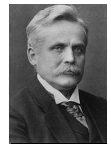
PHYSICS 534

ANSWERS

EXERCISE-15 The Horizontal Plane

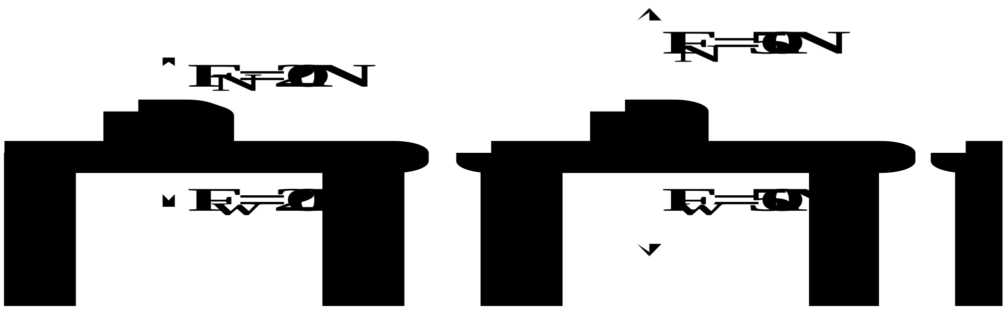


WIEN

Wilhelm Wien received the Nobel prize in physics in 1911 for his laws on heat radiation.

A horizontal plane is a level surface. When an object is placed on a horizontal plane, there are two forces acting on the object. One force is the ***weight*** of the object (which always acts downward and perpendicular to the horizontal) and the other force if the ***normal*** (which always acts outward and perpendicular from the plane).
The weight is a force applied by the earth's gravitation, the normal is applied by the horizontal plane. In calculating the weight, we use the formula w = mg where m is the mass (in kilograms) and g is the acceleration due to **g**ravity . However, to keep the math as simple as possible, we will use the "ideal" value of 10 m/s^2 for "g " rather than the "real" value of 9.8 m/s^2.

The illustration below shows three objects of different masses placed on a horizontal plane. In each case, the two forces acting (the weight downward and the normal upward) cancel each other to produce equilibrium ($F_R = 0$).



Notice how "smart" the table is in knowing exactly how much ***normal*** force to apply (an amount equal to the weight). Of course, the table can only exert a normal force up to a maximum value. This value is the maximum strength of the table (based on its construction and type of material used). Of course, if a weight larger than the maximum strength is placed on the table, the table will crash (and equilibrium is not attained).

➢ ***Note***: By definition, a horizontal plane is assumed to withstand (hold up) any weight.

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1. What is a ***horizontal*** plane?

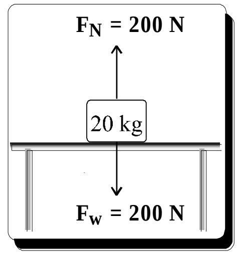
A horizontal plane is a level surface.

2. Define the following forces:

a) Normal force ***A force which acts perpendicular and out from a plane.***

b) Resultant force ***The sum of all the forces acting on a system.***

3. Illustrated on the right is a 20 kg box resting on a horizontal table:



a) Is the system in equilibrium? ***Yes***

b) Draw the forces acting on the system.

c) What is the resultant force? ***0***

d) What is the downward force? ***200 N***

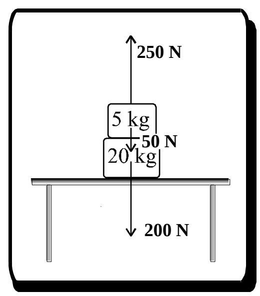
e) What is the sum of the vertical forces? ***0***

f) What is the sum of the horizontal forces? ***0***

g) What is the upward force? ***200 N***

h) What is the normal force? ***200 N***

4. Illustrated on the right is a 5 kg box and a 20 kg box resting on a horizontal table:



a) Is the system in equilibrium? ***Yes***

b) Draw the forces acting on the system.

c) What is the resultant force? ***0***

d) What is the downward force? ***250 N***

e) What is the sum of the vertical forces? ***0***

f) What is the sum of the horizontal forces? ***0***

g) What is the upward force? ***250 N***

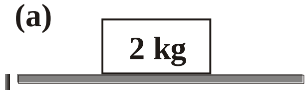
h) What is the normal force? ***250 N***

5. What determines the ***normal*** force applied by a horizontal plane?

The total force pressing into the horizontal plane.

6. The following exercise is intended to give you practice in identifying the normal force. Assume that each system below is ***at rest***. For each case, draw the forces acting on the object (box), identify the normal force, and fill in the blanks.

(a)



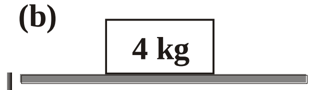
F_{LEFT} = **0**

F_{RIGHT} = **0**

F_{DOWN} = **20 N**

F_{UP} = **20 N**

(b)



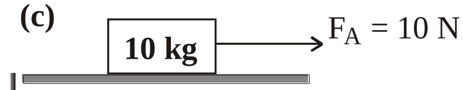
F_{LEFT} = **0**

F_{RIGHT} = **0**

F_{DOWN} = **40 N**

F_{UP} = **40 N**

(c)



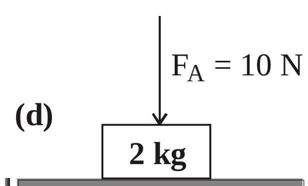
F_{LEFT} = **10 N**

F_{RIGHT} = **10 N**

F_{DOWN} = **100 N**

F_{UP} = **100 N**

(d)



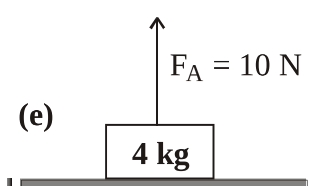
F_{LEFT} = **0**

F_{RIGHT} = **0**

F_{DOWN} = **30 N**

F_{UP} = **30 N**

(e)



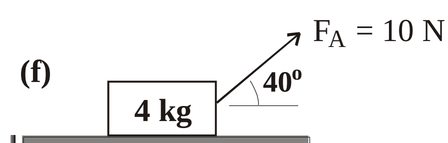
F_{LEFT} = **0**

F_{RIGHT} = **0**

F_{DOWN} = **30 N**

F_{UP} = **30 N**

(f)



F_{LEFT} = **7.7 N**

F_{RIGHT} = **7.7 N**

F_{DOWN} = **33.6 N**

F_{UP} = **33.6 N**