**Chapter 13**

![A close-up of a planet

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAeAB4AAD/4RDgRXhpZgAATU0AKgAAAAgABAE7AAIAAAAHAAAISodpAAQAAAABAAAIUpydAAEAAAAOAAAQyuocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAFZlcmdpbAAAAAWQAwACAAAAFAAAEKCQBAACAAAAFAAAELSSkQACAAAAAzE2AACSkgACAAAAAzE2AADqHAAHAAAIDAAACJQAAAAAHOoAAAAIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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Miranda, a satellite of Uranus, is shown in Figure P13.5a. It can be modeled as a sphere of radius 242 km and mass 6.68 x 1019 kg. (a) Find the free-fall acceleration on its surface. (b) A cliff on Miranda is 5.00 km high. It appears on the limb at the 11 o’clock position in Figure P13.5a and is magnified in Figure P13.5b. If a devotee of extreme sports runs horizontally off the top of the cliff at 8.50 m/s, for what time interval is he in flight? (c) How far from the base of the vertical cliff does he strike the icy surface of Miranda? (d) What will be his vector impact velocity?

Solution:

2. A spacecraft in the shape of a long cylinder has a length of 100 m, and its mass with occupants is 1 000 kg. It has strayed too close to a black hole having a mass 100 times that of the Sun (Fig. P13.7). The nose of the spacecraft points toward the black hole, and the distance between the nose and the center of the black hole is 10.0 km. (a) Determine the total force on the spacecraft. (b) What is the difference in the gravitational fields acting on the occupants in the nose of the ship and on those in the rear of the ship, farthest from the black hole? (This difference in accelerations grows rapidly as the ship approaches the black hole. It puts the body of the ship under extreme tension and eventually tears it apart.)

**![A diagram of a figure

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAeAB4AAD/4RDgRXhpZgAATU0AKgAAAAgABAE7AAIAAAAHAAAISodpAAQAAAABAAAIUpydAAEAAAAOAAAQyuocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAFZlcmdpbAAAAAWQAwACAAAAFAAAEKCQBAACAAAAFAAAELSSkQACAAAAAzE2AACSkgACAAAAAzE2AADqHAAHAAAIDAAACJQAAAAAHOoAAAAIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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JWf/f9f8ah/wCEb0P/AKAun/8AgKn+FL/wjeh/9AbT/wDwFT/CgDH+JUt1a/D3V72wvbizubW2aSOS3faciovFGuXNhpPh6ztZXS41i9t7RpgfmRCNzsD67VIz2zmtDxxo9/4g8G6jpGli3E97CYg9zKyKme/yqxNRar4eudV0XSPMEEWo6Vcw3UQEhaMsnBXdtBwykjOOM9Dihb691/wRvZej/SxzXiLxndeEbrxTZRO9x9j06C8sfOcyGN5GMRUk5JG7a3J7mtc39xoHjTw7pb3U9zDq9rMsvnyFz50Sq4cZ6ZBYEDA6ccUl/wCBRr7eIrjVmSGfWLaO1iEZ3/Z0j5U5wMnedxHTgD3q9DoN5feKdN1nWFgjbS7WSGCOGQvukkwHfJAwMLgDryc0R6X/AK3t+gpeX9bf8Evaz4ks9CvdPtbyK4Z9RlMNuYo9wMm0sFJzwTis6Tx7p0Vtqcr2d+DpDbdQj8pd1sMA7j82GGDn5Sxx2qTxRomo6trHh+5sBa+Vpl99qm8+VkZhsZcKApyfmzyR0rIufCWtzQeNo1Gng+IBi1JuH/d/uRF8/wC746Z4z6e9LWzfr+n/AASrK6+X6/8AAO1F5b/Y1uzMi27KHErNhcHocn61B/bWl/8AQSs/+/6/41FpumlfDdpp2qwW8xjt0ilj/wBZGxUAfxAZHGeRSf8ACN6H/wBAXT//AAFT/CqlZNpERvbUm/trS/8AoJWf/f8AX/Gj+2tL/wCglZ/9/wBf8ah/4RvQ/wDoC6f/AOAqf4Uf8I3of/QF0/8A8BU/wpDJv7a0v/oJWf8A3/X/ABo/trS/+glZ/wDf9f8AGof+Eb0P/oC6f/4Cp/hR/wAI3of/AEBdP/8AAVP8KAJv7a0v/oJWf/f9f8awNa+JvhXw9rEGn6tqSwm4j8yOdR5kR5I2llzg8dwByOa2f+Eb0P8A6Aun/wDgKn+FYWsfCvwjr2sQahqWlo/kR+WlvGfKi6k7iqYJPOOTjAHFAC3Ou6Te+LdD1C01Szms1s7wtcRzqY15h6tnAoi+KfhC58RQaLY6vFeXcxYboOYkAUklpPu447E9qjuvDWh2virQ9Nt9GsI7F7O832y2yeW/MPVcYP402L4R+DbXxFBrNjpS2s8JYmKM5hkBUgho2yuOe2OQKAOo/trS/wDoJWf/AH/X/Gj+2tL/AOglZ/8Af9f8ah/4RvQ/+gLp/wD4Cp/hR/wjeh/9AXT/APwFT/CgCLVPFGl6ZpVzeC8t7hoYyyQxTKXlb+FFGeSTgD3NYOoGfTfD+j+H7/UdmoapKWvbkzbdqZ8y4KkngEny1x03r6VNeaHpd34006xs9Ls4Y9OUajcyRW6qS2SsCZA/vB3/AO2a+tTaXp9p4k1jUda1K0huoBIbKxWeIOFjiYh3AI4LSbue6olAG7/bWl/9BKz/AO/6/wCNH9taX/0ErP8A7/r/AI1D/wAI3of/AEBdP/8AAVP8KP8AhG9D/wCgLp//AICp/hQBN/bWl/8AQSs/+/6/41PFPBewM1rcJKhyu+Jw2D9R3ql/wjeh/wDQF0//AMBU/wAKuW1nbWEBisLaG3TJby4kCKT64AoA4/wnqdxbXPjM6he3N3BpuoN5XnybikYhV9o9uTWXB4k1C18H+GfFNzcytNqt/Cl1C0hMflTsQFVOg25Ugjk7TnOTXQeG/DupWOpeJH1iOyNtrF0Z0WCdnZVMaptYFF7LnINVLfwVdHStB0O8aFtO0S6W4WUOS84jz5SlccYyCTk/d468Eel/7v8A9sEutv73/ANDx3rdxo+kWUVi5judT1CCwSUDmMSN8zD3Chse+KjsNTlsfiRdeHDLLNbSaal9D50hkaNg5RxuYkkH5TyeDmpNa0PU/EFpLHfCzhkstRiu9MeN2ORGQw8zI4J+ZTjOAan07Qpv+EvvfEeoLGlxNax2cEMb7vLiVixJOByWP4ACiPn/AErafiD20/rXX8DM8S3s2n/Ebwy63lxHazQ3huYBORFIEiDKSpO3IyeT/StO98X2enWmmXF/Z30A1OYQQI0ILB2BKhgCcZx/jisvxp4Nu/FevaPKHjisbJZxLIly8U6s6gKyYUglSoPJwahvvD/izU7DQ4dSk0u4uNK1SO6e5Ezx/aI0yAdnlkK5B5GcZ70R6Lz/AAvqN/192hpv45sY/wC1Fax1Dz9JG6+gESloUK7g+d21gRzhSTweK3oL+1udNiv4plNrLEJUlY7QUIyDz04NcnL4Y1ltT8Y3CrY7Ncto4bUG4fKFYymX/d8D5s8Z6Vu+H9KksvCGn6Tq0VvK9vaJbzKh8yN9qhf4gMg47ihba+X63/QT308/0/4Ja/trS/8AoJWf/f8AX/Gj+2tL/wCglZ/9/wBf8ah/4RvQ/wDoC6f/AOAqf4Uf8I3of/QF0/8A8BU/woAm/trS/wDoJWf/AH/X/GsnxJrsT6ULDRb+F9S1GQWlt5Mqs0ZbO6TAP8CBn/4DWh/wjeh/9AXT/wDwFT/CsGwsdLTxdqWsx2dtZ2WiwNbJJFCqBpCA8z8DkKuxQex8wUATX15bx+KNL0UXwtrXTIBd3Bkn2mQ4McMZJOWz87n/AHFz1re/trS/+glZ/wDf9f8AGsPw7oNpf6c+r65plvNf6pIbuQXEKu0SMAI4+RxtjCAj13HvWt/wjeh/9AXT/wDwFT/CgCb+2tL/AOglZ/8Af9f8a57U/ih4T0bxAukarqiW0zxrJHMw3QuCSPvrkDkHritv/hG9D/6Aun/+Aqf4Vgaj8KPB+r6+NW1HSkmkWNY0gB8uFACTnYmMk5Oc5oAtWmoWep+P4LnTbuC7gbSX2ywSB1P75O44rqK5ay0yx0nx9BbaXZ29nAukviK3iEaj98nYCupoAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKAOf8Bf8k78P/wDYOg/9AFdBUdvbw2ltHb2sSQwxKEjjjUKqKOAABwBUlABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQBz+pf8j9oP/XpefzhroKja3he4jneJGmiDLHIVBZA2MgHtnAz9BUlABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFAHPv/wAlJi/7BL/+jkroKj+zw/ahc+UnnhPLEu0bguc7c9cZGcVJQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFcj8T76607wFd3NhczW06yRhZYXKMMuAeRXXVxXxb/wCScXv/AF0i/wDQxW2H1rQT7r8zOt/Cl6P8il4I0i5kTS9WufGGoXjywCV7GW53qSycgjd2znp2rQ8I6rplvpGrXn/CR3ep21vMWmmvQ48jA+6M9vpUPgPwZoNno+k65bWRTUXtFdpvOc5LJ8x2k47ntXBaLHJJ8KfGIiBJF2pIHoGUn9K9CcY1ZTV9mlsl9o8+m5U4021vd7v+U9Ms/iR4Yv7i1gt75zNdyeXEjQOCxzgdunPWro8Y6IbjVIBdN5mlIXux5TfuwOvbn8K8mOo6fe6r8PYrCaOSW2WKOcJ1Rt68H3yD+dTzXltaeIviHHdTxwvNbyLEsjAFznoM9TzTlgqfS/X8HbsEcXN2vb7P4q/c9Nn8c6Bb6LaatNelbK8kMcMhif5iM5yMZHQ9aH8d+HU0M6u2oAWXnGFX8tsu47KuMmvJ9ZUP8HfCqtyDeuCP+BPXSfFiyjsE8NfY1jsbSG6ILpENkR+TDFeh4BP4VP1SlzqGusmvkhrFVHBz00in99zvNA8WaP4lMy6Vcl5Yf9ZFIjI6++COlcl8YNT1DTdN0o6ZfXNk0tyyu1vKyFhjvg81B4LhtZvibqd3Hrsmr3gtttxLFZpHC33cEMrkE8Y6djTPjeofStHU9DdMD/3zU06UIYqEVs7b/wDDL8ip1Zyw0291f+t3+ZWS61rwh8S9J0g+ILrV7a/C+bHdOWKbiR3Jx0znineKPE3iu08faZbyN/Z+mz3ohhjQgmdBIoLN35zx0/rXW6B8O/D3h+/S/sbaR7pR8kk0hfZkc4HTPvXM/FD/AJHjwf8A9fP/ALUjrSlUp1K8YpX0d21bu9jOpTqU8POV7bWSfotzW8W2nim41iWa21tNG0W3tyyyIy7ncLnkHB68degq58M9d1DxD4OS71Z/NnSZ4vN2geYoxg8fXH4Vn+Mtc8M6pqVx4W8TLNaiBPtKXLuEQtt42nOSfmPBHUVT+G3iSDSvhwlzr90YbaO9a3t5GjJyuAQPlB77uay5JSw3w66W07369WzVyUcQnzaa319OnRIt+OrLXdMtNS1628XT2lrGoaOyW2BAPACht3c98d63PANzqF74I0+61eZprqZWcu/UqWO39MVy/wAXbyS9XR/Ddocy6jcqzAf3c7V/U5/4DXotpbR2VlBawDbHDGsaD0AGBWdR2w0ebdvTRbLT8zSKviXy7Ja69X/wCaiiiuE7AooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACobuytdQtmt7+2huoGILRTRh1OOnB4qaijYBkMEVtAkFvEkUUahUjRQqqB0AA6Cs260SOHRr218PR2ulXFwpIkitk27/Vlxg+nIrVoqlJpi5UeaWPgTX7vX9Gutb/ALKtoNJcuTYpta4bIOSoUAZwK7u48P6Pd3jXd3pVlPcOuxpZbdWZhjGCSOeOK0KK1qV5za6W7GMKEIX637+RQfQdIezitH0qya2hbdFCbdCkZ9QuMA89qsXlla6hatb39tFcwN1jmQMp/A1PRWXNLubcqXQqafpWn6TCYtMsre0jY5ZYIggJ9TjrS32mWGpqi6lY212sZ3ILiFZAp9RkcVaoo5pXvfUXKrWtoFVbrTLC+nhmvbG2uJYDmKSaFXaM5zlSRx0HT0q1RSTad0NpNWZQ1DQ9K1Z0fVNNtLxk4Vp4VcgemSKkl0nTriyjs59PtZbWMgpA8KlEI6YUjAq3RT5pWtcXLG97FWXStPnvor2extpLqEYjneFTIg9mIyOpq1RRSu2OyQUUUUhhRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQB//Z)**

Solution:

**Chapter 14**

1. A 50.0-kg woman wearing high-heeled shoes is invited into a home in which the kitchen has vinyl floor covering. The heel on each shoe is circular and has a radius of 0.500 cm. (a) If the woman balances on one heel, what pressure does she exert on the floor? (b) Should the homeowner be concerned? Explain your answer.

Solution:

![A person lying on a bed with a needle

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAeAB4AAD/4RDgRXhpZgAATU0AKgAAAAgABAE7AAIAAAAHAAAISodpAAQAAAABAAAIUpydAAEAAAAOAAAQyuocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAFZlcmdpbAAAAAWQAwACAAAAFAAAEKCQBAACAAAAFAAAELSSkQACAAAAAzc2AACSkgACAAAAAzc2AADqHAAHAAAIDAAACJQAAAAAHOoAAAAIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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The human brain and spinal cord are immersed in the cerebrospinal fluid. The fluid is normally continuous between the cranial and spinal cavities and exerts a pressure of 100 to 200 mm of H2O above the prevailing atmospheric pressure. In medical work, pressures are often measured in units of millimeters of H2O because body fluids, including the cerebrospinal fluid, typically have the same density as water. The pressure of the cerebrospinal fluid can be measured by means of a spinal tap as illustrated in Figure P14.8. A hollow tube is inserted into the spinal column, and the height to which the fluid rises is observed. If the fluid rises to a height of 160 mm, we write its gauge pressure as 160 mm H2O. (a) Express this pressure in pascals, in atmospheres, and in millimeters of mercury. (b) Some conditions that block or inhibit the flow of cerebrospinal fluid can be investigated by means of Queckenstedt’s test. In this procedure, the veins in the patient’s neck are compressed to make the blood pressure rise in the brain, which in turn should be transmitted to the cerebrospinal fluid. Explain how the level of fluid in the spinal tap can be used as a diagnostic tool for the condition of the patient’s spine.

Solution:

**Chapter 15**

1. The amplitude of a system moving in simple harmonic motion is doubled. Determine the change in (a) the total energy, (b) the maximum speed, (c) the maximum acceleration, and (d) the period.

Solution:

2. A physical pendulum in the form of a planar object moves in simple harmonic motion with a frequency of 0.450 Hz. The pendulum has a mass of 2.20 kg, and the pivot is located 0.350 m from the center of mass. Determine the moment of inertia of the pendulum about the pivot point.

Solution:

**Solutions for Chapter 13**

1. Miranda, a satellite of Uranus, is shown in Figure P13.5a. It can be modeled as a sphere of radius 242 km and mass 6.68 x 1019 kg. (a) Find the free-fall acceleration on its surface. (b) A cliff on Miranda is 5.00 km high. It appears on the limb at the 11 o’clock position in Figure P13.5a and is magnified in Figure P13.5b. If a devotee of extreme sports runs horizontally off the top of the cliff at 8.50 m/s, for what time interval is he in flight? (c) How far from the base of the vertical cliff does he strike the icy surface of Miranda? (d) What will be his vector impact velocity?

Solution:

(a) For the gravitational force on an object in the neighborhood of Miranda, we have



(b) We ignore the difference (of about 4%) in *g* between the lip and the base of the cliff. For the vertical motion of the athlete, we have



(c) 

We ignore the curvature of the surface (of about 0.7°) over the athlete’s trajectory.

(d) 



Thus  at  below the *x* axis.



2. A spacecraft in the shape of a long cylinder has a length of 100 m, and its mass with occupants is 1 000 kg. It has strayed too close to a black hole having a mass 100 times that of the Sun (Fig. P13.7). The nose of the spacecraft points toward the black hole, and the distance between the nose and the center of the black hole is 10.0 km. (a) Determine the total force on the spacecraft. (b) What is the difference in the gravitational fields acting on the occupants in the nose of the ship and on those in the rear of the ship, farthest from the black hole? (This difference in accelerations grows rapidly as the ship approaches the black hole. It puts the body of the ship under extreme tension and eventually tears it apart.)

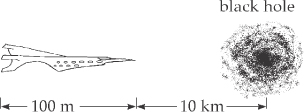
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JWf/f9f8ah/wCEb0P/AKAun/8AgKn+FL/wjeh/9AbT/wDwFT/CgDH+JUt1a/D3V72wvbizubW2aSOS3faciovFGuXNhpPh6ztZXS41i9t7RpgfmRCNzsD67VIz2zmtDxxo9/4g8G6jpGli3E97CYg9zKyKme/yqxNRar4eudV0XSPMEEWo6Vcw3UQEhaMsnBXdtBwykjOOM9Dihb691/wRvZej/SxzXiLxndeEbrxTZRO9x9j06C8sfOcyGN5GMRUk5JG7a3J7mtc39xoHjTw7pb3U9zDq9rMsvnyFz50Sq4cZ6ZBYEDA6ccUl/wCBRr7eIrjVmSGfWLaO1iEZ3/Z0j5U5wMnedxHTgD3q9DoN5feKdN1nWFgjbS7WSGCOGQvukkwHfJAwMLgDryc0R6X/AK3t+gpeX9bf8Evaz4ks9CvdPtbyK4Z9RlMNuYo9wMm0sFJzwTis6Tx7p0Vtqcr2d+DpDbdQj8pd1sMA7j82GGDn5Sxx2qTxRomo6trHh+5sBa+Vpl99qm8+VkZhsZcKApyfmzyR0rIufCWtzQeNo1Gng+IBi1JuH/d/uRF8/wC746Z4z6e9LWzfr+n/AASrK6+X6/8AAO1F5b/Y1uzMi27KHErNhcHocn61B/bWl/8AQSs/+/6/41FpumlfDdpp2qwW8xjt0ilj/wBZGxUAfxAZHGeRSf8ACN6H/wBAXT//AAFT/CqlZNpERvbUm/trS/8AoJWf/f8AX/Gj+2tL/wCglZ/9/wBf8ah/4RvQ/wDoC6f/AOAqf4Uf8I3of/QF0/8A8BU/wpDJv7a0v/oJWf8A3/X/ABo/trS/+glZ/wDf9f8AGof+Eb0P/oC6f/4Cp/hR/wAI3of/AEBdP/8AAVP8KAJv7a0v/oJWf/f9f8awNa+JvhXw9rEGn6tqSwm4j8yOdR5kR5I2llzg8dwByOa2f+Eb0P8A6Aun/wDgKn+FYWsfCvwjr2sQahqWlo/kR+WlvGfKi6k7iqYJPOOTjAHFAC3Ou6Te+LdD1C01Szms1s7wtcRzqY15h6tnAoi+KfhC58RQaLY6vFeXcxYboOYkAUklpPu447E9qjuvDWh2virQ9Nt9GsI7F7O832y2yeW/MPVcYP402L4R+DbXxFBrNjpS2s8JYmKM5hkBUgho2yuOe2OQKAOo/trS/wDoJWf/AH/X/Gj+2tL/AOglZ/8Af9f8ah/4RvQ/+gLp/wD4Cp/hR/wjeh/9AXT/APwFT/CgCLVPFGl6ZpVzeC8t7hoYyyQxTKXlb+FFGeSTgD3NYOoGfTfD+j+H7/UdmoapKWvbkzbdqZ8y4KkngEny1x03r6VNeaHpd34006xs9Ls4Y9OUajcyRW6qS2SsCZA/vB3/AO2a+tTaXp9p4k1jUda1K0huoBIbKxWeIOFjiYh3AI4LSbue6olAG7/bWl/9BKz/AO/6/wCNH9taX/0ErP8A7/r/AI1D/wAI3of/AEBdP/8AAVP8KP8AhG9D/wCgLp//AICp/hQBN/bWl/8AQSs/+/6/41PFPBewM1rcJKhyu+Jw2D9R3ql/wjeh/wDQF0//AMBU/wAKuW1nbWEBisLaG3TJby4kCKT64AoA4/wnqdxbXPjM6he3N3BpuoN5XnybikYhV9o9uTWXB4k1C18H+GfFNzcytNqt/Cl1C0hMflTsQFVOg25Ugjk7TnOTXQeG/DupWOpeJH1iOyNtrF0Z0WCdnZVMaptYFF7LnINVLfwVdHStB0O8aFtO0S6W4WUOS84jz5SlccYyCTk/d468Eel/7v8A9sEutv73/ANDx3rdxo+kWUVi5judT1CCwSUDmMSN8zD3Chse+KjsNTlsfiRdeHDLLNbSaal9D50hkaNg5RxuYkkH5TyeDmpNa0PU/EFpLHfCzhkstRiu9MeN2ORGQw8zI4J+ZTjOAan07Qpv+EvvfEeoLGlxNax2cEMb7vLiVixJOByWP4ACiPn/AErafiD20/rXX8DM8S3s2n/Ebwy63lxHazQ3huYBORFIEiDKSpO3IyeT/StO98X2enWmmXF/Z30A1OYQQI0ILB2BKhgCcZx/jisvxp4Nu/FevaPKHjisbJZxLIly8U6s6gKyYUglSoPJwahvvD/izU7DQ4dSk0u4uNK1SO6e5Ezx/aI0yAdnlkK5B5GcZ70R6Lz/AAvqN/192hpv45sY/wC1Fax1Dz9JG6+gESloUK7g+d21gRzhSTweK3oL+1udNiv4plNrLEJUlY7QUIyDz04NcnL4Y1ltT8Y3CrY7Ncto4bUG4fKFYymX/d8D5s8Z6Vu+H9KksvCGn6Tq0VvK9vaJbzKh8yN9qhf4gMg47ihba+X63/QT308/0/4Ja/trS/8AoJWf/f8AX/Gj+2tL/wCglZ/9/wBf8ah/4RvQ/wDoC6f/AOAqf4Uf8I3of/QF0/8A8BU/woAm/trS/wDoJWf/AH/X/GsnxJrsT6ULDRb+F9S1GQWlt5Mqs0ZbO6TAP8CBn/4DWh/wjeh/9AXT/wDwFT/CsGwsdLTxdqWsx2dtZ2WiwNbJJFCqBpCA8z8DkKuxQex8wUATX15bx+KNL0UXwtrXTIBd3Bkn2mQ4McMZJOWz87n/AHFz1re/trS/+glZ/wDf9f8AGsPw7oNpf6c+r65plvNf6pIbuQXEKu0SMAI4+RxtjCAj13HvWt/wjeh/9AXT/wDwFT/CgCb+2tL/AOglZ/8Af9f8a57U/ih4T0bxAukarqiW0zxrJHMw3QuCSPvrkDkHritv/hG9D/6Aun/+Aqf4Vgaj8KPB+r6+NW1HSkmkWNY0gB8uFACTnYmMk5Oc5oAtWmoWep+P4LnTbuC7gbSX2ywSB1P75O44rqK5ay0yx0nx9BbaXZ29nAukviK3iEaj98nYCupoAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKAOf8Bf8k78P/wDYOg/9AFdBUdvbw2ltHb2sSQwxKEjjjUKqKOAABwBUlABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQBz+pf8j9oP/XpefzhroKja3he4jneJGmiDLHIVBZA2MgHtnAz9BUlABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFAHPv/wAlJi/7BL/+jkroKj+zw/ahc+UnnhPLEu0bguc7c9cZGcVJQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFcj8T76607wFd3NhczW06yRhZYXKMMuAeRXXVxXxb/wCScXv/AF0i/wDQxW2H1rQT7r8zOt/Cl6P8il4I0i5kTS9WufGGoXjywCV7GW53qSycgjd2znp2rQ8I6rplvpGrXn/CR3ep21vMWmmvQ48jA+6M9vpUPgPwZoNno+k65bWRTUXtFdpvOc5LJ8x2k47ntXBaLHJJ8KfGIiBJF2pIHoGUn9K9CcY1ZTV9mlsl9o8+m5U4021vd7v+U9Ms/iR4Yv7i1gt75zNdyeXEjQOCxzgdunPWro8Y6IbjVIBdN5mlIXux5TfuwOvbn8K8mOo6fe6r8PYrCaOSW2WKOcJ1Rt68H3yD+dTzXltaeIviHHdTxwvNbyLEsjAFznoM9TzTlgqfS/X8HbsEcXN2vb7P4q/c9Nn8c6Bb6LaatNelbK8kMcMhif5iM5yMZHQ9aH8d+HU0M6u2oAWXnGFX8tsu47KuMmvJ9ZUP8HfCqtyDeuCP+BPXSfFiyjsE8NfY1jsbSG6ILpENkR+TDFeh4BP4VP1SlzqGusmvkhrFVHBz00in99zvNA8WaP4lMy6Vcl5Yf9ZFIjI6++COlcl8YNT1DTdN0o6ZfXNk0tyyu1vKyFhjvg81B4LhtZvibqd3Hrsmr3gtttxLFZpHC33cEMrkE8Y6djTPjeofStHU9DdMD/3zU06UIYqEVs7b/wDDL8ip1Zyw0291f+t3+ZWS61rwh8S9J0g+ILrV7a/C+bHdOWKbiR3Jx0znineKPE3iu08faZbyN/Z+mz3ohhjQgmdBIoLN35zx0/rXW6B8O/D3h+/S/sbaR7pR8kk0hfZkc4HTPvXM/FD/AJHjwf8A9fP/ALUjrSlUp1K8YpX0d21bu9jOpTqU8POV7bWSfotzW8W2nim41iWa21tNG0W3tyyyIy7ncLnkHB68degq58M9d1DxD4OS71Z/NnSZ4vN2geYoxg8fXH4Vn+Mtc8M6pqVx4W8TLNaiBPtKXLuEQtt42nOSfmPBHUVT+G3iSDSvhwlzr90YbaO9a3t5GjJyuAQPlB77uay5JSw3w66W07369WzVyUcQnzaa319OnRIt+OrLXdMtNS1628XT2lrGoaOyW2BAPACht3c98d63PANzqF74I0+61eZprqZWcu/UqWO39MVy/wAXbyS9XR/Ddocy6jcqzAf3c7V/U5/4DXotpbR2VlBawDbHDGsaD0AGBWdR2w0ebdvTRbLT8zSKviXy7Ja69X/wCaiiiuE7AooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACobuytdQtmt7+2huoGILRTRh1OOnB4qaijYBkMEVtAkFvEkUUahUjRQqqB0AA6Cs260SOHRr218PR2ulXFwpIkitk27/Vlxg+nIrVoqlJpi5UeaWPgTX7vX9Gutb/ALKtoNJcuTYpta4bIOSoUAZwK7u48P6Pd3jXd3pVlPcOuxpZbdWZhjGCSOeOK0KK1qV5za6W7GMKEIX637+RQfQdIezitH0qya2hbdFCbdCkZ9QuMA89qsXlla6hatb39tFcwN1jmQMp/A1PRWXNLubcqXQqafpWn6TCYtMsre0jY5ZYIggJ9TjrS32mWGpqi6lY212sZ3ILiFZAp9RkcVaoo5pXvfUXKrWtoFVbrTLC+nhmvbG2uJYDmKSaFXaM5zlSRx0HT0q1RSTad0NpNWZQ1DQ9K1Z0fVNNtLxk4Vp4VcgemSKkl0nTriyjs59PtZbWMgpA8KlEI6YUjAq3RT5pWtcXLG97FWXStPnvor2extpLqEYjneFTIg9mIyOpq1RRSu2OyQUUUUhhRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQB//Z)**

Solution:

(a) 

(b) 

ANS. FIG. P13.7



**Solutions for Chapter 14**

1. A 50.0-kg woman wearing high-heeled shoes is invited into a home in which the kitchen has vinyl floor covering. The heel on each shoe is circular and has a radius of 0.500 cm. (a) If the woman balances on one heel, what pressure does she exert on the floor? (b) Should the homeowner be concerned? Explain your answer.

Solution:

(a) 

(b) The pressure from the heel might damage the vinyl floor covering.

![A person lying on a bed with a needle

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAeAB4AAD/4RDgRXhpZgAATU0AKgAAAAgABAE7AAIAAAAHAAAISodpAAQAAAABAAAIUpydAAEAAAAOAAAQyuocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAFZlcmdpbAAAAAWQAwACAAAAFAAAEKCQBAACAAAAFAAAELSSkQACAAAAAzc2AACSkgACAAAAAzc2AADqHAAHAAAIDAAACJQAAAAAHOoAAAAIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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hJ4TncEwRXknmHHA+dv8DXus9vDdW7wXUUc0Mg2vHIoZWHoQeDXP8AibQb+bw2lh4TNjYmN932eS2QwyLySu0qQOeeldOHxTi0pau6d36WOevhlJPl0VmrLzscTpepWeq/Hw3emzJPA1qQJE6MREAf8K5azvbWDwN4xtJ7iOO5mu4vLhZgGfEnOB1OMV6L4b8H6snjh/EetRWVkFg8mG0sySo+ULnoAB1/Ourk8NaHNcTTzaPYSSz/AOtd7ZGL9+cjmtpYmnTaitVaP4O5jChUmnJ6O7f3xseR+LFWT4e+B1YBlYgEHuMLW58Yrf7PD4ekhxbW0Nyyl0QbYj8pBx06A8e1eiy6JpU9vBBNplnJDbf6iN7dCsX+6MYH4VYu7O2v7Zre+t4rmBvvRyoGU/gay+uJTjJLZt/ea/VHySi3vFL7jzPwrHY3HxUluI9eudavorY+bcJbRrAy7QB8yt2yB06itD40/wDIix/9fkf/AKC1dtp2kadpMbR6XY29mrHLCCIJu+uOtSXun2epQeRqNpBdxBt3lzxB1z64I61k8QnWjO2kbdunoaRoNUpQe8r9+1upyHhT4e+GrWx0zVV0/fdmCOYNJIzAOVByFJx1rN+N3/IoWf8A1+r/AOgNXo8caQxJFCixxooVUUYCgdAB2FQX2m2OpwrFqVnb3katuCXESyKD64I60liZe2VSTbsyvq8VRdOOjaOF8S+Hdf1aXw1f6EtpKunQLJ5d05C+ZhcHA69Kx/hXe38WseJrzUPs6Wiu0t4ygkrICx+Uf3cb/fpXrSIsaKiKFVRgKBgAelVINI021S4W10+1hW5/14jhVRL1+9gfN1PX1qliv3cqbW+333M/qvvxmnta/wAlY82+J/iGHVvC2jz6ZdSNo99dFbiVVZNwU9CCAezH8Ki8ES2dl8WL/T/Ckxk0R7beyo5dAwVeQT7kj8a9O/sfTf7N/s/+z7X7F/z7eQvl9c/dxjrRp+kabpKMml2FtZq/3hBEqbvrgc1UcTCNJ00n1/Hq/NClh5zqKba6fh29S5RRRXAdwUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQB//Z)2. The human brain and spinal cord are immersed in the cerebrospinal fluid. The fluid is normally continuous between the cranial and spinal cavities and exerts a pressure of 100 to 200 mm of H2O above the prevailing atmospheric pressure. In medical work, pressures are often measured in units of millimeters of H2O because body fluids, including the cerebrospinal fluid, typically have the same density as water. The pressure of the cerebrospinal fluid can be measured by means of a spinal tap as illustrated in Figure P14.8. A hollow tube is inserted into the spinal column, and the height to which the fluid rises is observed. If the fluid rises to a height of 160 mm, we write its gauge pressure as 160 mm H2O. (a) Express this pressure in pascals, in atmospheres, and in millimeters of mercury. (b) Some conditions that block or inhibit the flow of cerebrospinal fluid can be investigated by means of Queckenstedt’s test. In this procedure, the veins in the patient’s neck are compressed to make the blood pressure rise in the brain, which in turn should be transmitted to the cerebrospinal fluid. Explain how the level of fluid in the spinal tap can be used as a diagnostic tool for the condition of the patient’s spine.

Solution:

(a)  and the gauge pressure is



It would lift a mercury column to height



(b) 

**Solutions for Chapter 15**

1. The amplitude of a system moving in simple harmonic motion is doubled. Determine the change in (a) the total energy, (b) the maximum speed, (c) the maximum acceleration, and (d) the period.

Solution:

(a)  so if  

Therefore 

(b) , so if *A* is doubled, 

(c) , so if *A* is doubled, 

(d) is independent of *A*, so 

2. A physical pendulum in the form of a planar object moves in simple harmonic motion with a frequency of 0.450 Hz. The pendulum has a mass of 2.20 kg, and the pivot is located 0.350 m from the center of mass. Determine the moment of inertia of the pendulum about the pivot point.

Solution:

*f* = 0.450 Hz, *d* = 0.350 m, and *m* = 2.20 kg. Now,

**

Solving for the moment of inertia, we obtain

**



**ANS. FIG. P15.37**