PHYSICS 534

ANSWERS

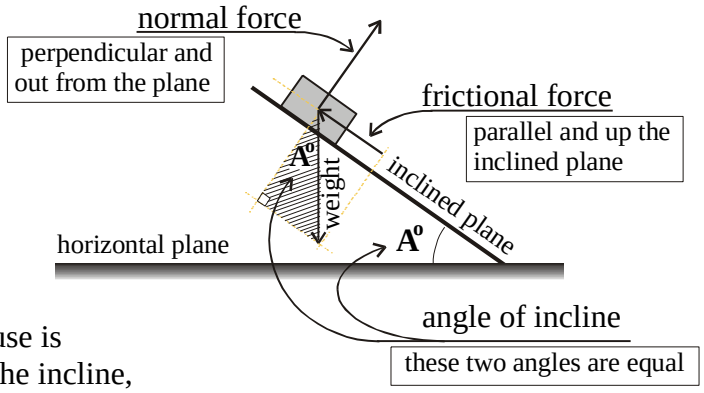
EXERCISE-19 The Inclined Plane

BRAGG

William Bragg senior received the Nobel prize in physics in 1915 for his X-ray analysis of crystal structure.

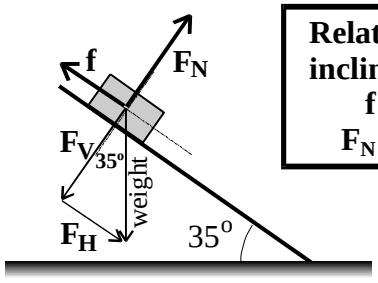
↳ ***Note***: Diagrams not drawn to scale. To convert mass to weight, use g = 10 m/s^2 rather than 9.8 m/s^2.

An inclined plane is a slanted surface The amount of the slant is known as the angle of incline. When the angle of incline is zero, the inclined plane becomes a horizontal plane. When the angle of incline is 90^O, the inclined plane is equivalent to "free fall".



In solving problems with the inclined plane, we use the shaded right triangle illustrated in the diagram on the right. In this right triangle, note that the top angle is equal to the angle of incline, the hypotenuse is equal to the weight of the object placed on the incline, the adjacent side equals the magnitude of the normal force, and the opposite side equals the magnitude of the frictional force.

Thus: Normal force = (weight)(cos A) and Fricti



Relative to the inclined plane:
$f = F_H$
$F_N = F_V$

1. A 50 kg box rests on an inclined plane as shown in the diagram on the right. Due to friction, the box remains motionless. Calculate:

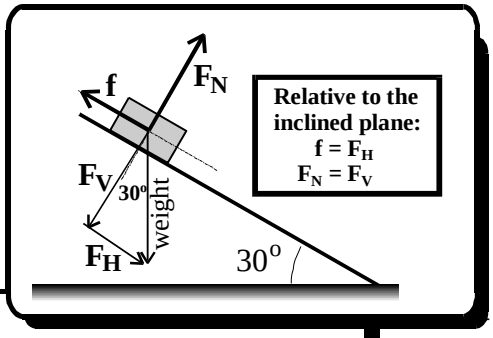
a) The normal force. [409.6 N]

Find F_V relative to the inclinedplane.
$F_N = F_V$ = (weight)(Cos 35°)
= (500 N)(Cos 35°)
= 409.57 = 409.6 N

b) The frictional force. [286.8 N]

Find F_H relative to the inclinedplane.
$f = F_H$ = (weight)(Sin 35°)
= (500 N)(Sin 35°)
= 286.78 = 286.8 N

2. A 100 kg box rests on an inclined plane as shown in the diagram on the right. Due to friction, the box remains motionless. Calculate:



a) The normal force. [866 N]

Relative to the inclined plane: $F_N = F_V$

$F_V = (\text{weight})(\cos 30^\circ)$

$= (1000\ \text{N})(\cos 30^\circ) = 866\ \text{N}$

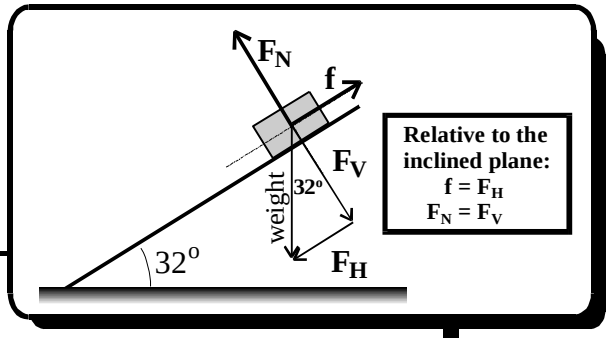
b) The frictional force. [500 N]

Relative to the inclined plane: $f = F_H$

$F_H = (\text{weight})(\sin 30^\circ)$

$= (1000\ \text{N})(\sin 30^\circ) = 500\ \text{N}$

3. A box rests on an inclined plane as shown on the right. If the normal force is 500 N.



a) What is the mass of the box? [59 N]

Find the weight (w) then the mass (m).

$F_N = F_V = (w)(\cos 32^\circ)$

or $500\ \text{N} = (w)(\cos 32^\circ) \quad \therefore \quad w = \dfrac{500\ \text{N}}{\cos 32^\circ} = 589.6 = 590\ \text{N}$

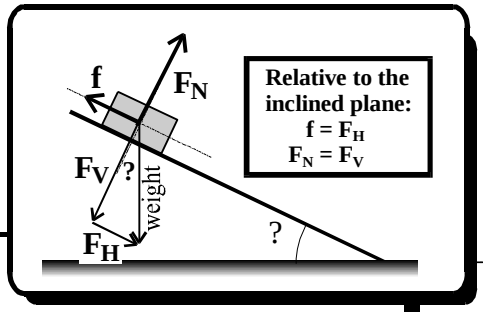
Since $w = mg \quad \therefore \quad m = \dfrac{590\ \text{N}}{10\ \text{m/s}^2} = 59\ \text{kg}$

b) What is the frictional force? [312 N]

$f = F_H$

$\tan 32^\circ = \dfrac{F_H}{500\ \text{N}}$ or $F_H = (500\ \text{N})(\tan 32^\circ) = 312\ \text{N}$

4. A 40 kg object rests on an inclined plane. If the frictional force is 169 N, find:



a) The angle of incline. [25°]

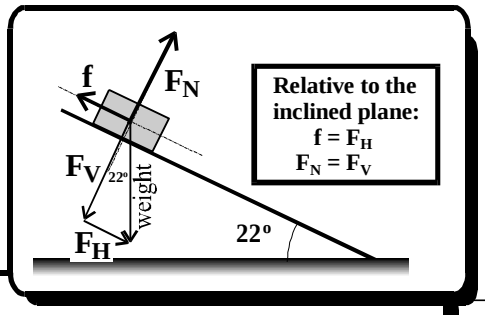
$$F_H = (\text{Weight})(\text{Sin}\,A)$$

$$\text{Sin}\,A = \frac{F_H}{\text{Weight}} = \frac{169\ \text{N}}{400\ \text{N}} = 0.4225 \quad \therefore\ A = 24.9^o = 25^o$$

b) The normal force. [362.5 N]

$$F_N = F_V = (\text{Weight})(\text{Cos}\ A) = (400\ \text{N})(\text{Cos}\ 25^o) = 362.5\ \text{N}$$

5. A 5 kg object slides down an inclined plane at ***constant velocity***. If the angle of incline is 22^O, find the coefficient of friction. [0.4]



$$f = F_H = (\text{Weight})(\text{Sin}\ 22^o) = (50\ \text{N})(\text{Sin}\ 22^o) = 18.7\ \text{N}$$

$$F_N = F_V = (\text{Weight})(\text{Cos}\ 22^o) = (50\ \text{N})(\text{Cos}\ 22^o) = 46.4\ \text{N}$$

$$\because\ f = kF_N \quad \therefore\ k = \frac{f}{F_N} = \frac{18.7\ \text{N}}{46.4\ \text{N}} = 0.4$$

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