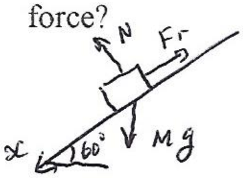
Forces worksheet 2

1. A particle slides down a smooth slope of 45°. What is its acceleration?

$a = g \sin 45^\circ$ $\quad a = 6.9\ m s^{-2}$

2. A 60 kg woman skis down a slope that makes an angle of 60° with the horizontal. The woman has an acceleration of 8 $m\,s^{-2}$. What is the magnitude of the resistive force?



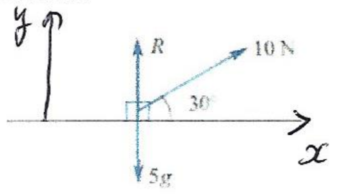
$mg \sin\theta - F_r = ma$

$F_r = mg \sin\theta - ma$

$F_r = 60 \times 9.8 \sin 60^\circ - 60 \times 8 = 29.2\ N$

3. Find the acceleration of a 5 kg mass and normal reaction for each of the following situations.

a

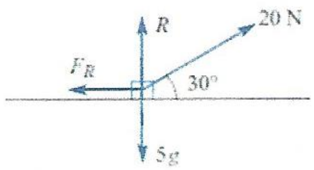


$x:\ 10 \cos 30^\circ = ma$ $\quad a = \frac{10 \cos 30^\circ}{5} = 1.7 m s^{-2}$

$y:\ R + 10 \sin 30^\circ - 5g = 0$

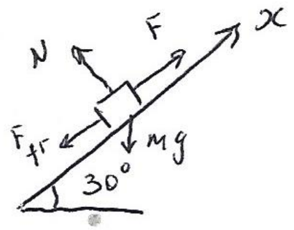
$R = 5g - 10 \sin 30^\circ = 44 N$

b



$F_R = 5\ N$

4. particle of mass 3 kg is being accelerated up a rough inclined plane, with friction force 8 N by a force of 30 Newtons acting parallel to the plane. The plane is inclined at an angle of 30° to the horizontal. Find its acceleration.



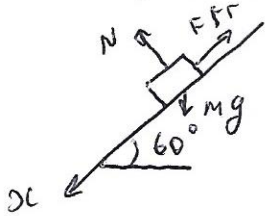
$F - F_{fr} - mg \sin\theta = ma$

$30 - 8 - 3 \times 9.8 \sin 30^\circ = 3a$

$7.3 = 3a$

$a = 2.4\ m s^{-2}$

5. A particle of mass 5 kg slides from rest down a rough plane inclined at 60° to the horizontal. Given that the of friction between the particle and the plane is 20 N, find the speed of the particle after it has travelled 5 m.



$mg\sin\theta - F_{fr} = ma$

$5 \times 9.8 \sin 60° - 20 = 5a$

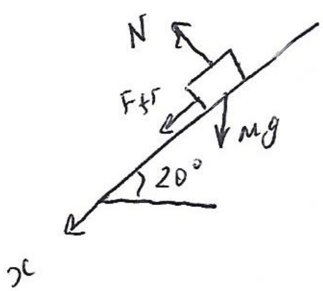
$22.4 = 5a$

$a = 4.48 \, ms^{-2}$

$v^2 = 2as$

$v = \sqrt{2 \times 4.48 \times 5} = 6.7 \, ms^{-1}$

6. A body of mass 8 kg is projected up an incline of 20° with a velocity of 10 $m\,s^{-1}$. If the friction between the body and the plane is 15 N, find the distance it goes up the plane and the velocity with which it returns to its starting point.



$mg\sin\theta + F_{fr} = ma$

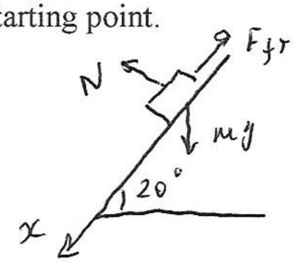
$8 \times 9.8 \sin 20° + 15 = 8a$

$41.8 = 8a$

$a = 5.225 \, ms^{-2}$

$0 = u^2 - 2as$

$S = \frac{10^2}{2 \times 5.225} = 9.57 \, m$



$mg\sin\theta - F_{fr} = ma_1$

$8 \times 9.8 \sin 20° - 15 = 8a_1$

$11.8 = 8a$

$a = 1.475 \, ms^{-2}$

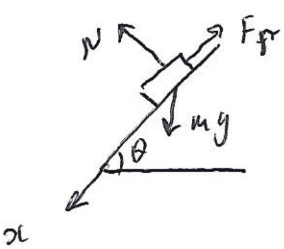
$v^2 = 2as$

$v = \sqrt{2 \times 1.475 \times 9.57}$

$= 5.3 \, ms^{-1}$

7. A car of mass one tonne coasts down a slope inclined at the angle θ ($\sin\theta = 0.05$) at constant speed. The car can ascend the same slope with a maximum acceleration of 1 $m\,s^{-2}$. Find:

a the total resistance to the motion (assumed constant)



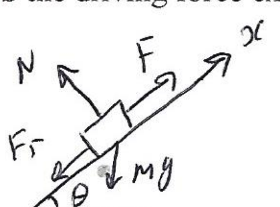
$mg\sin\theta - F_r = 0$

$F_r = mg\sin\theta$

$F_r = 1000 \times 9.8 \times 0.05$

$F_r = 490 \, N$

b the driving force exerted by the engine when the maximum acceleration is reached.



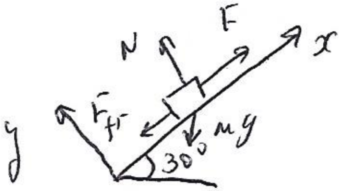
$F - F_r - mg\sin\theta = ma$

$F - 490 - 1000 \times 9.8 \times 0.05 = 1000 \times 1$

$F = 1980 \, N$

8. A particle of mass 5 kg is being pulled up a slope inclined at 30° to the horizontal. The pulling force, F Newtons, acts parallel to the slope, as does the resistance with a magnitude one-fifth of the magnitude of the normal reaction.

a Find the value of F, such that the acceleration is 1.5 $m\,s^{-2}$ up the slope.



$x: F - mg\sin\theta - F_{fr} = ma$

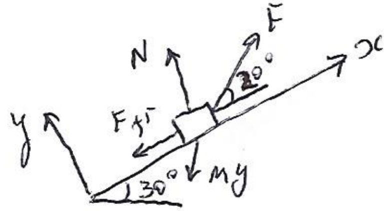
$y: N - mg\cos\theta = 0$

$N = mg\cos\theta = 5\times 9.8\cos 30° = 42.4\,N$

$F_{fr} = \frac{1}{5}N = 8.48\,N$

$F - 5\times 9.8\cos 30° - 8.48 = 5\times 1.5 \quad F = 58.4\,N$

b Also find the magnitude of the acceleration if this pulling force now acts at an angle of 20° to the slope (i.e. at 50° to the horizontal).



$x: F\cos 20° - mg\sin\theta - F_{fr} = ma$

$y: N + F\sin\theta - mg\cos\theta = 0$

$N = mg\cos\theta - F\sin\theta$

$N = 5\times 9.8\cos 30° - 58.4\sin 20°$

$N = 13.2\,N$

$F_{fr} = \frac{1}{5}\times 13.2 = 2.64\,N$

$58.4\cos 20° - 5\times 9.8\sin 30° - 2.64 = 5a$

$27.7 = 5a$

$a = 5.54\,m\,s^{-2}$