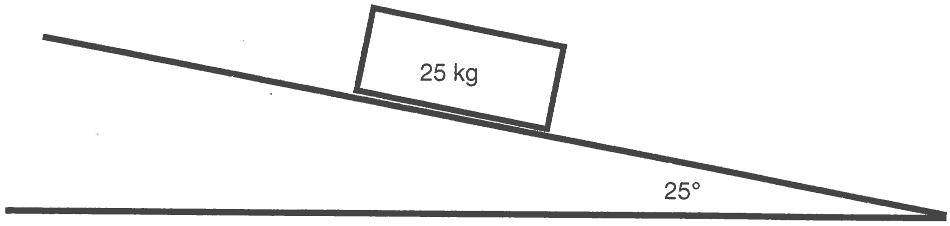
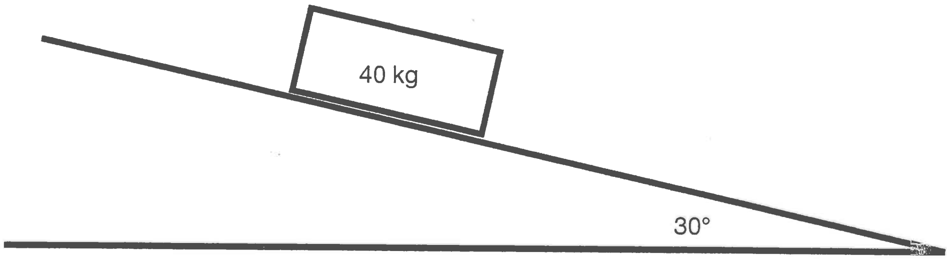
10 Motion on an Inclined Plane

QUESTIONS

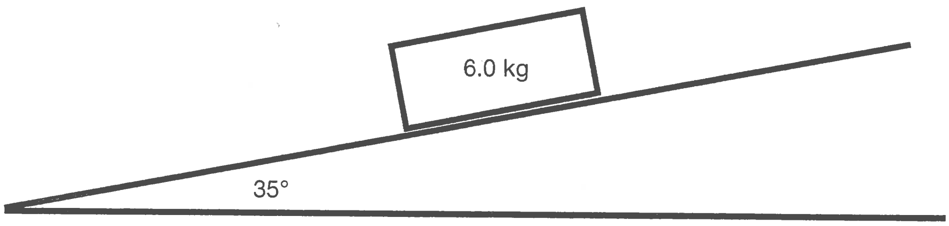
1. Show, by drawing a labelled vector diagram, that the acceleration of an object on an incline is given by $a = g \sin \theta$, where θ is the angle of inclination of the incline.
2. A 25 kg block sits on a smooth ramp which is inclined at ~~30~~ 25° as shown in the diagram.



   (a) Calculate the component of the weight force acting parallel to the ramp.
   (b) Calculate the force of the incline on the block.
   (c) Calculate the net force acting on the block.
   (d) What will be the acceleration of the block?
3. A 40 kg block sits on a ramp which is inclined at 30° as shown in the diagram. The ramp applies a frictional force of 0.18 N kg^{-1} on the block.

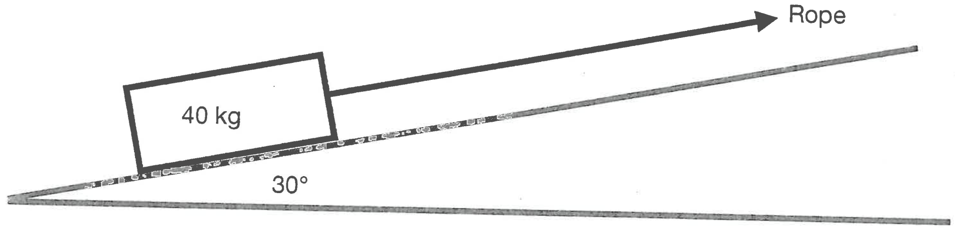


   (a) Copy the diagram and label all the forces acting on it.
   (b) By drawing a vector diagram, show that there is a net force acting on the block.
   (c) Calculate the component of the weight force acting parallel to the ramp.
   (d) Calculate the total frictional force acting on the block.
   (e) Calculate the net force acting on the block.
   (f) What will be the acceleration of the block?
4. A 6.0 kg block sits on a smooth ramp which is inclined at 35° as shown in the diagram. The block is sliding down the ramp with an acceleration of 3.4 m s^{-2}.

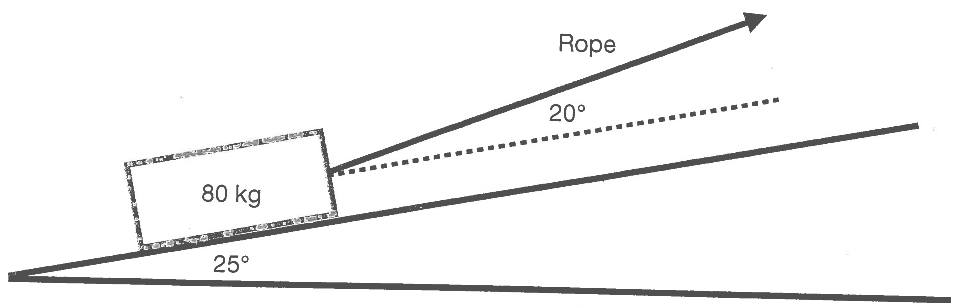


   (a) Calculate the component of the weight force acting parallel to the ramp.
   (b) Calculate the force of the incline on the block.
   (c) Calculate the net force acting on the block.
   (d) Calculate the frictional force in N kg^{-1} acting on the block.

5. A barrel of mass 200 kg is held at rest on a smooth ramp inclined at 35° by a string parallel to the ramp.
   (a) What is the tension in the string?
   (b) What is the force the ramp puts on the barrel?
6. A mass of 735 kg is being pulled up a 15° incline by a rope which is parallel to the incline with an acceleration 0.15 m s^{-2}.
   (a) Calculate the net force acting on the mass.
   (b) If the friction between the mass and the incline is 400 N, find the tension in the rope.
   (c) Calculate the force the incline places on the mass.
7. A 68 kg cyclist is riding his 16 kg bike down a 12° incline and is accelerating at 0.75 m s^{-2}.
   (a) Calculate the total net force acting on the cyclist and the bike.
   (b) Determine the downhill component of the weight of the cyclist and the bike.
   (c) What total frictional force is acting on the bike?
8. A 5.0 tonne truck moves up a smooth incline with a constant speed of 1.25 m s^{-1}. $\theta = 7.5°$
   (a) What is the net force on the truck?
   (b) What is the component of the weight force of the truck down the incline?
   (c) What force must be applied to the truck so that it moves up the incline at constant speed?
   (d) If the truck's engine suddenly cuts out and the brakes failed to work, what would the truck do?
9. A 40 kg block sits on a smooth ramp inclined at 30° as shown in the diagram. The block is pulled up the ramp w an acceleration of 0.6 m s^{-2} by a rope which is parallel to the surface of the incline.



   (a) Calculate the component of the weight force acting parallel to the ramp.
   (b) Calculate the net force acting on the block.
   (c) Calculate the tensional force in the rope.
   Suppose the acceleration of the block remains the same, but there is a total frictional force of 5.0 N opposing the motion of the block up the ramp.
   (d) Calculate the net force acting on the block.
   (e) Calculate the tensional force in the rope.
10. An 80 kg block sits on a smooth ramp which is inclined at 25° as shown in the diagram. The block is pulled up th ramp with an acceleration of 0.4 m s^{-2} by a rope which is inclined at 20° to the ramp as shown in the diagram.

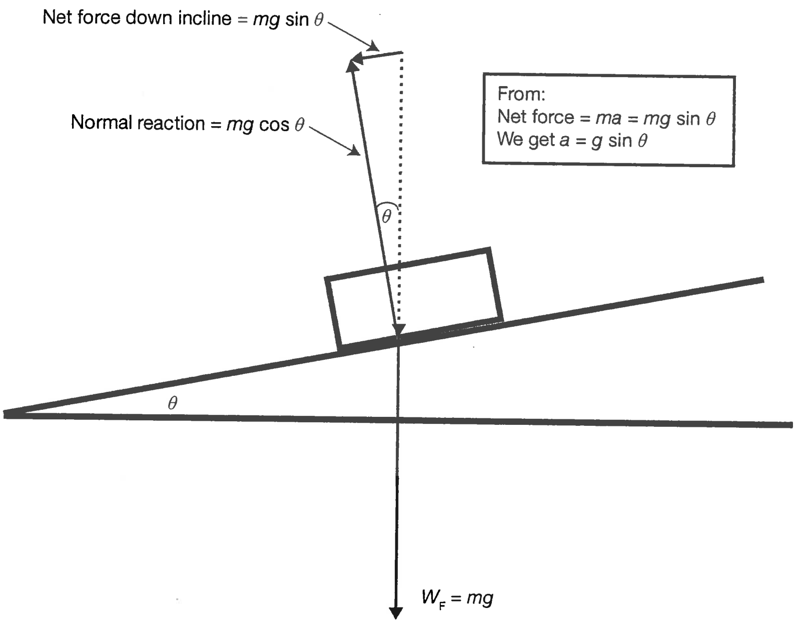


   (a) What is the net force acting on the block?
   (b) What is the component of the weight force of the block acting down the incline?
   (c) What is the tension in the rope?

2. (a) A = 5.2
B = 3.0
(b) C = 15
D = 10.6
(c) E = 90
F = 10
(d) G = 25
H = 12.5
(e) I = 136
J = 18
(f) K = 110
L = 7.05
(g) M = 18.2
N = 10.8
(h) O = 144
P = 58
(i) Q = 0.68
R = 0.18
(j) S = 97.3
T = 187.2

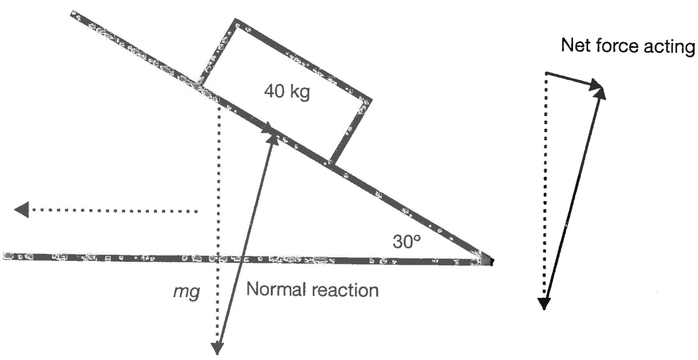
10 Motion on an Inclined Plane

1.



2. (a) From $F_{parallel} = mg \sin \theta = 25 \times 9.8 \times \sin 25° = 103.5$ N
(b) From $F_N = mg \cos \theta = 25 \times 9.8 \times \cos 25° = 244.9$ N up, perpendicular to the surface.
(c) 103.5 N down the incline.
(d) From $F = ma$, $a = 103.5/25 = 4.14$ m s^{-2}

3. (a) and (b)



(c) Weight down slope = $mg \sin \theta = 40 \times 9.8 \times \sin 30° = 196$ N
(d) Total friction = mass × friction per kg = $40 \times 0.18 = 7.2$ N
(e) Net force = 196 – 7.2 = 188.8 N
(f) From $F = ma$, $a = 4.72$ m s^{-2}

4. (a) From $F_{parallel} = mg \sin\theta = 6 \times 9.8 \times \sin 35° = 33.73$ N
(b) From $F_N = mg \cos\theta = 6 \times 9.8 \times \cos 35° = 48.2$ N up, perpendicular to the surface
(c) From $F = ma$, net force $= 6 \times 3.4 = 20.4$ N down the incline
(d) From net force = parallel component – friction, $20.4 = 33.73$ – friction, so friction = 13.33 N up the slope
5. (a) From $F_{parallel} = mg \sin\theta = 200 \times 9.8 \times \sin 35° = 1124.2$ N
(b) From $F_N = mg \cos\theta = 200 \times 9.8 \times \cos 35° = 1605.5$ N up, perpendicular to the surface
6. (a) From $F = ma = 735 \times 0.15 = 110.25$ N up the slope
(b) Tension = friction + net force = 510.25 N both ways in the rope
(c) From $F_N = mg \cos\theta = 735 \times 9.8 \times \cos 15° = 6957.6$ N up at 90° to the surface
7. (a) From $F = ma = 73 \times 0.75 = 54.75$ N down the slope
(b) From $F_{parallel} = mg \sin\theta = 73 \times 9.8 \times \sin 12° = 148.74$ N
(c) Net force = component down the slope – friction = 54.75 = 148.75 – friction, so friction = 94 N up the slope
8. (a) From $F = ma = 5000 \times 0 =$ zero (constant velocity)
(b) From $F_{parallel} = mg \sin\theta = 5000 \times 9.8 \times \sin 7.5° = 6395.8$ N
(c) 6395.8 up the slope
(d) Slow down, stop momentarily and then accelerate down the incline, all at 1.28 m s^{-2}
9. (a) From $F_{parallel} = mg \sin\theta =$ ~~40 × 9.8 × sin 37° = 235.9 N down the slope~~ 40 × 9.8 × sin 30° = 196 N down slope
(b) From $F = ma = 40 \times 0.6 = 24$ N up the slope
(c) Tension = net force + component down slope = ~~24 + 235.9 = 259.9 N (acting both ways)~~ 24 + 196 = 220 N
(d) If acceleration is the same, the net force acting will be the same = 32 N up the slope
(e) Tension in the rope will also include 5.0 N to overcome friction, so, tension = 331.3 + 32 + 5 = 368.3 N
10. (a) From $F = ma = 80 \times 0.4 = 32$ N up the slope
(b) From $F_{parallel} = mg \sin\theta = 80 \times 9.8 \times \sin 25° = 331.3$ N down the slope
(c) Total force to move block up slope = component down + net = 331.3 + 32 = 363.3 N
But rope is inclined at 20°, so tension in rope = total force/cos 20° = 386.6 N acting both ways

11 Projectile Motion

1. For projectile at 30° to horizontal:
$u_y = 40 \sin 30° = 20$ m s^{-1}
From $v_{top} = 0 = u_y + gt = 34.641 - 9.8t$
Time to rise = 2.0408 s
So, time of flight = 4.0816 s
Therefore range, $= u_x \times t_{flight} = 40 \cos 30° \times 4.0816 = 141.39$ m
For projectile at 60° to horizontal:
$u_y = 40 \sin 60° = 34.641$ m s^{-1}
From $v_{top} = 0 = u_y + gt = 34.641 - 9.8t$
Time to rise = 3.5347 s
So, time of flight = 7.0796 s
Therefore range, $= u_x \times t_{flight} = 40 \cos 30° \times 7.0696 = 141.39$ m
Therefore, on the basis of this one calculation, Galileo's prediction is supported.

12 Projectile Motion Problems 1

All answers in order of information requested in the chapter (answers may differ slightly due to rounding errors).
1. 140 m s^{-1}, 140 m s^{-1}, 0, 2100 m, 140 m s^{-1}, 147 m s^{-1}, 203 m s^{-1} at 46.4° to horizontal, 15 s, 1102.5 m, 143.1 m s^{-1} at 11.9° to horizontal, 980 m
2. 80 m s^{-1}, 80 m s^{-1}, 0, 720 m, 80 m s^{-1}, 88.2 m s^{-1}, 119.1 m s^{-1} at 47.8° to horizontal, 9 s, 396.9 m, 85.2 m s^{-1} at 20.2° to horizontal, 274.4 m
3. 16.7 m s^{-1}, 16.7 m s^{-1}, 0, 50 m, 16.7 m s^{-1}, 29.4 m s^{-1}, 33.8 m s^{-1} at 60.4° to horizontal, 3 s, 44.1 m, 33.8 m s^{-1} at 60.4° to horizontal, 0 m
4. 14.6 m s^{-1}, 14.6 m s^{-1}, 0, 80 m, 14.6 m s^{-1}, 53.6 m s^{-1}, 55.6 m s^{-1} at 74.8° to horizontal, 5.5 s, 147 m, 32.8 m s^{-1} at 63.6° to horizontal, 24.5 m
5. 33.95 m s^{-1}, 33.95 m s^{-1}, 0, 203.7 m, 33.95 m s^{-1}, 58.8 m s^{-1}, 67.9 m s^{-1} at 60° to horizontal, 6.0 s, 176.4 m, 44.9 m s^{-1} at 40.9° to horizontal, 53.9 m
6. 20 m s^{-1}, 20 m s^{-1}, 0, 150 m, 20 m s^{-1}, 73.5 m s^{-1}, 76.2 m s^{-1} at 74.8° to horizontal, 7.5 s, 275.6 m, 35.6 m s^{-1} at 55.8° to horizontal, 153.1 m
7. 125 m s^{-1}, 125 m s^{-1}, 0, 50 m, 125 m s^{-1}, 3.92 m s^{-1}, 125.1 m s^{-1} at 1.8° to horizontal, 0.4 s, 0.8 m, 0, 0 m
8. 150 m s^{-1}, 150 m s^{-1}, 0, 675 m, 150 m s^{-1}, 44.1 m s^{-1}, 156.3 m s^{-1} at 16.4° to horizontal, 4.5 s, 99.2 m, 152.9 m s^{-1} at 11.1° to horizontal, 0 m
9. 22.2 m s^{-1}, 22.2 m s^{-1}, 0, 177.8 m, 22.2 m s^{-1}, 78.4 m s^{-1}, 81.5 m s^{-1} at 74.2° to horizontal, 8 s, 313.6 m, 36.8 m s^{-1} at 52.9° to horizontal, 191.1 m
10. 39.4 m s^{-1}, 39.4 m s^{-1}, 0, 590.8 m, 39.4 m s^{-1}, 147 m s^{-1}; 152.2 m s^{-1} at 75° to horizontal, 15 s, 1102.5 m, 49.2 m s^{-1} at 36.7° to horizontal, 980 m
11. (a) 3.46 s
(b) 103.9 m
(c) 45.3 m s^{-1}
12. (a) 6.4 s
(b) 44.3 m s^{-1} at 89.2° down from horizontal
(c) 3.06 s
(d) 62.72 m s^{-1} at 89.5° (If you forgot to take the initial horizontal component into account your answer will be 62.610.)