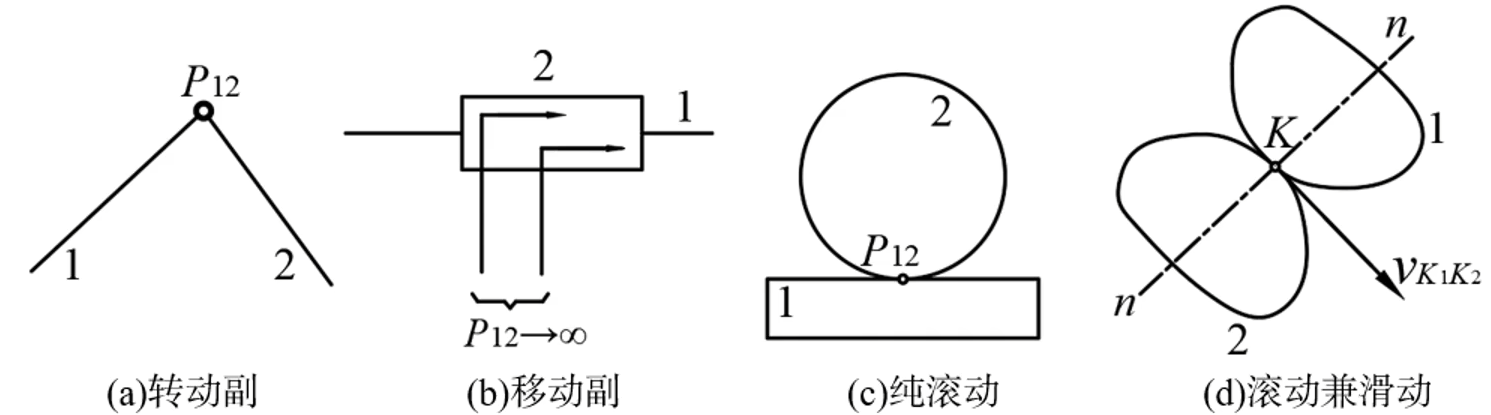
## 平面机构运动分析

### 速度瞬心法

#### 速度瞬心

相对速度瞬心是两构件上相对速度为0的重合点，或者说是瞬时绝对速度相同的重合点。绝对速度瞬心就是构件上绝对速度为0的点。

构件和构件的相对速度瞬心一般用符号表示



对于直接接触的形成转动副的二构件，由定义可知其速度瞬心为转动副。如图(a)。

对于移动副，其速度瞬心在垂直于移动副导路的无穷远处。移动副的瞬心可以进行平移，效果相同。

对于纯滚动的高副，两构件的接触点即为两构件的瞬心。

对于滚动兼滑动的高副，瞬心在两构件接触点的公法线上，但不能确定其具体位置。

一般默认高副为滚动兼滑动的。齿轮一般为纯滚动，凸轮一般为滚动兼滑动。

#### 三心定理

作平面平行运动的三个构件共有三个瞬心，它们位于同直线上。

图示

AI 生成的内容可能不正确。图表, 图示, 折线图

AI 生成的内容可能不正确。

#### 图片包含 灯光, 线, 挂, 交通 AI 生成的内容可能不正确。瞬心法求解速度和角速度

已知，求

瞬心的定义是两构件上速度相同的点。



即可求出。

从而我们可以得到一个普遍性的公式

对于任意两活动构件1,2,以及机架3

有



图示

AI 生成的内容可能不正确。已知，求图示凸轮机构中构件2的运动速度

显然

### 相对运动图解法（矢量图解法）

#### 同一构件

在理论力学中我们学过，对于同一刚体（构件）上两点，其速度的关系为



加速度的关系为



#### 移动副两构件上瞬时重合点

图示

AI 生成的内容可能不正确。在理论力学中我们学过，绝对运动是相对运动和牵连运动的矢量和，体现在移动副两构件上瞬时重合点间的运动关系即为



加速度的关系为



其中为科氏加速度



其中为动系绕定轴转动的角速度矢量（这里就是杆的角速度矢量）。

也可以这么说：的大小是，方向为沿着（顺/逆时针）的方向旋转。

当两构件通过移动副连接时，则这两个构件的角速度和角加速度大小和方向均相同。

#### 例题1（展示一般求解过程）

图示

AI 生成的内容可能不正确。已知一机构如图所示，已知原动件等角速度转动且转动角速度为，试求的大小与方向。

经过测量可以得出

（假设是这样）

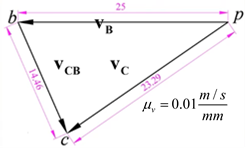
也即





|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
| 方向 |  |  |  |
| 大小 |  |  |  |

据此可以画出速度矢量图（右图）

点为画图的起点，也称为**极点，**由出发的指向的有向线段即为点的速度，以此类推。

由图可知



可以求得

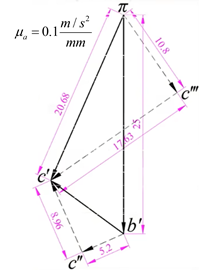
，方向为顺时针

，方向为逆时针



|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |
| 方向 |  |  |  |  |  |
| 大小 |  |  |  |  |  |

可以求得



据此可以画出加速度矢量图（右图）

（这里认为两点都是求的过程量因此这样标）

量出



方向都为逆时针

#### 图示 AI 生成的内容可能不正确。速度影像法

机构中某个构件上的点形成的图形，与速度和加速度矢量图中的图形应该是对应相似的。

如果上题中构件2不是杆而是如右图所示的三角形BCE，那么会有速度三角形中

图示

AI 生成的内容可能不正确。

图示

AI 生成的内容可能不正确。不妨看看右图，对于相似三角形，点有四种可能。其中从对应就可以排除掉，速度影像法还要求顺时针读顶点的顺序一样，原图中顺时针读为，速度矢量图中点若在则顺序为，与上述不符。而则满足题意。从而得到了正确的速度矢量图。

对线段上的点也适用。某个构件上某个点在速度矢量图中有，可以认为是三角形的极限情况。

#### 文本 AI 生成的内容可能不正确。重合点的选取



#### 卡通人物 AI 生成的内容可能不正确。例题2

已知各杆长，构件1逆时针匀速转动，其角速度已知。求此时构件5的速度。

思路：求构件5的速度就是求E的速度，找到构件3的绝对瞬心（），从而问题转化为求解构件3的角速度。图片包含 图示

AI 生成的内容可能不正确。

## 平面机构力分析

### 运动副中的反力

#### 移动副

构件手机屏幕的截图

AI 生成的内容可能不正确。2对构件1的力与速度方向成角

其中为摩擦角

#### 图示, 工程绘图 AI 生成的内容可能不正确。转动副

构件2对构件1的力切于摩擦圆

其中摩擦圆半径

为当量摩擦系数

是发生转动时阻碍转动副转动的力，也就是说，其产生力矩与的方向应该相反。

#### 例题1

手机屏幕的截图

AI 生成的内容可能不正确。已知各构件的尺寸、各转动副的半径和当量摩擦系数、作用在构件3上的工作阻力及其作用位置，求作用在曲柄1上的驱动力矩 (不计重力和惯性力)。

手机屏幕的截图

AI 生成的内容可能不正确。解：

1. 根据已知条件画摩擦圆。
2. 作二力杆反力的作用线

由二力杆的性质，可以知道等大反向，只能是在与两摩擦圆同时相切的一条直线上。由的方向可以写出的方向，由产生力矩的方向与相反就可以找到的确切方向，如图。

1. 图示

   AI 生成的内容可能不正确。分析其它构件的受力状况
2. 由求出（绘图）



即可求出。

#### 高副

高副的情况与移动副相同。