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# Galileo galilei sarkaçlar ve saatler

Skip to content The Museum of Space History is seeking a passionate, experienced leader to serve as Executive Director. Application Details Galileo Galilei, 15 şubat 1564 yılında İtalya'da doğmuştur. İtalyan astronom, fizikçi, filozof ve matematikçi bir bilim adamıdır. Babası tanınmış ünlü müzisyenlerinden Vincenzo Galilei'dir. 5 kardeşi vardır ve kardeşlerin en büyüğüdür. Adını büyük büyük dedesinden alan Galileo, birçok dalda başarısıyla adını duyurmuş bir bilim adamıdır. Galileo, 1581 yılında Pisa Üniversitesi'nde Tıp okuluna başladı. Fakat maddi durumu el vermediği için okulu yarıda bırakmak zorunda kaldı. 1583 yılında matematiğe yönelerek araştırmalar yaptı. Bu dalda başarısından dolayı Pisa'da profesör oldu. Sarkacın, yüzen cisimlerin ve kinetiğin Aristo fiziğinden farklı bir düşünceyle, matematiksel olarak ele alınması gerektiğini düşündü. Galileo, Pisa Kulesine çıkıp aşağıya ağırlıklar bırakarak, düşen bütün cisimlerin aynı ivmeye sahip olduğunu kanıtladı ve Aristo mantığının yanlış olduğunu gösterdi. Galileo, astronomiye de merak salarak bu alanda da birçok araştırma ve çalışma yaptı. Güneş merkezli astronomi fiziğini geliştirdi. Kendi ürettiği teleskobuyla birçok gök cismi üzerinde araştırmalar yaptı. Güneşi gözlemleyen bilim adamı, Güneş'in üzerindeki gölgelerin aslında etrafından geçen gök cisimlerinin gölgesi olmadığını, Güneş'in kendi lekesi olduğunu kanıtladı. O zamanlar bir arkadaşının 8. Urban olarak Papa seçilmesinden cesaret alarak yazdığı "İki Kainat Sistemi Üzerine Konuşmalar'' adlı kitabı, 1632 yılında yayınlandı. Fakat daha önce yapılan uyarılardan dolayı Roma'da mahkemeye çağrıldı ve kitabı bir yıl sonra yayından kaldırıldı. Maalesef Aslen NERELİ , kimdir , kaç yaşında öbür boyu evinde müebbet kararı alındı. 70 yaşında eve hapsedilen bilim adamı Galileo'nun gözleri kör oldu ve 1642 yılında vefat etti. Galileo Galilei'in buluşları: -Teleskop: Aslında Galileo'dan öncesi mercekleri kullanarak uzağı görme aletleri yapılmıştı. Fakat Galileo, daha da ileri giderek yıldızları ve gezegenleri inceleyecek kadar güçlü hale getirdi. 1609 yılında yaptığı teleskopla birçok astronomik gözlemler gerçekleştirmiştir. Ay'ın yüzeyindeki kraterler ilk kez tespit edilmiştir. Kendi yaptığı teleskobuyla Jüpiter'i incelerken, Jüpiter'in yakın çevresinde 3 küçük, parlak gezegen keşfetmiştir. Daha önce incelemelerinde bunların yıldız olduğunu düşünen bilim adamı, sonraki incelemeler sonucu, yıldız olmayıp Jüpiter'in etrafında dönen küçük gezegenler olduğunu keşfetti. -Mikroskop: Gözle görülmeyen cisimlerin incelenmesi yönünde Galileo teleskobu icat etti. Bunun için teleskobun silindir kısmına mercekler yerleştirerek küçük maddelerin görülebilmesini sağladı. 1619-1624 yılları arasında da bu aletten çok sayıda üretti. -Sarkaçlar ve Saatler: Galileo'nun sarkaçlar üzerinde yaptığı araştırmalar, modern saatin ortaya çıkmasında katkı sağladı. Bununla ilgili Galileo'un bir hikayesi vardır: Galileo, henüz küçük yaşlardayken kiliseye gider ve ayin sırasında bir adamın kafası kandile çarpar. Kandilin ileri geri sallanmasını seyrederken, kandil yavaşlasa bile hep aynı süre içinde ileri geri gittiği için bu durum Galileo'nun dikkatini çeker. Sonraki yıllarda da sarkaçların (yani ipe bağlı ağırlıkların) hareketini inceler ve bilimsel bulgular tespit eder. Eskiden saat yapımında sorun olarak karşılarına çıkan konularda Galileo'nun tespitleri yarar sağlamıştır. Bu sarkaçlarla ilgili buluşlarının saatlere uygulanması sayesinde var olan sorunlar ortadan kalkmış ve "tik tak tik tak" seslerini çıkaran modern saat yapılmıştır. – Pusula: 1597 yılında kullanım açısından çok faydası olan, yön bulmada insanlara kolaylık sağlayan pusulayı ticari olarak piyasaya sundu. Kaynakça: iyi mi böyle Diğer birçok deney gibi Galileo'nun sarkaç deneyi de üzerinde epey çalıştığı deneyleri arasındadır. Galileo'nun yaşadığı dönemlerde cisimlerin hareketine ilişkin yaygın görüş Aristoteles fiziğinin söylediği görüştü. Buna göre Dünya üzerindeki ağır cisimler evrenin merkezine doğru yönelme eğilimindeydi. Evrenin merkezinde de Dünya olduğu için cisimler aslında Dünya'nın merkezine doğru düşüyor gözüküyordu. Bir ipten sarkıtılan ağır bir cismin ileri geri doğru hareketi ise Aristoteles fiziğine göre açıklanamayan bir olguydu. Galileo da Pisa Üniversitesi'nde Aristoteles fiziği öğrenmişti. Fakat hızlı bir şekilde öğrendiği bu yaklaşımı sorgulamaya başladı. Mantığın babası olarak görülen Aristoteles, dış dünyaya karşı niteliksel ve mantıksal bir açıklama ile yaklaşırken Galileo tam tersini yapmıştı. Parlak zekası ve fizik bilgisi nedeniyle fenomenlere niceliksel ve matematiksel olarak yaklaşımı benimsemişti. Galileo'nun sarkaç deneyi de bu yaklaşımının bir sonucudur. (Galileo'nun, Aristoteles Fiziği'ni tamamen çürüttüğü teleskop ile yaptığı gözlemleri anlattığımız bu yazımıza da okuyabilirsiniz.) Galileo'nun Düşünce Deneyleri Aristoteles'in görüşünü savunanlar ağır cisimlerin, aynı ortamda hafif cisimlerden daha hızlı düştüğünü savunuyorlardı. Daha gençlik yıllarında Galileo, hızdaki farklılığın cisimlerin ağırlığına değil, yoğunluğuna bağlı olduğuna inanıyordu. Aristotelesçilerin inandığı bir başka olgu ise hava direncinin olmadığı durumda bir cismin sonsuza kadar yol almasıydı. Böylece hava boşluğunun(vakum) imkansız olduğunu düşünüyorlardı. Galileo ise hava boşluğunda bütün cisimlerin aynı hızla düşeceğini, bu hızın ise düşüş zamanıyla orantılı olduğu çıkarımını yapmıştı. Bir Sarkaç "Hareket" olgusuna matematiksel yaklaşımı sayesinde Galileo, asılı haldeki bir ağırlığın(sarkaç) ileri geri doğru hareketi üzerine kafa yormaya başladı. Bu harekete ilişkin görüşlerinin, henüz Pisa Üniversitesi'nde çalışmadan önceki tarihlere kadar dayandığı söyleniyor. Galileo'nun ilk biyografi yazarı Vincenzo Viviani, bu durumu şöyle açıklıyor: Galileo öğrencilik yıllarındayken Pisa Katedrali'ni ziyaret etmişti. Orada katedralin duvarında bir sarkacın ileri geri doğru salınım yapmasını gözlemledi. Bundan çok etkilenmiş olmalı ki sarkaçlarla ilgili çalışmasına bu gözleminden sonra başladı. Galileo'nun bu konu üzerine ilk notları 1588 yılına tarihleniyor. Fakat ciddi olarak çalışmaları 1602 yılından sonra başlayacaktı. Ucunda ağırlık olan sarkaçlar ise ilginç bir problemi gün yüzüne çıkarıyordu: Hangi yükseklikten bırakılan sarkaç en yüksek hıza sahipti? Ağırlığın az ya da çok olması sarkacın salınım süresinde bir değişiklik yaratıyor muydu? Sarkacın uzunluğu ve süre arasındaki ilişki neydi? Deneysel çalışmaları sürerken bu sorular Galileo'nun aklından hiç çıkmıyordu. Öte yandan sarkaçların pratik alanda kullanılıp kullanılamayacağı muamması da mevcuttu. Bu soruların hepsi, aşağıda göreceğimiz üzere Galileo'nun sarkaç deneyleri ile teker teker açıklanacaktı. Galileo'nun Sarkaç Deneyi Galileo, sarkaçları deneylerinde çok kapsamlı bir şekilde kullandı. Kariyerinin başlarında, yukarıda da söylendiği gibi sarkaçların hareketinin özellikleri üzerine kafa yormuştu. Sarkaçların hareketini etraflıca araştırdıktan sonra onları, sonraki deneylerinde zaman ölçüm aletleri olarak kullanacaktı. Sarkaçlar Neredeyse Bırakıldığı Yüksekliğe Geri Dönüyor Galileo, ağırlık takılı olan sarkaçların hemen hemen bırakıldığı yüksekliğe geri geldiğini gözlemlemişti. Bugün bu olgu kendisini "enerjinin korunumu" ilkesi olarak gösterir. İşin enteresan tarafı ise bu ilke Galileo'nun zamanında henüz keşfedilmemiş bir olguydu. Deneyin bir parçası olarak, Galileo sarkaçları farklı yüksekliklerden bırakıyordu. Sarkacın geri döndüğü yükseklik not ediliyor ve bırakılmadan önceki yüksekliği ile karşılaştırılıyordu. Bu olguya ilişkin Galileo hiçbir sayısal ölçüm yapmamıştı. Fakat her denemesinde sarkacın geri geldiği yükseklik, ilk bırakıldığı yüksekliğine çok yakındı. Tahminlerine göre yükseklikler arasındaki fark 3 milimetreden fazla olamazdı. Hafif Olanları Daha Çabuk Duran Sarkaçların Hepsi Önünde Sonunda Duruyordu. Galileo daha hafif ağırlık takılı sarkaçların daha önce durduğuna dikkat çekiyordu. Bu gözlemi yapan Galileo özdeş maddeden olan fakat uçlarına farklı ağırlıklar takılan sarkaçları aynı anda ve aynı yükseklikten bırakmıştı. Sonuç hep aynıydı: Hafif olan sarkaçlar daha önce durma noktasına geliyordu. Salınım Süresi Her Cisim İçin Aynıdır Galileo'nun sarkaç deneyi şaşırtıcı sonuçlar vermeye devam ediyordu. Deneyinde, birisinin ucunda kurşundan yapılan, diğerinde ise mantardan yapılan sarkaçların salınımını ölçtü. Gözlemin sonucu olarak her iki sarkacın da bir salınım yapması için geçen sürenin aynı olduğunu fark etti. Günümüzde Galileo'nun deneyini tekrar edenler iki sarkaç arasındaki süre farklılığın sadece %0.1 olduğu sonucuna ulaşmıştır. Bu da Galileo'nun haklılığının bir göstergesi olarak görülebilir. Salınım Süresi Genlikten(Gerilme) Bağımsızdır. Galileo, "İki Yeni Bilim" kitabında sarkacın salınım süresinin gerilme miktarlarından farklı olduğunu iddia ediyordu. Uzmanlar ise Galileo'nun aslında, salınım süresinin tam olarak aynı olduğunu mu yoksa çok az farklılık gösterdiğini mi kastettiği üzerinde tartışıyorlar. Günümüzde yapılan deneylerde ise özdeş iki kurşun ağırlıklı sarkaç aynı yükseklikten bırakılıyor. Birisi 5 derecelik bir açıyla bırakılırken diğeri ise 45 derecelik bir açıyla salınım yapıyor. Deneyin sonunda daha büyük açıyla bırakılan sarkacın süresi daha uzun oluyor. Her ne kadar fark az olsa da daha büyük genlikli sarkaçların salınım süresi daha uzun gerçekleşiyor. Sarkaçlar ile ilgili deneylerine devam eden Galileo, birden fazla sarkacı kullanarak, çarpışmalarının sonucunu incelemek üzere gözlemler gerçekleştirdi. Fakat bu deneylerden pek bir sonuca ulaşamayan Galileo bir daha sarkaçların çarpışması üzerine deneyler yapmadı. Galileo, bir sarkacın salınımı için geçen sürenin onun genliğinden(gerilme halinden) bağımsız olduğunu keşfettiğini söylemiştik. Sarkacın eşzamanlılığı ismini verdiği keşif, zaman ölçümü hususunda önemli bir yere sahip olacaktı. 1602 yılında arkadaşına, uzun sarkaçların eşzamanlılığını anlattığı bir mektup yazmıştı. Bir yıl sonra ise fizyolog olan diğer bir arkadaşı Santorio Santorio, hastalarının nabzını ölçmek için kısa sarkaç kullanmaya başladı. Sarkaç üzerine ciddi çalışmalar da bu dönemde yoğunlaşmıştır. Sarkacın Kullanımı Sarkaç, nabız ölçümünde zamanlama aracı olarak ya da müzik öğrencileri için bir metronom olarak kullanılabilir. Çünkü sarkacın her bir salınımı eşit zaman aralıklarında gerçekleşiyor. Sarkaç ayrıca saatleri geliştirmek için de kullanılabilir mi? İtici gücü sağlamak için bir ağırlık kullanılan mekanik saatler, Orta Çağ döneminde çok eski olan su saatlerinin yerini almaya başlamıştı. Öte yandan devam eden geliştirmelerle birlikte sarkaç daha küçük ve güvenilir olma yolunda ilerliyordu. Fakat en iyi olduğu düşünülen saatlerin güvenilirliği o kadar düşüktü ki örneğin, astronomik amaçlar için kullanılması düşünülemezdi. 17.yüzyıldan kalma sarkaçlı saat tasarımı O dönemde kullanılan saatlerin zamanı ileri veya geri göstermesi bir yana, tam olarak ne zaman yanlış zamanı göstereceği bile tahmin edilemiyordu. Bir sarkaç, zamanı doğru ölçme konusunda saatin çalışma mekanizmasıyla ilişki kurulabilecek kadar kullanışlı olabilir miydi? 1641 yılında 77 yaşında, artık görme engeli olmuş Galileo dikkatini bu konu üzerine yoğunlaştırdı. Vincenzo Viviani gelişen olayları aşağıdaki gibi açıklıyor: 1641 yılı idi. Bir gün Arcetri'deki villasında O'nunla oturuyorduk. Sarkaçların saatlere monte edilebileceği fikrini benimle paylaştığını hatırlıyorum. Böylece sarkacın doğal ve değişmeyen hareketinin, saat tasarımındaki kusurların hepsini gidereceğini düşünmüştü. Fakat görme engeli nedeniyle, yaptığı çizimler ve modeller istediği etkiyi yaratmasını engelliyordu. Oğlu Vincenzio ise bir gün Floransa'dan Arcetri'ye gelmişti. Galileo, fikrini oğluyla paylaştı ve bir dizi tartışmaya tutuştular. Sonuç olarak bir tasarım üzerinde fikir birliğine varmışlardı fakat tasarımın gerçekleştirilmesi konusundaki zorluğunda farkındaydılar. Viviani bu kısmı 1659 yılında, Galileo'nun ölümünden 18 yıl sonra yazdı. Ayrıca Christiaan Huygens'in sarkaçlı saati tanıttığı Horologium adlı eseri de Viviani'nin biyografisinden 2 yıl önce yazılmıştı. Huygens'in sarkaçlı saat tasarımı ise tarihte ilk sarkaçlı saat örneği olarak bilinir. Galileo ise kafasındaki sarkaçlı saat tasarımı düşüncesini gerçekleştiremeden hayata gözlerini yummuştur. Galileo'nun evren görüşü ve çalışmaları hakkında daha fazla bilgi için şu yazımızı okuyabilirsiniz. Kaynak: The Galileo Project Share — copy and redistribute the material in any medium or format for any purpose, even commercially. Adapt — remix, transform, and build upon the material for any purpose, even commercially. 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Pisa Katedralindeki Galileo'nun lambası olarak da bilinen avize. (Wikimedia Commons - Pisa.Duomo.dome.Riminaldi01.jpg) Modern bilimin kurucusu, büyük fizikçi ve astronom Galileo Galilei (1564-1642), yaşamı boyunca hız ve zaman ölçümüne büyük bir önem verdi. Çünkü çözümlemeye çalıştığı sorunlarda hemen her zaman bu iki büyüklüğü belirleme zorunluluğuyla karşı karşıya kalıyordu. Fakat elinde su saatinden başka zaman ölçecek bir aygıt yoktu. Ancak su saatiyle hassas ölçümler yapmak imkansızdı. "Bilimsel keşif şansı, sadece zihinlerini ona hazırlamış olanlara güler" (Pasteur). Galileo Galilei (1564-1642) Galilei, bir gün gittiği Pisa Katedrali'nde, katedralin tavanına asılı olan avizenin, mumları yerleştirildikten sonra serbest bırakıldığında hızla ileri geri gittiğini görür. Avize her ileri geri gidişinde büyük bir mesafe kat eder. Bu mesafe giderek küçülmektedir. Galilei, avizenin salınım süresinin azalıp azalmadığını merak eder. Salınımların süresini ölçecek bir aleti olmayan Galilei hemen bir eliyle diğer bileğinden nabzını ölçmeye başlar ve giderek küçülen yaylar boyunca ileri geri salınımlar için geçen süreleri, nabız atışlarının sayısıyla karşılaştırır. Her salınım için geçen sürenin aynı olduğunu saptar. Galilei, bazı yazarların rivayet olarak nitelendirdiği bu olaydan sonra bu defa kendi yaptığı sarkaçla, bir dizi ölçüm yaptı. Bu gözlem ve deneylere göre, sarkacın salınımları, hız değiştiği için hep aynı süreler içinde gerçekleşiyordu. Galileo böylece basit sarkaç yasası olarak bildiğimiz yasayı keşfetmiş oldu. Bir sarkacın salınım yayı uzun veya kısa olabilirdi, fakat sarkaç sallandığı sürece salınım süreleri değişmiyordu. Salınım sürelerinin değişimi sadece sarkacın uzunluğuna bağlıydı. Christiaan Huygens tarafından 1657'de icat edilmiş ve saat yapımcısı Saloman Coster tarafından yapılmış ilk sarkaçlı saat. Christiaan Huygens'in Horologium başlıklı kitabından (1658) Wikimedia Commons Galilei, bu gözleminden ve keşfinden sonra kullanılabilir gerçek bir sarkaçlı saat yapmak istedi ama bunu başaramadı. Yine de doktorların kullanımına yarayacak bir ölçme aleti yapmayı başarmıştı. Bu, boyu değişken olabilen, sicimden yapılmış basit bir sarkaçtı. Doktor, salınımlar hastanın nabız atışlarıyla senkronize olacak şekilde sarkacın boyunu ayarlayabiliyor ve başka bir gün tekrar ölçüm alıp iki sonucu karşılaştırarak hastanın sağlık durumundaki gelişmeleri izleyebiliyordu. Gerçek anlamda sarkaçlı saati, Hollandalı fizikçi ve astronom Christiaan Huygens (1629-1695) yaptı. Galilei'nin keşfettiği GAPONE

olgu ise hava direncinin olmadığı durumunda bir cismin sonsuza kadar yol almasıydı. Böylece hava boşluğunun(vakum) imkansız olduğunu düşünüyorlardı. Galileo ise hava boşluğunda bütün cisimlerin aynı hızla düşeceğini, bu hızın ise düşüş zamanıyla orantılı olduğu çıkarımını yapmıştı. Bir Sarkaç "Hareket" olgusuna matematiksel yaklaşımı sayesinde Galileo, asılı haldeki bir ağırlığın(sarkaç) ileri geri doğru hareketi üzerine kafa yormaya başladı. Bu harekete ilişkin görüşlerinin, henüz Pisa Üniversitesi'nde çalışmadan önceki tarihlere kadar dayandığı söyleniyor. Galileo'nun ilk biyografi yazarı Vincenzo Viviani, bu durumu şöyle açıklıyor: Galileo öğrencilik yıllarındayken Pisa Katedrali'ni ziyaret etmişti. Orada katedralin duvarında bir sarkacın ileri geri doğru salınım yapmasını gözlemledi. Bundan çok etkilenmiş olmalı ki sarkaçlarla ilgili çalışmasına bu gözleminden sonra başladı. Galileo'nun bu konu üzerine ilk notları 1588 yılına tarihleniyor. Fakat ciddi olarak çalışmaları 1602 yılından sonra başlayacaktı. Ucunda ağırlık olan sarkaçlar ise ilginç bir problemi gün yüzüne çıkarıyordu: Hangi yükseklikten bırakılan sarkaç en yüksek hıza sahipti? Ağırlığın az ya da çok olması sarkacın salınım süresinde bir değişiklik yaratıyor muydu? Sarkacın uzunluğu ve süre arasındaki ilişki neydi? Deneysel çalışmaları sürerken bu sorular Galileo'nun aklından hiç çıkmıyordu. Öte yandan sarkaçların pratik alanda kullanılıp kullanılamayacağı muamması da mevcuttu. Bu soruların hepsi, aşağıda göreceğimiz üzere Galileo'nun sarkaç deneyleri ile teker teker açıklanacaktı. Galileo'nun Sarkaç Deneyi Galileo, sarkaçları deneylerinde çok kapsamlı bir şekilde kullandı. Kariyerinin başlarında, yukarıda da söylendiği gibi sarkaçların hareketinin özellikleri üzerine kafa yormuştu. Sarkaçların hareketini etraflıca araştırdıktan sonra onları, sonraki deneylerinde zaman ölçüm aletleri olarak kullanacaktı. Sarkaçlar Neredeyse Bırakıldığı Yüksekliğe Geri Dönüyor Galileo, ağırlık takılı olan sarkaçların hemen hemen bırakıldığı yüksekliğe geri geldiğini gözlemlemişti. Bugün bu olgu kendisini "enerjinin korunumu" ilkesi olarak gösterir. İşin enteresan tarafı ise bu ilke Galileo'nun zamanında henüz keşfedilmemiş bir olguydu. Deneyin bir parçası olarak, Galileo sarkaçları farklı yüksekliklerden bırakıyordu. Sarkacın geri döndüğü yükseklik not ediliyor ve bırakılmadan önceki yüksekliği ile karşılaştırılıyordu. Bu olguya ilişkin Galileo hiçbir sayısal ölçüm yapmamıştı. Fakat her denemesinde sarkacın geri geldiği yükseklik, ilk bırakıldığı yüksekliğine çok yakındı. Tahminlerine göre yükseklikler arasındaki fark 3 milimetreden fazla olamazdı. Hafif Olanları Daha Çabuk Duran Sarkaçların Hepsi Önünde Sonunda Duruyordu. Galileo daha hafif ağırlık takılı sarkaçların daha önce durduğuna dikkat çekiyordu. Bu gözlemi yapan Galileo özdeş maddeden olan fakat uçlarına farklı ağırlıklar takılan sarkaçları aynı anda ve aynı yükseklikten bırakmıştı. Sonuç hep aynıydı: Hafif olan sarkaçlar daha önce durma noktasına geliyordu. Salınım Süresi Her Cisim İçin Aynıdır Galileo'nun sarkaç deneyi şaşırtıcı sonuçlar vermeye devam ediyordu. Deneyinde, birisinin ucunda kurşundan yapılan, diğerinde ise mantardan yapılan sarkaçların salınımını ölçtü. Gözlemin sonucu olarak her iki sarkacın da bir salınım yapması için geçen sürenin aynı olduğunu fark etti. Günümüzde Galileo'nun deneyini tekrar edenler iki sarkaç arasındaki süre farklılığın sadece %0.1 olduğu sonucuna ulaşmıştır. Bu da Galileo'nun haklılığının bir göstergesi olarak görülebilir. Salınım Süresi Genlikten(Gerilme) Bağımsızdır. Galileo, "İki Yeni Bilim" kitabında sarkacın salınım süresinin gerilme miktarlarından farklı olduğunu iddia ediyordu. Uzmanlar ise Galileo'nun aslında, salınım süresinin tam olarak aynı olduğunu mu yoksa çok az farklılık gösterdiğini mi kastettiği üzerinde tartışıyorlar. Günümüzde yapılan deneylerde ise özdeş iki kurşun ağırlıklı sarkaç aynı yükseklikten bırakılıyor. Birisi 5 derecelik bir açıyla bırakılırken diğeri ise 45 derecelik bir açıyla salınım yapıyor. Deneyin sonunda daha büyük açıyla bırakılan sarkacın süresi daha uzun oluyor. Her ne kadar fark az olsa da daha büyük genlikli sarkaçların salınım süresi daha uzun gerçekleşiyor. Sarkaçlar ile ilgili deneylerine devam eden Galileo, birden fazla sarkacı kullanarak, çarpışmalarının sonucunu incelemek üzere gözlemler gerçekleştirdi. Fakat bu deneylerden pek bir sonuca ulaşamayan Galileo bir daha sarkaçların çarpışması üzerine deneyler yapmadı. Galileo, bir sarkacın salınımı için geçen sürenin onun genliğinden(gerilme halinden) bağımsız olduğunu keşfettiğini söylemiştik. Sarkacın eşzamanlılığı ismini verdiği keşif, zaman ölçümü hususunda önemli bir yere sahip olacaktı. 1602 yılında arkadaşına, uzun sarkaçların eşzamanlılığını anlattığı bir mektup yazmıştı. Bir yıl sonra ise fizyolog olan diğer bir arkadaşı Santorio Santorio, hastalarının nabzını ölçmek için kısa sarkaç kullanmaya başladı. Sarkaç üzerine ciddi çalışmalar da bu dönemde yoğunlaşmıştır. Sarkacın Kullanımı Sarkaç, nabız ölçümünde zamanlama aracı olarak ya da müzik öğrencileri için bir metronom olarak kullanılabilir. Çünkü sarkacın her bir salınımı eşit zaman aralıklarında gerçekleşiyor. Sarkaç ayrıca saatleri geliştirmek için de kullanılabilir mi? İtici gücü sağlamak için bir ağırlık kullanılan mekanik saatler, Orta Çağ döneminde çok eski olan su saatlerinin yerini almaya başlamıştı. Öte yandan devam eden geliştirmelerle birlikte sarkaç daha küçük ve güvenilir olma yolunda ilerliyordu. Fakat en iyi olduğu düşünülen saatlerin güvenilirliği o kadar düşüktü ki örneğin, astronomik amaçlar için kullanılması düşünülemezdi. 17.yüzyıldan kalma sarkaçlı saat tasarımı O dönemde kullanılan saatlerin zamanı ileri veya geri göstermesi bir yana, tam olarak ne zaman yanlış zamanı göstereceği bile tahmin edilemiyordu. Bir sarkaç, zamanı doğru ölçme konusunda saatin çalışma mekanizmasıyla ilişki kurulabilecek kadar kullanışlı olabilir miydi? 1641 yılında 77 yaşında, artık görme engeli olmuş Galileo dikkatini bu konu üzerine yoğunlaştırdı. Vincenzo Viviani gelişen olayları aşağıdaki gibi açıklıyor: 1641 yılı idi. Bir gün Arcetri'deki villasında O'nunla oturuyorduk. Sarkaçların saatlere monte edilebileceği fikrini benimle paylaştığını hatırlıyorum. Böylece sarkacın doğal ve değişmeyen hareketinin, saat tasarımındaki kusurların hepsini gidereceğini düşünmüştü. Fakat görme engeli nedeniyle, yaptığı çizimler ve modeller istediği etkiyi yaratmasını engelliyordu. Oğlu Vincenzio ise bir gün Floransa'dan Arcetri'ye gelmişti. Galileo, fikrini oğluyla paylaştı ve bir dizi tartışmaya tutuştular. Sonuç olarak bir tasarım üzerinde fikir birliğine varmışlardı fakat tasarımın gerçekleştirilmesi konusundaki zorluğunda farkındaydılar. Viviani bu kısmı 1659 yılında, Galileo'nun ölümünden 18 yıl sonra yazdı. Ayrıca Christiaan Huygens'in sarkaçlı saati tanıttığı Horologium adlı eseri de Viviani'nin biyografisinden 2 yıl önce yazılmıştı. Huygens'in sarkaçlı saat tasarımı ise tarihte ilk sarkaçlı saat örneği olarak bilinir. Galileo ise kafasındaki sarkaçlı saat tasarımı düşüncesini gerçekleştiremeden hayata gözlerini yummuştur. Galileo'nun evren görüşü ve çalışmaları hakkında daha fazla bilgi için şu yazımızı okuyabilirsiniz. Kaynak: The Galileo Project Sarkaçlı saat Sarkaçlı saat, zaman işleyişi olarak bir sallanan ağırlık olan bir sarkaç kullanan bir saattir. Bir sarkacın zaman işleyişi için avantajı, harmonik bir osilatör olmasıdır. Uzunluğuna bağlı olarak kesin bir zaman aralığında ileri geri sallanır ve diğer oranlarda sallanmaya direnir. 1656'da Christiaan Huygens tarafından Galileo Galilei'den esinlenerek icat edilmesinden 1930'lara kadar sarkaçlı saat, yaygın kullanımının hesaba katılmasıyla dünyanın en hassas zaman tutucusuydu.[1][2] 18. ve 19. yüzyıllar boyunca, evlerdeki, fabrikalardaki, ofislerdeki ve tren istasyonlarındaki sarkaçlı saatler, günlük yaşamı, iş vardiyalarını ve toplu taşıma araçlarını planlamak için birincil zaman standartları olarak hizmet etti. Daha yüksek doğrulukları, Sanayi Devrimi için gerekli olan daha hızlı yaşam hızına izin verdi. Ev tipi sarkaçlı saatler, 1930'larda ve 40'larda daha ucuz, senkronize, elektrikli saatler ile değiştirildi. Sarkaçlı saatler artık çoğunlukla dekoratif ve antika değerleri nedeniyle saklanmaktadır. Sarkaçlı saatlerin çalışması için sabit olması gerekir. Herhangi bir hareket veya ivme sarkacın hareketini etkileyerek yanlışlıklara neden olacak ve bu nedenle taşınabilir saatlerde kullanılmak üzere başka mekanizmalar gerektirecektir. ^ Milham, Willis I. (1945). Time and Timekeepers. New York: MacMillan. s. 330, 334. ISBN 0-7808-0008-7. ^ Marrison, Warren (1948). "The Evolution of the Quartz Crystal Clock". Bell System Technical Journal. Cilt 27. ss. 510-588. doi:10.1002/j.1538-7305.1948.tb01343.x. 13 Mayıs 2007 tarihinde kaynağından arşivlendi. Wikimedia Commons'ta Sarkaçlı saat ile ilgili ortam dosyaları mevcuttur. The Invention of Clocks 28 Mayıs 2020 tarihinde Wayback Machine sitesinde arşivlendi. The (Not So) Simple Pendulum 28 Haziran 2011 tarihinde Wayback Machine sitesinde arşivlendi. The earliest Dutch and French Pendulum clocks, 1657-1662 Computer-Aided Design and Kinematic Simulation of Huygens's Pendulum Clock 26 Mayıs 2021 tarihinde Wayback Machine sitesinde arşivlendi. 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No warranties are given. The license may not give you all of the permissions necessary for your intended use. For example, other rights such as publicity, privacy, or moral rights may limit how you use the material. Florentine physicist and astronomer (1564–1642) "Galileo" redirects here. For other uses, see Galileo (disambiguation) and Galileo Galilei (disambiguation). Galileo GalileiPortrait c. 1640BornGalileo di Vincenzo Bonaiuti de' Galilei[1](1564-02-15)15 February 1564[2]Pisa, Duchy of FlorenceDied8 January 1642(1642-01-08)(aged 77)Arcetri, Grand Duchy of TuscanyEducationUniversity of PisaKnown forAnalytical dynamicsheliocentrismkinematicsobservational astronomyScientific careerFieldsAstronomyphysicsengineeringnatural philosophymathematicsInstitutionsUniversity of PisaUniversity of PaduaPatrons Cosimo II de Medici Federico Cesi Ferdinando II de Medici Fra Paolo Sarpi Francesco Maria del Monte Academic advisorsOstilio Ricci da FermoNotable studentsBenedetto CastelliMario GuiducciVincenzo Viviani Signature Part of a series onPhysical cosmology Big Bang · Universe Age of the universe Chronology of the universe Early universe Inflation · Nucleosynthesis Backgrounds Gravitational wave (GWB) Microwave (CMB) · Neutrino (CNB) Expansion · Future Hubble's law · Redshift Expansion of the universe FLRW metric · Friedmann equations Lambda-CDM model Future of an expanding universe Ultimate fate of the universe Components · Structure Components Dark energy · Dark matter Photons · Baryons Structure Shape of the universe Galaxy filament · Galaxy formation Large quasar group Large-scale structure Reionization · Structure formation Experiments Black Hole Initiative (BHI) BOOMERanG Cosmic Background Explorer (COBE) Dark Energy Survey Planck space observatory Sloan Digital Sky Survey (SDSS) 2dF Galaxy Redshift Survey ("2dF") Wilkinson Microwave AnisotropyProbe (WMAP) Scientists Aaronson Alfvén Alpher Copernicus de Sitter Dicke Ehlers Einstein Ellis Friedmann Galileo Gamow Guth Hawking Hubble Huygens Kepler Lemaître Mather Newton Penrose Penzias Rubin Schmidt Smoot Suntzeff Sunyaev Tolman Wilson Zeldovich List of cosmologists Subject history Discovery of cosmic microwavebackground radiation History of the Big Bang theory Timeline of cosmological theories Category Astronomy portalvte Galileo di Vincenzo Bonaiuti de' Galilei (15 February 1564 – 8 January 1642), commonly referred to as Galileo Galilei (/ˌɡælɪˈleɪoʊ ˌɡælɪˈleɪ/, US also /ˌɡælɪˈliːoʊ -/; Italian: [ɡaliˈlɛːo ɡaliˈlɛːi]) or mononymously as Galileo, was an Italian[a] astronomer, physicist and engineer, sometimes described as a polymath. He was born in the city of Pisa, then part of the Duchy of Florence.[8] Galileo has been called the father of observational astronomy,[9] modern-era classical physics,[10] the scientific method,[11] and modern science.[12] Galileo studied speed and velocity, gravity and free fall, the principle of relativity, inertia, projectile motion and also worked in applied science and technology, describing the properties of the pendulum and "hydrostatic balances". He was one of the earliest Renaissance developers of the thermoscope[13] and the inventor of various military compasses. With an improved telescope he built, he observed the stars of the Milky Way, the phases of Venus, the four largest satellites of Jupiter, Saturn's rings, lunar craters and sunspots. He also built an early microscope. Galileo's championing of Copernican heliocentrism was met with opposition from within the Catholic Church and from some astronomers. The matter was investigated by the Roman Inquisition in 1615, which concluded that his opinions contradicted accepted Biblical interpretations.[14][15][16] Galileo later defended his views in Dialogue Concerning the Two Chief World Systems (1632), which appeared to attack and ridicule Pope Urban VIII, thus alienating both the Pope and the Jesuits, who had both strongly supported Galileo up until this point.[14] He was tried by the Inquisition, found "vehemently suspect of heresy", and forced to recant. He spent the rest of his life under house arrest.[17][18] During this time, he wrote Two New Sciences (1638), primarily concerning kinematics and the strength of materials.[19] Galileo was born in Pisa (then part of the Duchy of Florence) on 15 February 1564,[20] the first of six children of Vincenzo Galilei, a leading lutenist, composer, and music theorist, and Giulia Ammannati, the daughter of a prominent merchant, who had married two years earlier in 1562, when he was 42, and she was 24. Galileo became an accomplished lutenist himself and would have learned early from his father to be skeptical of established authority, who expressed such skepticism in his own writings on music.[21] Three of Galileo's five siblings survived infancy. The youngest, Michelangelo (or Michelagnolo), also became a lutenist and composer who added to Galileo's financial burdens for the rest of his life.[22] Michelangelo was unable to contribute his fair share of their father's promised dowries to their brothers-in-law, who later attempted to seek legal remedies for payments due. Michelangelo also occasionally had to borrow funds from Galileo to support his musical endeavours and excursions. These financial burdens may have contributed to Galileo's early desire to develop inventions that would bring him additional income.[23] When Galileo Galilei was eight, his family moved to Florence, but he was left under the care of Muzio Tedaldi for two years. When Galileo was ten, he left Pisa to join his family in Florence, where he came under the tutelage of Jacopo Borghini.[20] He was educated, particularly in logic, from 1575 to 1578 in the Vallombrosa Abbey, about 30 km southeast of Florence.[24][25] Galileo tended to refer to himself only by his first name. At the time, surnames were optional in Italy, and his first name had the same origin as his sometimes-family name, Galilei. Both his given and family name ultimately derived from an ancestor, Galileo Bonaiuti, an important physician, professor, and politician in Florence in the 15th century.[26] Galileo Bonaiuti was buried in the same church, the Basilica of Santa Croce in Florence, where about 200 years later, Galileo Galilei was also buried.[27] When he did refer to himself with more than one name, it was sometimes as Galileo Galilei Linceo, a reference to his being a member of the Accademia dei Lincei, an elite science organization founded in the Papal States. It was common for mid-16th century Tuscan families to name the eldest son after the parents' surname.[28] Hence, Galileo Galilei was not necessarily named after his ancestor Galileo Bonaiuti. The Italian male given name "Galileo" (and thence the surname "Galilei") derives from the Latin "Galilaeus", meaning "of Galilee".[29][26] The biblical roots of Galileo's name and surname were to become the subject of a famous (supposed[b]) pun. In 1614, during the Galileo affair, one of Galileo's opponents, the Dominican priest Tommaso Caccini, delivered against Galileo a controversial and influential sermon. In it he made a point of quoting Acts 1:11: "Ye men of Galilee, why stand ye gazing up into heaven?".[30] Portrait believed to be of Galileo's elder daughter Virginia, who was particularly devoted to her father. Despite being a genuinely pious Catholic,[31] Galileo fathered three children out of wedlock with Marina Gamba. They had two daughters, Virginia (born 1600) and Livia (born 1601), and a son, Vincenzo (born 1606).[32] Due to their illegitimate birth, Galileo considered the girls unmarriageable, if not posing problems of prohibitively expensive support or dowries, which would have been similar to Galileo's previous extensive financial problems with two of his sisters.[33] Their only worthy alternative was the religious life. Both girls were accepted by the convent of San Matteo in Arcetri and remained there for the rest of their lives.[34] Virginia took the name Maria Celeste upon entering the convent. She died on 2 April 1634, and is buried with Galileo at the Basilica of Santa Croce, Florence. Livia took the name Sister Arcangela and was ill for most of her life. Vincenzo was later legitimised as the legal heir of Galileo and married Sestilia Bocchineri.[35] Although Galileo seriously considered the priesthood as a young man, at his father's urging he instead enrolled in 1580 at the University of Pisa for a medical degree.[36] He was influenced by the lectures of Girolamo Borro, Domingo de Soto and Francesco Buonamici of Florence.[25] In 1581, when he was studying medicine, he noticed a swinging chandelier, which air currents shifted about to swing in larger and smaller arcs. To him, it seemed, by comparison with his heartbeat, that the chandelier took the same amount of time to swing back and forth, no matter how far it was swinging. When he returned home, he set up two pendulums of equal length and swung one with a large sweep and the other with a small sweep and found that they kept time together. It was not until the work of Christiaan Huygens, almost one hundred years later, that the tautochrone nature of a swinging pendulum was used to create an accurate timepiece.[37] Up to this point, Galileo had deliberately been kept away from mathematics, since a physician earned a higher income than a mathematician. However, after accidentally attending a lecture on geometry, he talked his reluctant father into letting him study mathematics and natural philosophy instead of medicine.[37] He created a thermoscope, a forerunner of the thermometer, and, in 1586, published a small book on the design of a hydrostatic balance he had invented (which first brought him to the attention of the scholarly world). Galileo also studied disegno, a term encompassing fine art, and, in 1588, obtained the position of instructor in the Accademia delle Arti del Disegno in Florence, teaching perspective and chiaroscuro. In the same year, upon invitation by the Florentine Academy, he presented two lectures, On the Shape, Location, and Size of Dante's Inferno, in an attempt to propose a rigorous cosmological model of Dante's Inferno.[38] Being inspired by the artistic tradition of the city and the works of the GAPTWO brought before inquisitor Vincenzo Maculani to be charged. Throughout his trial, Galileo steadfastly maintained that since 1616 he had faithfully kept his promise not to hold any of the condemned opinions, and initially he denied even defending them. However, he was eventually persuaded to admit that, contrary to his true intention, a reader of his Dialogue could well have obtained the impression that it was intended to be a defence of Copernicanism. In view of Galileo's rather implausible denial that he had ever held Copernican ideas after 1616 or ever intended to defend them in the Dialogue, his final interrogation, in July 1633, concluded with his being threatened with torture if he did not tell the truth, but he maintained his denial despite the threat.[154][155][156] The sentence of the Inquisition was delivered on 22 June. It was in three essential parts: Galileo was found "vehemently suspect of heresy" (though he was never formally charged with heresy, relieving him of facing corporal punishment),[157] namely of having held the opinions that the Sun lies motionless at the centre of the universe, that the Earth is not at its centre and moves, and that one may hold and defend an opinion as probable after it has been declared contrary to Holy Scripture. He was required to "abjure, curse and detest" those opinions.[158][159][160][161] He was sentenced to formal imprisonment at the pleasure of the Inquisition.[162] On the following day, this was commuted to house arrest, under which he remained for the rest of his life.[163] His offending Dialogue was banned; and in an action not announced at the trial, publication of any of his works was forbidden, including any he might write in the future.[164][165] Portrait, originally attributed to Murillo, of Galileo gazing at the words "E pur si muove" (And yet it moves) (not legible in this image) scratched on the wall of his prison cell. The attribution and narrative surrounding the painting have since been contested. According to popular legend, after recanting his theory that the Earth moved around the Sun, Galileo allegedly muttered the rebellious phrase "And yet it moves". There was a claim that a 1640s painting by the Spanish painter Bartolomé Esteban Murillo or an artist of his school, in which the words were hidden until restoration work in 1911, depicts an imprisoned Galileo apparently gazing at the words "E pur si muove" written on the wall of his dungeon. The earliest known written account of the legend dates to a century after his death. Based on the painting, Stillman Drake wrote "there is no doubt now that the famous words were already attributed to Galileo before his death".[166] However, an intensive investigation by astrophysicist Mario Livio has revealed that said painting is most probably a copy of an 1837 painting by the Flemish painter Roman-Eugene Van Maldeghem.[167] After a period with the friendly Ascanio Piccolomini (the Archbishop of Siena), Galileo was allowed to return to his villa at Arcetri near Florence in 1634, where he spent part of his life under house arrest. Galileo was ordered to read the Seven Penitential Psalms once a week for the next three years. However, his daughter Maria Celeste relieved him of the burden after securing ecclesiastical permission to take it upon herself.[168] It was while Galileo was under house arrest that he dedicated his time to one of his finest works, Two New Sciences. Here he summarised work he had done some forty years earlier, on the two sciences now called kinematics and strength of materials, published in Holland to avoid the censor. This book was highly praised by Albert Einstein.[169] As a result of this work, Galileo is often called the "father of modern physics". He went completely blind in 1638 and developed a painful hernia and insomnia, so he was permitted to travel to Florence for medical advice.[19] Dava Sobel argues that prior to Galileo's 1633 trial and judgement for heresy, Pope Urban VIII had become preoccupied with court intrigue and problems of state and began to fear persecution or threats to his own life. In this context, Sobel argues that the problem of Galileo was presented to the pope by court insiders and enemies of Galileo. Having been accused of weakness in defending the church, Urban reacted against Galileo out of anger and fear.[170] Mario Livio places Galileo and his discoveries in modern scientific and social contexts. In particular, he argues that the Galileo affair has its counterpart in science denial.[171] This and other facts, not few in number or less worth knowing, I have succeeded in proving; and what I consider more important, there have been opened up to this vast and most excellent science, of which my work is merely the beginning, ways and means by which other minds more acute than mine will explore its remote corners.—Galileo Galilei, Two New Sciences Galileo made original contributions to the science of motion through an innovative combination of experiments and mathematics.[172] More typical of science at the time were the qualitative studies of William Gilbert, on magnetism and electricity. Galileo's father, Vincenzo Galilei, a lutenist and music theorist, had performed experiments establishing perhaps the oldest known non-linear relation in physics: for a stretched string, the pitch varies as the square root of the tension.[173] These observations lay within the framework of the Pythagorean tradition of music, well known to instrument makers, which included the fact that subdividing a string by a whole number produces a harmonious scale. Thus, a limited amount of mathematics had long related to music and physical science, and young Galileo could see his own father's observations expand on that tradition.[174] Galileo was one of the first modern thinkers to clearly state that the laws of nature are mathematical. In The Assayer, he wrote "Philosophy is written in this grand book, the universe ... It is written in the language of mathematics, and its characters are triangles, circles, and other geometric figures;...."[175] His mathematical analyses are a further development of a tradition employed by late scholastic natural philosophers, which Galileo learned when he studied philosophy.[176] His work marked another step towards the eventual separation of science from both philosophy and religion; a major development in human thought. He was often willing to change his views in accordance with observation. In order to perform his experiments, Galileo had to set up standards of length and time, so that measurements made on different days and in different laboratories could be compared in a reproducible fashion. This provided a reliable foundation on which to confirm mathematical laws using inductive reasoning.[citation needed] Galileo showed a modern appreciation for the proper relationship between mathematics, theoretical physics, and experimental physics. He understood the parabola, both in terms of conic sections and in terms of the ordinate (y) varying as the square of the abscissa (x). Galileo further asserted that the parabola was the theoretically ideal trajectory of a uniformly accelerated projectile in the absence of air resistance or other disturbances. He conceded that there are limits to the validity of this theory, noting on theoretical grounds that a projectile trajectory of a size comparable to that of the Earth could not possibly be a parabola,[177][178][179] but he nevertheless maintained that for distances up to the range of the artillery of his day, the deviation of a projectile's trajectory from a parabola would be only very slight.[177][180][181] A replica of the earliest surviving telescope attributed to Galileo Galilei, on display at the Griffith Observatory Using his refracting telescope, Galileo observed in late 1609 that the surface of the Moon is not smooth.[39] Early the next year, he observed the four largest moons of Jupiter.[56] Later in 1610, he observed the phases of Venus as well as Saturn, though he thought the planet's rings were two other planets.[71] In 1612, he observed Neptune and noted its motion, but did not identify it as a planet.[73] Galileo made studies of sunspots,[74] the Milky Way, and made various observations about stars, including how to measure their apparent size without a telescope.[83][84][85] He coined the term Aurora Borealis in 1619 from the Roman goddess of the dawn and the Greek name for the north wind, to describe lights in the northern and southern sky when particles from the solar wind energise the magnetosphere.[182] Self-Portrait in a Circle of Friends from Mantua by Rubens, 1602-06. Galilei is the third man on the left. The picture depicts the Aurora Borealis in the distance. Galileo made a number of contributions to what is now known as engineering, as distinct from pure physics. Between 1595 and 1598, Galileo devised and improved a geometric and military compass suitable for use by gunners and surveyors. This expanded on earlier instruments designed by Niccolò Tartaglia and Guidobaldo del Monte. For gunners, it offered, in addition to a new and safer way of elevating cannons accurately, a way of quickly computing the charge of gunpowder for cannonballs of different sizes and materials. As a geometric instrument, it enabled the construction of any regular polygon, computation of the area of any polygon or circular sector, and a variety of other calculations. Under Galileo's direction, instrument maker Marc'Antonio Mazzoleni produced more than 100 of these compasses, which Galileo sold (along with an instruction manual he wrote) for 50 lire and offered a course of instruction in the use of the compasses for 120 lire.[183] Galileo's geometrical and military compass, thought to have been made c. 1604 by his personal instrument-maker Marc'Antonio Mazzoleni In 1593, Galileo constructed a thermometer, using the expansion and contraction of air in a bulb to move water in an attached tube.[184] In 1609, Galileo was, along with Englishman Thomas Harriot and others, among the first to use a refracting telescope as an instrument to observe stars, planets or moons. The name "telescope" was coined for Galileo's instrument by a Greek mathematician, Giovanni Demisiani,[185][186] at a banquet held in 1611 by Prince Federico Cesi to make Galileo a member of his Accademia dei Lincei.[187] In 1610, he used a telescope at close range to magnify the parts of insects.[188][189] By 1624, Galileo had used a compound microscope. He gave one of these instruments to Cardinal Zollern in May of that year for presentation to the Duke of Bavaria,[190] and in September, he sent another to Prince Cesi.[191] The Linceans played a role again in naming the "microscope" a year later when fellow academy member Giovanni Faber coined the word for Galileo's invention from the Greek words μικρόν (micron) meaning "small", and σκοπεῖν (skopein) meaning "to look at". The word was meant to be analogous with "telescope".[192][193] Illustrations of insects made using one of Galileo's microscopes and published in 1625, appear to have been the first clear documentation of the use of a compound microscope.[191] The earliest known pendulum clock design, conceived by Galileo Galilei In 1612, having determined the orbital periods of Jupiter's satellites, Galileo proposed that with sufficiently accurate knowledge of their orbits, one could use their positions as a universal clock, and this would make possible the determination of longitude. He worked on this problem from time to time during the remainder of his life, but the practical problems were severe. The method was first successfully applied by Giovanni Domenico Cassini in 1681 and was later used extensively for large land surveys; this method, for example, was used to survey France, and later by Zebulon Pike of the midwestern United States in 1806. For sea navigation, where delicate telescopic observations were more difficult, the longitude problem eventually required the development of a practical portable marine chronometer, such as that of John Harrison.[194] Late in his life, when totally blind, Galileo designed an escapement mechanism for a pendulum clock (called Galileo's escapement), although no clock using this was built until after the first fully operational pendulum clock was made by Christiaan Huygens in the 1650s.[citation needed] Galileo was invited on several occasions to advise on engineering schemes to alleviate river flooding. In 1630 Mario Guiducci was probably instrumental in ensuring that he was consulted on a scheme by Bartolotti to cut a new channel for the Bisenzio River near Florence.[195] An issue with simple ball bearings is that the balls rub against each other, causing additional friction. This can be reduced by enclosing each individual ball within a cage. The captured, or caged, ball bearing was originally described by Galileo in the 17th century.[196] Galileo e Viviani, by Tito Lessi, 1892 Dome of the Cathedral of Pisa with the "lamp of Galileo"Galileo's theoretical and experimental work on the motions of bodies, along with the largely independent work of Kepler and René Descartes, was a precursor of the classical mechanics developed by Sir Isaac Newton. Main article: Pendulum § History Galileo conducted several experiments with pendulums. It is popularly believed (thanks to the biography by Vincenzo Viviani) that these began by watching the swings of the bronze chandelier in the Cathedral of Pisa, using his pulse as a timer. The first recorded interest in pendulums made by Galileo was in his posthumously published notes titled On Motion,[197] but later experiments are described in his Two New Sciences. Galileo claimed that a simple pendulum is isochronous, i.e. that its swings always take the same amount of time, independently of the amplitude. In fact, this is only approximately true,[198] as was discovered by Christiaan Huygens. Galileo also found that the square of the period varies directly with the length of the pendulum. Galileo is lesser known for, yet still credited with, being one of the first to understand sound frequency. By scraping a chisel at different speeds, he linked the pitch of the sound produced to the spacing of the chisel's skips, a measure of frequency. Main article: Vacuum pump § History By the 17th century, water pump designs had improved to the point that they produced measurable vacuums, but this was not immediately understood. What was known was that suction pumps could not pull water beyond a certain height: 18 Florentine yards according to a measurement taken around 1635, or about 34 feet (10 m).[199] This limit was a concern in irrigation projects, mine drainage, and decorative water fountains planned by the Duke of Tuscany, so the duke commissioned Galileo to investigate the problem. In his Two New Sciences (1638) Galileo suggested, incorrectly, that the column of water pulled up by a water pump would break of its own weight once reaching beyond 34 feet.[199] Main article: Speed of light § History In 1638, Galileo described an experimental method to measure the speed of light by arranging that two observers, each having lanterns equipped with shutters, observe each other's lanterns at some distance. The first observer opens the shutter of his lamp, and, the second, upon seeing the light, immediately opens the shutter of his own lantern. The time between the first observer's opening his shutter and seeing the light from the second observer's lamp indicates the time it takes light to travel back and forth between the two observers. Galileo reported that when he tried this at a distance of less than a mile, he was unable to determine whether or not the light appeared instantaneously.[200] Sometime between Galileo's death and 1667, the members of the Florentine Accademia del Cimento repeated the experiment over a distance of about a mile and obtained a similarly inconclusive result.[201] The speed of light has since been determined to be far too fast to be measured by such methods. Main article: Galilean invariance Galileo put forward the basic principle of relativity, that the laws of physics are the same in any system that is moving at a constant speed in a straight line, regardless of its particular speed or direction. In Dialogue Concerning the Two Chief World Systems, Salviati gives the following thought experiment: Shut yourself up with some friend in the main cabin below the decks of some ship, and have with you there some flies, butterflies, and other small, flying animals. Have a large bowl of water with some fish in it; hang up a bottle that empties drop by drop into a narrow-mouthed vessel beneath it. With the ship standing still, observe carefully how the little animals fly with equal speed to all sides of the cabin. The fish swim indifferently in all directions; the drops fall into the vessel beneath; and in throwing something to your friend, you need throw it no more strongly in one direction than another, the distances being equal; jumping with your feet together, you pass equal spaces in every direction. When you have observed all these things carefully (though there is no doubt that when the ship is standing still, everything must happen this way), have the ship proceed with any speed you like, so long as the motion is uniform and not fluctuating this way and that. You will discover not the least change in all the effects named, nor could you tell from any of them whether the ship was moving or standing still.[202] This principle provided the basic framework for Newton's laws of motion and is central to Einstein's special theory of relativity. See also: History of gravitational theory § European Renaissance, and Free fall § History That unequal weights would fall with the same speed may have been proposed as early as 60BC by the Roman philosopher Lucretius.[203] Observations that similarly sized objects of different weights fall at the same speed are documented in sixth-century works by John Philoponus, of which Galileo was aware.[204][205] In the 14th century, Nicole Oresme had derived the time-squared law for uniformly accelerated change,[206][207] and in the 16th century, Domingo de Soto had suggested that bodies falling through a homogeneous medium would be uniformly accelerated.[208] De Soto, however, did not anticipate many of the qualifications and refinements contained in Galileo's theory of falling bodies. He did not, for instance, recognise, as Galileo did, that a body would fall with a strictly uniform acceleration only in a vacuum, and that it would otherwise eventually reach a uniform terminal velocity. Main article: Delft tower experiment In 1586, Simon Stevin (commonly known as Stevinus) and Jan Cornets de Groot dropped lead balls from the Nieuwe Kerk in the Dutch city of Delft. The experiment established that objects of identical size, but different masses, fall at the same speed.[37][209] While the Delft tower experiment had been a success, it was not conducted with the same scientific rigour that later experiments were. Stevin was forced to rely on audio feedback (caused by the spheres impacting a wooden platform below) to deduce that the balls had fallen at the same speed. The experiment was given less credence than the more substantive work of Galileo Galilei and his famous Leaning Tower of Pisa thought experiment of 1589. Main article: Galileo's Leaning Tower of Pisa experimentDuring the Apollo 15 mission in 1971, astronaut David Scott showed that Galileo was right: acceleration is the same for all bodies subject to gravity on the Moon, even for a hammer and a feather.A biography by Galileo's pupil Vincenzo Viviani stated that Galileo had dropped balls of the same material, but different masses, from the Leaning Tower of Pisa to demonstrate that their time of descent was independent of their mass.[210] This was contrary to what Aristotle had taught: that heavy objects fall faster than lighter ones, in direct proportion to weight.[211][212] While this story has been retold in popular accounts, there is no account by Galileo himself of such an experiment, and it is generally accepted by historians that it was at most a thought experiment which did not actually take place.[213] An exception is Stillman Drake,[214] who argues that the experiment did take place, more or less as Viviani described it. However, most of Galileo's experiments with falling bodies were carried out using inclined planes where both the issues of timing and air resistance were much reduced.[215] In his Two New Sciences (1638), Salviati, widely regarded as Galileo's spokesman, held that all unequal weights would fall with the same finite speed in a vacuum: "In a medium totally devoid of all resistance all bodies would fall with the same speed."[216] Salviati also held that this could be experimentally demonstrated by the comparison of pendulum motions in air with bobs of lead and of cork which had different weights but which were otherwise similar. Galileo proposed that a falling body would fall with a uniform acceleration, as long as the resistance of the medium through which it was falling remained negligible, or in the limiting case of its falling through a vacuum.[217][218] He also derived the correct kinematical law for the distance travelled during a uniform acceleration starting from rest—namely, that it is proportional to the square of the elapsed time (d∝t2).[208][219] Galileo expressed the time-squared law using geometrical constructions and mathematically precise words, adhering to the standards of the day. (It remained for others to re-express the law in algebraic terms.)[citation needed] See also: Newton's laws of motion § History Galileo also concluded that objects retain their velocity in the absence of any impediments to their motion,[220] thereby contradicting the generally accepted Aristotelian hypothesis that a body could only remain in so-called "violent", "unnatural", or "forced" motion so long as an agent of change (the "mover") continued to act on it.[221] Philosophical ideas relating to inertia had been proposed by John Philoponus and Jean Buridan. Galileo stated:[222][223] Imagine any particle projected along a horizontal plane without friction; then we know, from what has been more fully explained in the preceding pages, that this particle will move along this same plane with a motion which is uniform and perpetual, provided the plane has no limits.—Galileo Galilei, Two New Sciences, Fourth Day But the surface of the earth would be an instance of such a plane if all its unevenness could be removed.[224] This was incorporated into Newton's laws of motion (first law), except for the direction of the motion: Newton's is straight, Galileo's is circular (for example, the planets' motion around the Sun, which according to him, and unlike Newton, takes place in absence of gravity). According to Dijksterhuis Galileo's conception of inertia as a tendency to persevere in circular motion is closely related to his Copernican conviction.[225] While Galileo's application of mathematics to experimental physics was innovative, his mathematical methods were the standard ones of the day, including dozens of examples of an inverse proportion square root method passed down from Fibonacci and Archimedes. The analysis and proofs relied heavily on the Eudoxian theory of proportion, as set forth in the fifth book of Euclid's Elements. This theory had become available only a century before, thanks to accurate translations by Tartaglia and others; but by the end of Galileo's life, it was being superseded by the algebraic methods of Descartes. The concept now named Galileo's paradox was not original with him. His proposed solution, that infinite numbers cannot be compared, is no longer considered useful.[226] Tomb of Galileo, Santa Croce, Florence Galileo continued to receive visitors until his death on 8 January 1642, aged 77, following a fever and heart palpitations.[19][227] The Grand Duke of Tuscany, Ferdinando II, wished to bury him in the main body of the Basilica of Santa Croce, next to the tombs of his father and other ancestors, and to erect a marble mausoleum in his honour.[228][229] Galileo's middle finger from his right hand These plans were dropped, however, after Pope Urban VIII and his nephew, Cardinal Francesco Barberini, protested,[228][229][230] because Galileo had been condemned by the Catholic Church for "vehement suspicion of heresy".[231] He was instead buried in a small room next to the novices' chapel at the end of a corridor from the southern transept of the basilica to the sacristy.[228][232] He was reburied in the main body of the basilica in 1737 after a monument had been erected there in his honour;[233][234] during this move, three fingers and a tooth were removed from his remains.[235] One of these fingers is currently on exhibition at the Museo Galileo in Florence, Italy.[236] The Galileo affair was largely forgotten after Galileo's death, and the controversy subsided. The Inquisition's ban on reprinting Galileo's works was lifted in 1718 when permission was granted to publish an edition of his works (excluding the condemned Dialogue) in Florence.[237] In 1741, Pope Benedict XIV authorised the publication of an edition of Galileo's complete scientific works[238] which included a mildly censored version of the Dialogue.[239][238] In 1758, the general prohibition against works advocating heliocentrism was removed from the Index of prohibited books. However, the specific ban on uncensored versions of the Dialogue and Copernicus's De Revolutionibus remained.[240][238] All traces of official opposition to heliocentrism by the church disappeared in 1835 when these works were finally dropped from the Index.[241][242] Interest in the Galileo affair was revived in the early 19th century when Protestant polemicists used it (and other events such as the Spanish Inquisition and the myth of the flat Earth) to attack Roman Catholicism.[14] Interest in it has waxed and waned ever since. In 1939, Pope Pius XII, in his first speech to the Pontifical Academy of Sciences, within a few months of his election to the papacy, described Galileo as being among the "most audacious heroes of research... not afraid of the stumbling blocks and the risks on the way, nor fearful of the funereal monuments".[243] His close advisor of 40 years, Professor Robert Leiber, wrote: "Pius XII was very careful not to close any doors (to science) prematurely. He was energetic on this point and regretted that in the case of Galileo."[244] On 15 February 1990, in a speech delivered at the Sapienza University of Rome,[245][246] Cardinal Ratzinger (later Pope Benedict XVI) cited some current views on the Galileo affair as forming what he called "a symptomatic case that permits us to see how deep the self-doubt of the modern age, of science and technology goes today".[247] Some of the views he cited were those of the philosopher Paul Feyerabend, whom he quoted as saying: "The Church at the time of Galileo kept much more closely to reason than did Galileo himself, and it took into consideration the ethical and social consequences of Galileo's teaching too. Its verdict against Galileo was rational and just and the revision of this verdict can be justified only on the grounds of what is politically opportune."[247] The Cardinal did not clearly indicate whether he agreed or disagreed with Feyerabend's assertions. He did, however, say: "It would be foolish to construct an impulsive apologetic on the basis of such views."[247] On 31 October 1992, Pope John Paul II acknowledged that the Inquisition had erred in condemning Galileo for asserting that the Earth revolves around the Sun. "John Paul said the theologians who condemned Galileo did not recognize the formal distinction between the Bible and its interpretation."[248] In March 2008, the head of the Pontifical Academy of Sciences, Nicola Cabibbo, announced a plan to honour Galileo by erecting a statue of him inside the Vatican walls.[249] In December of the same year, during events to mark the 400th anniversary of Galileo's earliest telescopic observations, Pope Benedict XVI praised his contributions to astronomy.[250] A month later, however, the head of the Pontifical Council for Culture, Gianfranco Ravasi, revealed that the plan to erect a statue of Galileo on the grounds of the Vatican had been suspended.[251] Galileo showing the Doge of Venice how to use the telescope (fresco by Giuseppe Bertini, 1858) According to Stephen Hawking, Galileo probably bears more of the responsibility for the birth of modern science than anybody else,[252] and Albert Einstein called him the father of modern science.[253][254] In a Foreword to Dialogue Concerning the Two Chief World Systems, Einstein wrote: "The leitmotif I recognize in Galileo's work is the passionate fight against any kind of dogma based on authority. Only experience and careful reflection are accepted by him as criteria of truth."[255] Author John G. Simmons notes Galileo's place in the history of science as the embracing of a new outlook on science, stating that:[256]But perhaps most significant, Galileo epitomized a new scientific outlook. By his rhetoric, supported by mathematical reasoning, and the force of his personality, Galileo helped to establish the Copernican model of the solar system as a revolution in science.Galileo's astronomical discoveries and investigations into the Copernican theory have led to a lasting legacy which includes the categorisation of the four large moons of Jupiter discovered by Galileo (Io, Europa, Ganymede and Callisto) as the Galilean moons. Other scientific endeavours and principles are named after Galileo including the Galileo spacecraft.[257] Partly because the year 2009 was the fourth centenary of Galileo's first recorded astronomical observations with the telescope, the United Nations scheduled it to be the International Year of Astronomy.[258] Statue outside the Uffizi, Florence Statue of Galileo by Pio Fedi (1815–1892) inside the Lanyon Building of the Queen's University Belfast. Sir William Whitla (Professor of Materia Medica 1890–1919) brought the statue back from Italy and donated it to the university. Galileo's early works describing scientific instruments include the 1586 tract entitled The Little Balance (La Billancetta) describing an accurate balance to weigh objects in air or water[259] and the 1606 printed manual Le Operazioni del Compasso Geometrico et Militare on the operation of a geometrical and military compass.[260] His early works on dynamics, the science of motion and mechanics were his circa 1590 Pisan De Motu (On Motion) and his circa 1600 Paduan Le Meccaniche (Mechanics). The former was based on Aristotelian–Archimedean fluid dynamics and held that the speed of gravitational fall in a fluid medium was proportional to the excess of a body's specific weight over that of the medium, whereby in a vacuum, bodies would fall with speeds in proportion to their specific weights. It also subscribed to the Philoponan impetus dynamics in which impetus is self-dissipating and free-fall in a vacuum would have an essential terminal speed according to specific weight after an initial period of acceleration.[261] Galileo's 1610 The Starry Messenger (Sidereus Nuncius) was the first scientific treatise to be published based on observations made through a telescope. It reported his discoveries of: the Galilean moons the roughness of the Moon's surface the existence of a large number of stars invisible to the naked eye, particularly those responsible for the appearance of the Milky Way differences between the appearances of the planets and those of the fixed stars—the former appearing as small discs, while the latter appeared as unmagnified points of light Galileo published a description of sunspots in 1613 entitled Letters on Sunspots suggesting the Sun and heavens are corruptible.[262] The Letters on Sunspots also reported his 1610 telescopic observations of the full set of phases of Venus, and his discovery of the puzzling "appendages" of Saturn and their even more puzzling subsequent disappearance. In 1615, Galileo prepared a manuscript known as the "Letter to the Grand Duchess Christina" which was not published in printed form until 1636. This letter was a revised version of the Letter to Castelli, which was denounced to the Inquisition by Niccolò Lorini (as discussed previously).[263] In 1616, after the order by the Inquisition for Galileo not to hold or defend the Copernican position, Galileo wrote the "Discourse on the Tides" (Discorso sul flusso e il reflusso del mare) based on the Copernican earth, in the form of a private letter to Cardinal Orsini.[264] In 1619, Mario Guiducci, a pupil of Galileo's, published a lecture written largely by Galileo under the title Discourse on the Comets (Discorso Delle Comete), arguing against the Jesuit interpretation of comets.[265] In 1623, Galileo published The Assayer—Il Saggiatore, which attacked theories based on Aristotle's authority and promoted experimentation and mathematical formulation of scientific ideas. The book was highly successful; Pope Urban was "so charmed by it as to have it read aloud to him at table."[266] Following the success of The Assayer, Galileo published the Dialogue Concerning the Two Chief World Systems (Dialogo sopra i due massimi sistemi del mondo) in 1632. Despite taking care to adhere to the Inquisition's 1616 instructions, the claims in the book favouring Copernican theory and a non-geocentric model of the solar system led to Galileo being tried and banned from publication. Despite the publication ban, Galileo published his Discourses and Mathematical Demonstrations Relating to Two New Sciences (Discorsi e Dimostrazioni Matematiche, intorno a due nuove scienze) in 1638 in Holland, outside the jurisdiction of the Inquisition.[267] Galileo's main written works are as follows:[268] The Little Balance (1586; in Italian: La Bilancetta) On Motion (c. 1590; in Latin: De Motu Antiquiora)[269] Mechanics (c. 1600; in Italian: Le mecaniche) The Operations of Geometrical and Military Compass (1606; in Italian: Le operazioni del compasso geometrico et militare) The Starry Messenger (1610; in Latin: Sidereus Nuncius) Discourse on Floating Bodies (1612; in Italian: Discorso intorno alle cose che stanno in su l'acqua, o che in quella si muovono, "Discourse on Bodies that Stay Atop Water, or Move in It") History and Demonstration Concerning Sunspots (1613; in Italian: Istoria e dimostrazioni intorno alle macchie solari; work based on the Three Letters on Sunspots, Tre lettere sulle macchie solari, 1612) "Letter to the Grand Duchess Christina" (1615; published in 1636) "Discourse on the Tides" (1616; in Italian: Discorso del flusso e reflusso del mare) Discourse on the Comets (1619; in Italian: Discorso delle Comete) The Assayer (1623; in Italian: Il Saggiatore) Dialogue Concerning the Two Chief World Systems (1632; in Italian: Dialogo sopra i due massimi sistemi del mondo) Two New Sciences (1638; in Italian: Discorsi e Dimostrazioni Matematiche, intorno a due nuove scienze) In the last years of his life, Galileo kept a library of at least 598 volumes (560 of which have been identified) at Villa Il Gioiello, on the outskirts of Florence.[270] Under the restrictions of house arrest, he was forbidden to write or publish his ideas. However, he continued to receive visitors right up to his death and it was through them that he remained supplied with the latest scientific texts from Northern Europe.[271] Given his past experience, Galileo may have feared that his collection of books and manuscripts would be seized by authorities and burned, as no reference to them was made in his last will and testament. An itemized inventory was only later produced after Galileo's death, when the majority of his possessions including his library passed to his son, Vincenzo Galilei Jr. On his death in 1649, the collection was inherited by his wife Sestilia Bocchineri.[271] Galileo's books, personal papers and unedited manuscripts were then collected by Vincenzo Viviani, his former assistant and student, with the intent of preserving his old teacher's works in published form. It was a project that never materialised and in his final will, Viviani bequeathed a significant portion of the collection to the Hospital of Santa Maria Nuova in Florence, where there already existed an extensive library. The value of Galileo's possessions was not realised, and duplicate copies were dispersed to other libraries, such as the Biblioteca Comunale degli Intronati, the public library in Sienna. In a later attempt to specialise the library's holdings, volumes unrelated to medicine were transferred to the Biblioteca Magliabechiana, an early foundation for what was to become the Biblioteca Nazionale Centrale di Firenze, the National Central Library in Florence.[271] A small portion of Viviani's collection, including the manuscripts of Galileo and those of his peers Evangelista Torricelli and Benedetto Castelli, was left to his nephew, Abbot Jacopo Panzanini. This minor collection was preserved until Panzanini's death when it passed to his great-nephews, Carlo and Angelo Panzanini. The books from both Galileo and Viviani's collection began to disperse as the heirs failed to protect their inheritance. Their servants sold several of the volumes for waste paper. Around 1750 the Florentine senator Giovanni Battista Clemente de'Nelli heard of this and purchased the books and manuscripts from the shopkeepers, and the remainder of Viviani's collection from the Panzanini brothers. As recounted in Nelli's memoirs: "My great fortune in obtaining such a wonderful treasure so cheaply came about through the ignorance of the people selling it, who were not aware of the value of those manuscripts..." The library remained in Nelli's care until his death in 1793. Knowing the value of their father's collected manuscripts, Nelli's sons attempted to sell what was left to the French government. Ferdinand III, Grand Duke of Tuscany intervened in the sale and purchased the entire collection. The archive of manuscripts, printed books and personal papers was deposited with the Biblioteca Palatina in Florence, merging the collection with the Biblioteca Magliabechiana in 1861.[271] Catholic Church and science Seconds pendulum Tribune of Galileo Villa Il Gioiello ^ Though an Italian nation state would not be established until 1861, the Latin equivalent of the term Italian (italus) had been in use for the region since antiquity.[3] Crucially, the intellectuals and the bourgeoisie of the region self-identified as Italians at least since Dante's epoch (13th century),[4][5][6] and Galileo himself did.[7] ^ Maurice Finocchiaro, in the source referenced for this "pun" story (Finocchiaro 1989, 330-331) states, "I am not aware of any direct documentary evidence [for this story], nor is any reference given by the various authors who repeat the legend." He also notes that the earliest mention of the story seems to be 1773. ^ The inception of this belief is attributed to the influence of the work of Thomas Aquinas (1225–1274) [45] ^ i.e., invisible to the naked eye. ^ In the Capellan model only Mercury and Venus orbit the Sun, whilst in its extended version such as expounded by Riccioli, Mars also orbits the Sun, but the orbits of Jupiter and Saturn are centred on the Earth. ^ In geostatic systems the apparent annual variation in the motion of sunspots could only be explained as the result of an implausibly complicated precession of the Sun's axis of rotation[76][77][78] This did not apply, however, to the modified version of Tycho's system introduced by his protégé, Longomontanus, in which the Earth was assumed to rotate. Longomontanus's system could account for the apparent motions of sunspots just as well as the Copernican. ^ a b Such passages include Psalm 93:1, 96:10, and 1 Chronicles 16:30 which include text stating, "The world also is established. It can not be moved." In the same manner, Psalm 104:5 says, "He (the Lord) laid the foundations of the earth, that it should not be moved forever." Further, Ecclesiastes 1:5 states, "The sun also rises, and the sun goes down, and hurries to its place where it rises", and Joshua 10:14 states, "Sun, stand still on Gibeon...".[132] ^ The discovery of the aberration of light by James Bradley in January 1729 was the first conclusive evidence for the movement of the Earth, and hence for Aristarchus, Copernicus and Kepler's theories; it was announced in January 1729.[133] The second evidence was produced by Friedrich Bessel in 1838. ^ According to Maurice Finocchiaro, this was done in a friendly and gracious manner, out of curiosity.[136] ^ Ingoli wrote that the great distance to the stars in the heliocentric theory "clearly proves ... the fixed stars to be of such size, as they may surpass or equal the size of the orbit circle of the Earth itself".[142] ^ Drake asserts that Simplicio's character is modelled on the Aristotelian philosophers Lodovico delle Colombe and Cesare Cremonini, rather than Urban.[149] He also considers that the demand for Galileo to include the Pope's argument in the Dialogue left him with no option but to put it in the mouth of Simplicio.[150] Even Arthur Koestler, who is generally quite harsh on Galileo in The Sleepwalkers, after noting that Urban suspected Galileo of having intended Simplicio to be a caricature of him, says "this of course is untrue".[151]

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Galileo Galilei at Wikipedia's sister projects Media from CommonsQuotations from WikiquoteTexts from Wikisource Works by Galileo Galilei at Open Library Works by Galileo Galilei at Project Gutenberg Works by Galileo Galilei at LibriVox (public domain audiobooks) Works by or about Galileo Galilei at the Internet Archive Works in Galileo's Personal Library at LibraryThing Portals: Biography Physics Astronomy Stars Earth sciences Engineering Italy History of science Retrieved from " Galileo Galilei, 15 şubat 1564 yılında İtalya'da doğmuştur. İtalyan astronom, fizikçi, filozof ve matematikçi bir bilim adamıdır. Babası tanınmış ünlü müzisyenlerinden Vincenzo Galilei'dir. 5 kardeşi vardır ve kardeşlerin en büyüğüdür. Adını büyük büyük dedesinden alan Galileo, birçok dalda başarısıyla adını duyurmuş bir bilim adamıdır. Galileo, 1581 yılında Pisa Üniversitesi'nde Tıp okuluna başladı. Fakat maddi durumu el vermediği için okulu yarıda bırakmak zorunda kaldı. 1583 yılında matematiğe yönelerek araştırmalar yaptı. Bu dalda başarısından dolayı Pisa'da profesör oldu. Sarkacın, yüzen cisimlerin ve kinetiğin Aristo fiziğinden farklı bir düşünceyle, matematiksel olarak ele alınması gerektiğini düşündü. Galileo, Pisa Kulesine çıkıp aşağıya ağırlıklar bırakarak, düşen bütün cisimlerin aynı ivmeye sahip olduğunu kanıtladı ve Aristo mantığının yanlış olduğunu gösterdi. Galileo, astronomiye de merak salarak bu alanda da birçok araştırma ve çalışma yaptı. Güneş merkezli astronomi fiziğini geliştirdi. Kendi ürettiği teleskobuyla birçok gök cismi üzerinde araştırmalar yaptı. Güneşi gözlemleyen bilim adamı, Güneş'in üzerindeki gölgelerin aslında etrafından geçen gök cisimlerinin gölgesi olmadığını, Güneş'in kendi lekesi olduğunu kanıtladı. O zamanlar bir arkadaşının 8. Urban olarak Papa seçilmesinden cesaret alarak yazdığı "İki Kainat Sistemi Üzerine Konuşmalar'' adlı kitabı, 1632 yılında yayınlandı. Fakat daha önce yapılan uyarılardan dolayı Roma'da mahkemeye çağrıldı ve kitabı bir yıl sonra yayından kaldırıldı. Maalesef hakkında öbür boyu evinde müebbet kararı alındı. 70 yaşında eve hapsedilen bilim adamı Galileo'nun gözleri kör oldu ve 1642 yılında vefat etti. Galileo Galilei'in buluşları: -Teleskop: Aslında Galileo'dan öncesi mercekleri kullanarak uzağı görme aletleri yapılmıştı. Fakat Galileo, daha da ileri giderek yıldızları ve gezegenleri inceleyecek kadar güçlü hale getirdi. 1609 yılında yaptığı teleskopla birçok astronomik gözlemler gerçekleştirmiştir. Ay'ın yüzeyindeki kraterler ilk kez tespit edilmiştir. Kendi yaptığı teleskobuyla Jüpiter'i incelerken, Jüpiter'in yakın çevresinde 3 küçük, parlak gezegen keşfetmiştir. Daha önce incelemelerinde bunların yıldız olduğunu düşünen bilim adamı, sonraki incelemeler sonucu, yıldız olmayıp Jüpiter'in etrafında dönen küçük gezegenler olduğunu keşfetti. -Mikroskop: Gözle görülmeyen cisimlerin incelenmesi yönünde Galileo teleskobu icat etti. Bunun için teleskobun silindir kısmına mercekler yerleştirerek küçük maddelerin görülebilmesini sağladı. 1619-1624 yılları arasında da bu aletten çok sayıda üretti. -Sarkaçlar ve Saatler: Galileo'nun sarkaçlar üzerinde yaptığı araştırmalar, modern saatin ortaya çıkmasında katkı sağladı. Bununla ilgili Galileo'un bir hikayesi vardır: Galileo, henüz küçük yaşlardayken kiliseye gider ve ayin sırasında bir adamın kafası kandile çarpar. Kandilin ileri geri sallanmasını seyrederken, kandil yavaşlasa bile hep aynı süre içinde ileri geri gittiği için bu durum Galileo'nun dikkatini çeker. Sonraki yıllarda da sarkaçların (yani ipe bağlı ağırlıkların) hareketini inceler ve bilimsel bulgular tespit eder. Eskiden saat yapımında sorun olarak karşılarına çıkan konularda Galileo'nun tespitleri yarar sağlamıştır. Bu sarkaçlarla ilgili buluşlarının saatlere uygulanması sayesinde var olan sorunlar ortadan kalkmış ve "tik tak tik tak" seslerini çıkaran modern saat yapılmıştır. – Pusula: 1597 yılında kullanım açısından çok faydası olan, yön bulmada insanlara kolaylık sağlayan pusulayı ticari olarak piyasaya sundu. Yorumlar