B.2.3 Components of a Force

Key Concepts:	Vectors
	Weight
Materials:	Inclined plane
	Stick and clamp
	Metal roller with handle
	Display protractor
	Two vertical rods with pulleys
	Two 50 g weight hangers and a selection of masses
Set Up Time:	
Time Estimate:	

Set Up And Display

Set the inclined plane to somewhere within 15 to 50°. Place the roller on the inclined plane, braced by clamping the stick to the plane. By a string parallel to the inclined plane and pulley, balance out the component of weight and demonstrate that the stick can now be removed. With the second string perpendicular to the inclined plane and through a pulley, balance the normal force of the roller to the plane. Remove the inclined plane. The weights needed for a variety of angles are tabulated here for the roller that has a mass of 521 g.

θ	m_1(g)	m_2(g)	θ	m_1(g)	m_2(g)	θ	m_1(g)	m_2(g)
15	135	503	27	237	464	39	328	405
16	144	501	28	245	460	40	335	399
17	152	499	29	253	456	41	342	393
18	161	496	30	261	451	42	349	387
19	170	493	31	269	447	43	355	381
20	178	490	32	276	442	44	362	375
21	187	486	33	284	437	45	368	368
22	195	483	34	291	432	46	375	362
23	204	480	35	299	427	47	381	355
24	212	476	36	306	422	48	387	349
25	220	472	37	314	416	49	393	342
26	228	468	38	321	411	50	399	335

Explanation

In order for an object to stay still, all forces on it must cancel. In this problem, the key force to be cancelled is the weight of the roller. This weight can be treated as two components defined by its contact with the inclined plane. One component is normal to the inclined plane and is effectively how much of the weight the plane has to support. The other component is parallel to the inclined plane and is the force that would make the roller roll down the plane if the stick were not there to support it.

The fact that the weight can be divided into components is directly exhibited by the two hanging weights used to offset the components one at a time. The components of the weight are related to the angle of the inclined plane as follows:

$$m_1 g = m_w g \sin\theta$$

$$m_2 g = m_w g \cos\theta$$

where m_1 is the mass needed to counter the parallel component of the roller's weight, m_2 is the mass needed to counter the normal component of the roller's weight, m_w is the mass of the roller, g is the acceleration due to gravity, and θ is the angle of the inclined plane. For the 521 g roller, the total mass needed for m_1 and m_2 are tabulated above. Remember to include the 50 g of the mass hangers when adding masses.

Related Demonstrations: B 2.1 B 2.2 B 2.24 B 2.42