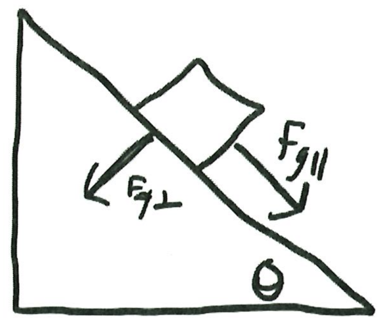
Inclines Practice Name:______________________________

F_g is the force of gravity acting on an object. It always points straight down.

In an incline, F_g is broken into two perpendicular components:

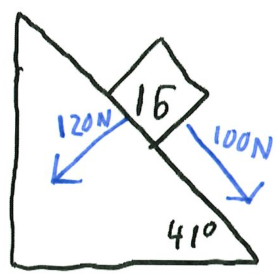
$F_{g||} = \sin\theta \times F_g$ is the component of F_g parallel to the incline, this is the force which will pull the object down the incline.



$F_{g\perp} = \cos\theta \times F_g$ is the component of F_g perpendicular to the incline, this will equal the normal force.

1. For each of the following determine $F_{g||}$ and $F_{g\perp}$

a.



$F_{g||} = \sin 41 \times F_g$

$= \sin 41 \times 16 \times 9.8$

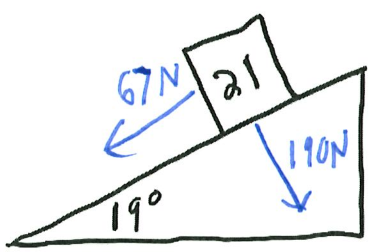
$= 102.87 \approx 1.0 \times 10^2\ N$

$F_{g\perp} = \cos 41 \times F_g$

$= \cos 41 \times 16 \times 9.8$

$= 120N$

b.



$F_{g||} = \sin 19 \times F_g$

$= \sin 19 \times 21 \times 9.8$

$= 67N$

$F_{g\perp} = \cos 19 \times F_g$

$= \cos 19 \times 21 \times 9.8$

$= 190N$

2. A 26 kg block is on a 23 degree incline. Determine the force pulling it down the incline and the normal force acting on it.

Force pulling it down $= F_{g\parallel} = \sin 23 \times 26\,kg \times 9.8\,\frac{m}{s^2}$

$= 1.0 \times 10^{2}\,N$

Normal Force $= F_{g\perp} = \cos 23 \times 26\,kg \times 9.8\,\frac{m}{s^2}$

$= 230\,N$

3. A 2.9 kg block is on a 73 degree incline. Determine the force pulling it down the incline and the normal force acting on it.

Force pulling it down $= F_{g\parallel} = \sin 73 \times 2.9\,kg \times 9.8\,\frac{m}{s^2}$

$= 27.18\,N$

$\approx 27\,N$

Normal force $= F_{g\perp} = \cos 73 \times 2.9\,kg \times 9.8\,\frac{m}{s^2}$

$= 8.3\,N$

Inclines Practice Name:______________________________

4. A 2.5 kg block is on a 48 degree frictionless incline. Determine the acceleration of the block down the incline.

$$F_{g\parallel} = \sin 48 \cdot 2.5kg \times 9.8\frac{m}{s^2} = 18.21N$$

$$a = \frac{F_{net}}{m} = \frac{18.21N}{2.5kg} = 7.3 m/s^2 \text{ down the ramp}$$

5. A 59 kg skier is atop a 25 degree, frictionless ski hill.
   a. What is the force pulling the skier down the hill?

$$F_{g\parallel} = \sin 25 \times 59kg \times 9.8 m/s^2 = 244.36 N$$

$$\approx 240N$$

   b. How long will it take the skier to travel down the hill if it is 250 m long?

$$a = \frac{F_{net}}{m} = \frac{244.36N}{59kg} = 4.142 m/s^2$$

Use $d = v_0 t + \frac{1}{2}at^2 \rightarrow t = 10.99$ sec

$\approx 11 sec$

   c. How fast will the skier be moving at the bottom of the hill?

Use $v_f^2 = v_0^2 + 2ad$

$$V_f = 46 m/s$$

6. A 2.0 kg block is placed on top of a 35°, 4.2-metre-long frictionless incline.
   a. What is the force acting to pull the block down the incline?

$$F_{g\parallel} = \sin 35 \times 2.0\,kg \times 9.8\,m/s^2$$
$$= 11.24\,N \approx 11\,N$$

   b. What is the velocity of the block at the bottom of the incline?

$$a = \frac{F_{net}}{m} = \frac{11.24\,N}{2.0\,kg} = 5.621\,m/s^2$$

Use $V_f^2 = V_0^2 + 2ad \rightarrow V_f = 6.9\,m/s$

   c. How long does it take for the block to reach the bottom of the incline?

Use $d = V_0 t + \frac{1}{2}at^2$

$$t = 1.2\,sec$$

7. A 5.0 kg block is pushed up a frictionless, 56° incline at a constant velocity of 4.2 m/s. What is the applied force needed to do this?

If the block moves at constant velocity

F up the ramp = F down the ramp

$= F_{g\parallel} =$ ~~[scribbled out]~~

$= \sin 56 \times 5.0\,kg \times 9.8\,m/s^2$

$= 40.62\,N$

Force up the ramp is 40.62 N

$= 41\,N$

8. A 25 kg block is pushed up a frictionless 35° incline accelerating up the ramp at 2.0 m/s². What is the force applied to the block?

F_{net} up the ramp is $ma = 25kg \times 2.0 m/s^2$
$= 50\ N$

Force applied is 50N more than F down

$F_{g\parallel} = \sin 35° \times 25kg \times 9.8 m/s^2 = 140.53N$

$F_{app} = 140.53 + 50 = 191N$

9. A 65 kg block is pushed up a frictionless 54° incline with an applied force of 725 N. What is the acceleration?

$F_{g\parallel} = \sin 54° \times 65kg \times 9.8 \frac{m}{s^2} = 515.34\ N$

$F_{net} = 725N - 515.34N = 209.66\ N$ up ramp

$a = \frac{F_{net}}{m} = \frac{209.66N}{65kg} = 3.2\ m/s^2$ up ramp

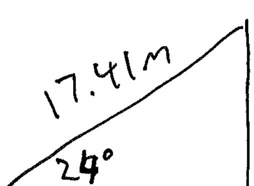
10. A 29 kg block is pushed up a frictionless 24° incline with a force of 156 N. What is the vertical and horizontal displacements after 5.0 seconds?

$F_{g\parallel} = \sin 24 \times 29 \times 9.8 = 115.59N$

$F_{net} = 156 - 115.59 = 40.41\ N$ up ramp

$a = \frac{40.41N}{29\ kg} = 1.393\ m/s^2$

$d = v_0 t + \frac{1}{2}at^2 \rightarrow d = 17.41m$ up ramp



$\cos 24 \times 17.41$
$= 16m$

$\sin 24 \times 17.41m$
$= 7.1m$

Vertical displacement is 7.1m
Horizontal displacement is 16m

Inclines Practice Name:______________________________

Inclines with Friction

11. A 49 kg block is on a 29 degree incline. The coefficient of friction between the block and the incline is 0.26.

    a. Determine the normal force acting on the block.

$$F_N = F_{g\perp} = \cos 29 \times 49\,kg \times 9.8\,m/s^2$$
$$= 420\,N$$

    b. Determine the force of friction acting on the block.

$$F_{fric} = \mu F_N = 0.26 \times 420\,N$$
$$= 109.2\,N$$
$$\approx 110\,N$$

    c. Determine the force pulling the block down the incline. ($F_{g||}$)

$$F_{g||} = \sin 29 \times 49\,kg \times 9.8\,m/s^2$$
$$= 232.8\,N \approx 230\,N$$

    d. Determine the net force acting on the block.

$$F_{net} = F_{g||} - F_{fric}$$
$$= 232.8\,N - 109.2\,N$$
$$= 123.6\,N \approx 120\,N$$

    e. Determine the acceleration of the block down the incline.

$$a = \frac{F_{net}}{m} = \frac{123.6\,N}{49\,kg} = 2.5\,m/s^2$$

Inclines Practice Name:___________________

12. A 2.5 kg block is on a 48 degree incline with $\mu = 0.19$. Determine the acceleration of the block down the incline.

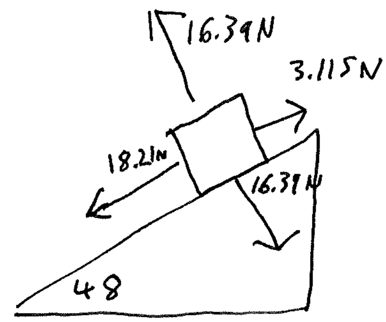
$$F_{g\parallel} = \sin 48 \times 2.5kg \times 9.8m/s^2 = 18.21N$$

$$F_{g\perp} = \cos 48 \times 2.5kg \times 9.8m/s^2 = 16.39N$$

$$F_{fric} = \mu F_N$$

$$= 0.19 \times 16.39N$$

$$= 3.115N$$



$$F_{net} = F_{g\parallel} - F_{fric}$$

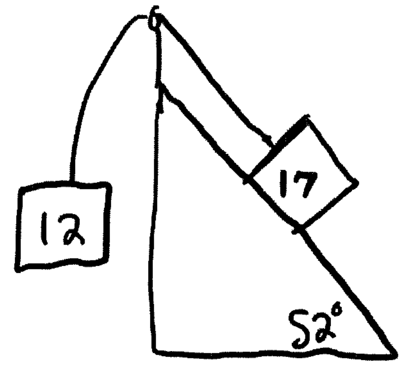
$$= 18.21 - 3.115$$

$$= 15.095N$$

$$a = \frac{F_{net}}{m} = \frac{15.095N}{2.5kg} = 6.0m/s^2$$

Inclines Practice Name:________________________________

13. A 17 kg block on a 52 degree incline with $\mu = 0.11$ is attached to a free hanging 12 kg block.



a. What is the magnitude of the force pulling the 12 kg block downwards?

$F_g = mg = 12kg \times 9.8 m/s^2$
$= 117.6N \approx 120N$

b. What is the magnitude of the force pulling the 17 kg block down the incline?

$F_{g\parallel} = \sin 52 \times 17kg \times 9.8 m/s^2$
$= 131.28N \approx 130N$

c. Will the 17 kg block move up the incline or down the incline?

Since $F_{g\parallel}$ is bigger than F_g, 17kg block goes down

d. What is the normal force acting on the 17kg block?

$F_N = F_{g\perp} = \cos 52 \times 17kg \times 9.8 m/s^2 = 102.57N$
$\approx 1.0 \times 10^2 N$

e. What is the force of friction working against motion?

$F_{fric} = \mu F_N = 0.11 \times 102.57N = 11.28N \approx 11N$

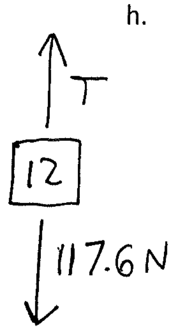
f. What is the net force acting on the blocks?

F_g on 12 kg block + F_{fric} = Forces causing 17 block to move up = 128.88 N
F_{net} = winners − losers = 131.28 − 128.88 = 2.4 N

g. What is the acceleration of the blocks?

$a = \frac{F_{net}}{m} = \frac{2.4 N}{29 kg} = 0.08276 m/s^2 \approx 0.083 m/s^2$

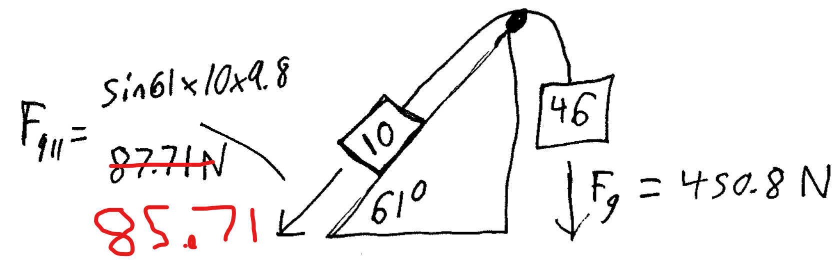
h. What is the tension in the rope connecting the blocks?



$F_{net} = ma = 12kg \times 0.08276 m/s^2 = 1.0 N$

T is winning force, it is 1.0 N more than F_g → $T = 117.6N + 1.0N = 118.6N \approx 120N$

14. A 10.0 kg block is on a 61° incline with $\mu = 0.42$. It is attached to a 46 kg block which is initially held 1.00m above the ground, the 46 kg block is then allowed to fall freely. How long will it take for the 46 kg block to fall 1.0 m?



Without friction 46 kg block will fall and 10 kg block will be pulled upwards

F_{fric} will act ... against that motion

$F_{fric} = \mu F_N = \mu F_{g\perp} = 0.42 \times \cos 61 \times 10\,kg \times 9.8\,m/s^2$
$= 19.95\,N$

$F_{net} = 450.8N - 8~~7~~5.71N - 19.95N = 34~~3~~5.14\,N$

$a = \frac{F_{net}}{m} = \frac{34~~3~~5.14N}{56\,kg} = 6.1~~275~~637\,m/s^2$

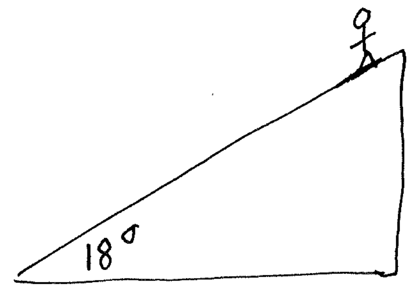
$v_0 = 0$, $d = 1.0m$ $t = ?$

Use $d = v_0 t + \frac{1}{2}at^2$

$t = 0.57\,sec$ ✓

Inclines Practice Name:________________________

15. A 65 kg skier is on top of a 250 m long ski hill, with $\mu = 0.19$. The hill has an angle of 18°. How long will it take the skier to reach the bottom of the hill and how fast will they be moving when they reach it?



$F_{g\parallel} = \sin 18 \times 65\,kg \times 9.8\,m/s^2 = 196.84\,N$

$F_{fric} = \mu F_N = 0.19 \times \cos 18 \times 65 \times 9.8 = 115.11\,N$

$F_{net} = 196.84N - 115.11N = 81.73\,N$

$a = \frac{F_{net}}{m} = \frac{81.73\,N}{65\,kg} = 1.2574\,m/s^2$

Use $d = v_0 t + \frac{1}{2} a t^2$ to find t

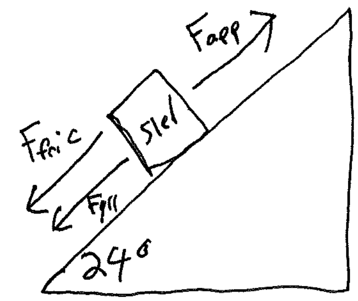
$t = 19.94\,sec \approx 2.0 \times 10^1\,sec$

Use $v_f^2 = v_i^2 + 2ad$ to find v_f

$v_f = 25\,m/s$

Inclines Practice Name:______________________________

16. A person pulls a 25 kg sled up a hill with incline of 24°. What force must they apply to pull the sled at a constant velocity if $\mu = 0.26$?



$$F_{fric} = \mu F_N = 0.26 \times \cos 24 \times 25\,kg \times 9.8\,m/s^2$$
$$= 58.19\,N$$

$$F_{g\parallel} = \sin 24 \times 25\,kg \times 9.8\,\frac{m}{s^2} = 99.65\,N$$

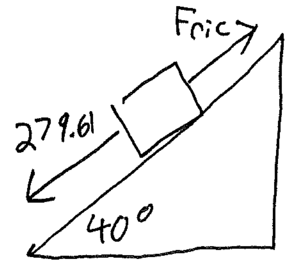
$$F_{app} = F_{fric} + F_{g\parallel}$$
$$= 58.19\,N + 99.65\,N$$
$$= 157.84\,N$$
$$\approx 160\,N$$

Inclines Practice Name:__________________________________

17. A box of weight 435 N is sliding down a 40.0° inclined plane. If the acceleration of the box is 0.250 m/s², what is the force of friction acting on the box?

$m = \frac{435\,N}{9.8\,m/s^2} = 44.39\,kg$

$F_{g\parallel} = \sin 40 \times 435\,N = 279.61\,N$

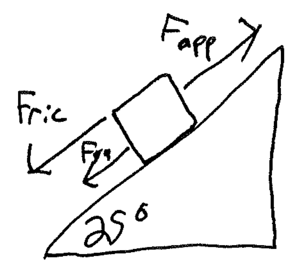


$F_{net} = ma$
$= 44.39 \times 0.250$
$= 11.09\,N$

F_{fric} is losing force, $F_{g\parallel}$ is 11.09 N more than it,
$F_{fric} = 279.61 - 11.09\,N = 270\,N$

18. A student pulls a 125 N object up a 25° incline. If the coefficient of friction is 0.180, what force must the student pull with to move the object at a constant velocity? Assume the applied force is parallel to the ramp.

$F_{g\parallel} = \sin 25 \times 125\,N$
$= 52.83\,N$

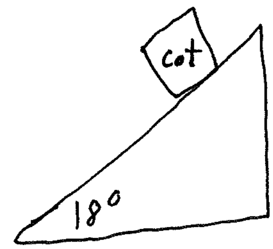


$F_{fric} = \mu F_N = 0.180 \times \cos 25 \times 125\,N$
$= 20.39\,N$

$F_{app} = F_{g\parallel} + F_{fric} = 73.22\,N$
$\approx 73\,N$

19. Fluffy the cat slides freely down the long porcelain cat slide into the Beverly Hills pet pool. If the incline is 18° and μ = 0.10 determine the time it takes Fluffy to reach the bottom of the 10.0 m slide.

(HINT: find "a" first, don't worry about the cat's mass, it cancels out)



$$F_{net} = F_{g\parallel} - F_{fric}$$

$$= \sin 18 \times mg - 0.10 \times \cos 18 \times mg$$

$$= 3.028\,m - 0.932\,m$$

$$= 2.096\,m$$

$$a = \frac{F_{net}}{m} = \frac{2.096\,m}{m} = 2.096\,m/s^2$$

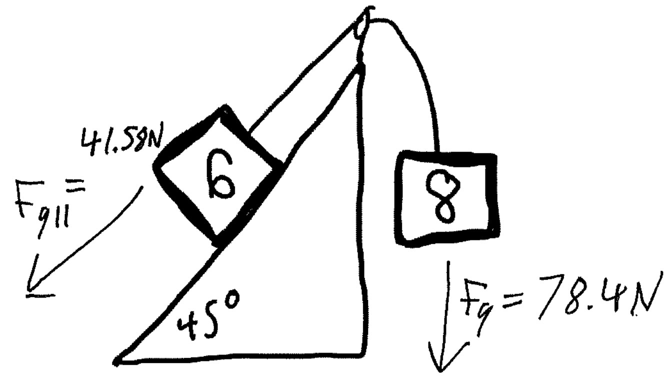
$d = 10.0\,m$ $v_0 = 0$ $t = ?$

Use $d = v_0 t + \frac{1}{2}at^2$

$t = 3.1\,sec$

Inclines Practice Name:______________________________

20. A 6.0 kg block on a 45 degree incline is attached to an 8.0 kg block which hangs freely. What is the coefficient of friction between the 6.0 kg block and the incline if the 6.0 kg block is pulled up the ramp at 1.0 m/s^2?



F_{net} without friction would be $78.4N - 41.55N$
$= 36.82N$

F_{net} must be $ma = 14kg \cdot 1.0 m/s^2$
$= 14N$

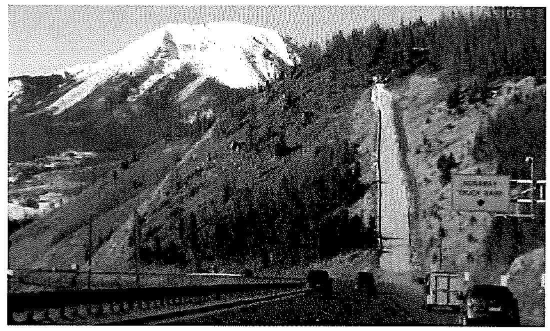
$F_{friction} = 36.82N - 14N = 23N$
$= 22.82N$

$22.82N = \mu F_N \rightarrow \frac{22.82N}{\cos 45 \times 6 \times 9.8} = \mu$

$\mu = 0.55$

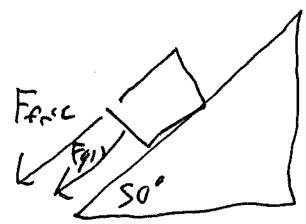
Inclines Practice Name:______________________________

21. A trucker is driving down a hill when he loses his brakes, luckily there is a runaway truck ramp which is a steep upwards offshoot of the main road. He is travelling at 150 km/h when he reaches the runaway ramp which is inclined upwards at 50° and friction against the truck is approximately equal to a sliding coefficient of 0.20. If the runoff road is 100.0 m long, is it long enough?



$$V_0 = 150\ Km/hr \times \frac{1000m}{1\ Km} \times \frac{1\ hr}{3600\ sec} = 41.6667 m/s$$

$$F_{fric} = 0.20 \times F_{g\perp}$$
$$= 0.20 \times \cos 50 \times m \times 9.8$$
$$= 1.260 \times mass$$



$$F_{g\parallel} = \sin 50 \times F_g$$
$$= \sin 50 \times m \times 9.8$$
$$= 7.507 \times mass$$

$$F_{net} = 7.507 \times mass + 1.260 \times mass$$
$$= 8.7669 \times mass$$

$$a = \frac{F_{net}}{m} = 8.7669 m/s^2$$
against motion

$a = -8.7669\ m/s^2$

$V_0 = 41.6667\ m/s$

$V_f = 0$

$d = ?$

Use $V_f^2 = V_0^2 + 2ad$

$d = 99 m$

It is just barely long enough