Higher Grade Physics

OUR DYNAMIC UNIVERSE

Forces, Energy & Power

Newton's Laws

1. What unbalanced force is required to give a car, mass 800 kg, an acceleration of 1.2 ms^{-2} ?

2. What is the acceleration of a 250g object experiencing an unbalanced force of 0.5 N ?

3. What is the mass of an object which accelerates at 48 cms^{-2} when the unbalanced force is 1.44 N ?

4. Find the acceleration in each of the following cases:

(a) 120 N ← 12 kg → 180 N

(b) 2400 N ← 360 kg → 9600 N

(c) 48 N ← 250 g → 72 N

(d) 500 N ← 300 kg → 350 N

5. Calculate the mass of each objects:

(a) **1.2** ms^{-2} ⇒ 2 N ← [ ] → 8 N

(b) **1.6** ms^{-2} ⇒ 400 N ← [ ] → 480 N

(c) **40** cms^{-2} ⇒ 5.0 N ← [ ] → 5.2 N

(d) **15** cms^{-2} ⇒ 1200 N ← [ ] → 1500 N

6. Find the missing force in each case :

(a) **4.0** ms^{-2} ⇒ 2.0 kg → 48 N

(b) **0.5** ms^{-2} ⇒ 50 kg → 400 N

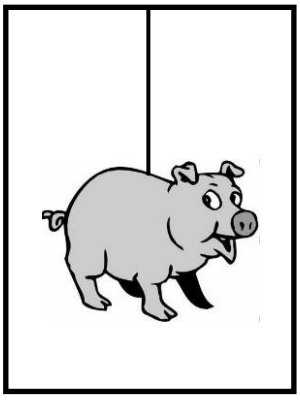
7. A box is pulled along a rough surface with a constant force of 140 N. If the mass of the box is 30 kg and it accelerates at 4 ms^{-2} calculate:
   (a) the unbalanced force causing the acceleration
   (b) the force of friction between the box and the surface.

8. Two girls push a car of mass 2000 kg. Each applies a force of 50 N and the force of friction is 60 N. Calculate the acceleration of the car.

9. A car, mass 1200 kg, can travel at a steady speed of 25 ms^{-1} when the engine exerts a force of 4800 N. What is the acceleration of the car when the engine force increases to 7200 N, assuming that all other forces acting on the car remain unchanged ?

10. (a) A rocket of mass 40000 kg is launched vertically upwards. Its engines produce a constant thrust of 700000 N.
    (i) Draw a diagram showing all the forces acting on the rocket.
    (ii) Calculate the initial acceleration of the rocket.
    (b) As the rocket rises its acceleration is found to increase. Give three reasons for this.
    (c) Calculate the acceleration of the same rocket from the surface of the Moon if the Moon's gravitational field strength is 1.6 N kg^{-1}.
    (d) Explain in terms of Newton's laws of motion why a rocket can travel from the Earth to the Moon and for most of the journey not burn up any fuel.

11. An 80 kg pig hangs from the ceiling of a lift by means of a length of rope as shown.
    (a) Draw a force diagram to show the forces acting on the pig when the lift is stationary. Indicate the value of each force.
    (b) What is the tension in the rope when the lift is accelerating downwards at 1.5 ms^{-2} ?
    (c) What is the tension in the rope once the lift reaches a steady speed of 2.5 ms^{-1} ?
    (d) The rope will break if the tension exceeds 1400 N. What is the minimum deceleration required at the bottom of the lift shaft to break the rope ?



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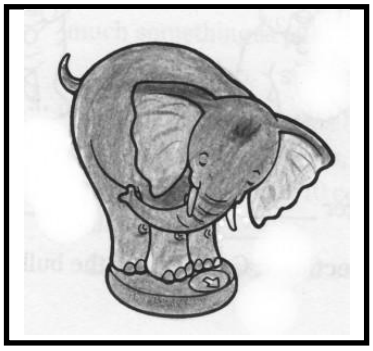
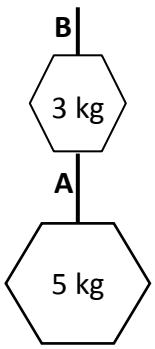


In the same multi-storey zoo, an elephant of mass 2000 kg stands on a set of scales in the lift.
(a) What is the reading on the scales before the lift starts to move?
(b) What is the reading when the lift is accelerating upwards at 2.0 ms^{-2}?
(c) What is the reading when it is moving upwards at a steady speed of 3.0 ms^{-1}?
(d) What is the deceleration of the lift at the end of the journey if the scales read 15 000 N ?

13. The diagram, opposite, shows a 5kg mass hanging by a length of string, A, below a 3 kg mass which is, in turn hanging by a second length of string, B.

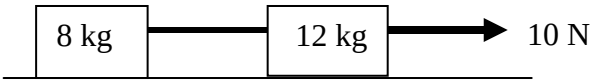
    (a) What is the tension in each length of string?

    (b) If string B is cut so that both masses fall freely, what is the tension in string A now ?



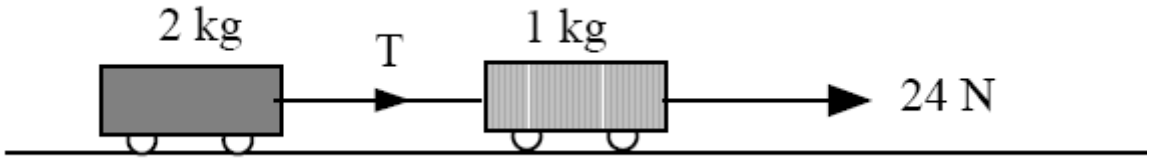
14. A small lift in a hotel is fully loaded and has a mass of 250 kg. For safety reasons the tension in the pulling cable must never be greater than 3500 N.
    (a) What is the tension in the cable when the lift is:
        (i) at rest
        (ii) moving up at a constant speed of 1 ms^{-1}
        (iii) accelerating upwards at 2 ms^{-2}
        (iv) accelerating downwards at 2 ms^{-2} ?
    (b) Calculate the maximum permitted upward acceleration of the fully loaded lift.
    (c) Describe a situation where the lift could have an upward acceleration greater than the value in (b) without breaching safety regulations.

15. Two masses joined by a cord rest on a horizontal, friction free surface.



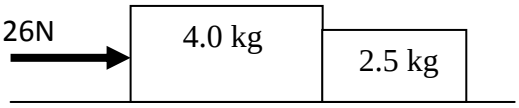
    (a) What is the acceleration when the 12 kg mass experiences a pulling force of 10 N ?
    (b) What is the tension in the cord ?

16. Two masses are pulled along a flat surface as shown below.



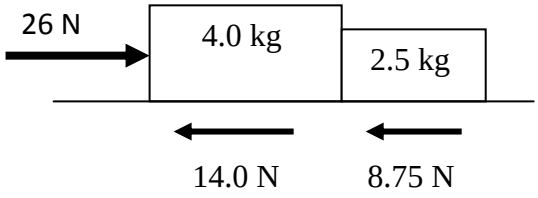
    Find the (a) acceleration of the masses
    (b) tension, T.

17. Two packing cases rest on a friction free surface as shown. A force of 26 N is applied to the 4.0 kg packing case.



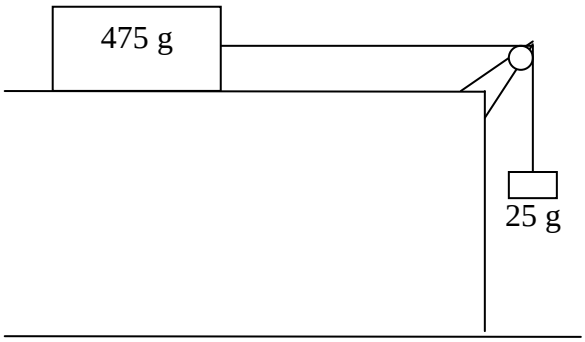
    (a) What is the acceleration?
    (b) What force does the 4.0 kg packing case exert on the 2.5 kg packing case ?
    (c) What force does the 2.5 kg packing case exert on the 4.0 kg packing case ?

18. The two packing cases in the last question are pushed into the real world, where friction forces of 14.0 N and 8.75 N act on the two cases.

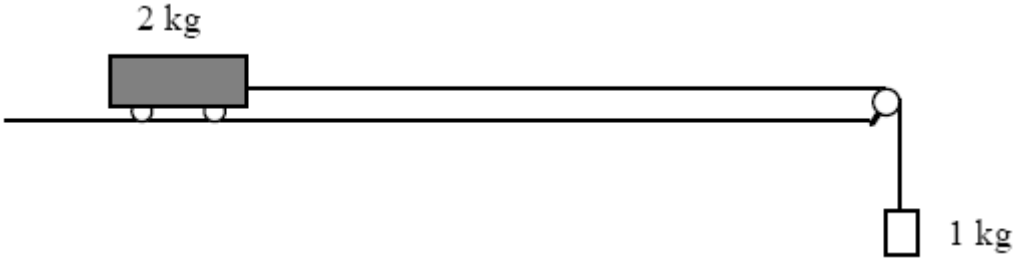


(a) What is the acceleration now?
(b) What is the force exerted by the 4.0 kg packing case on the 2.5 kg packing case?
(c) Draw a free body diagram for the 4.0 kg packing case showing all the forces acting on it. Give numerical values for all the forces.

19. The diagram shows a hanging mass of 25 g attached to a 475 g vehicle on an air track. The pulley wheel is friction free.
(a) What is the acceleration of the 475 g vehicle?
(b) What is the tension in the string?
(c) If the 25g mass starts at a height of 50 cm, how long does it take to reach the ground?

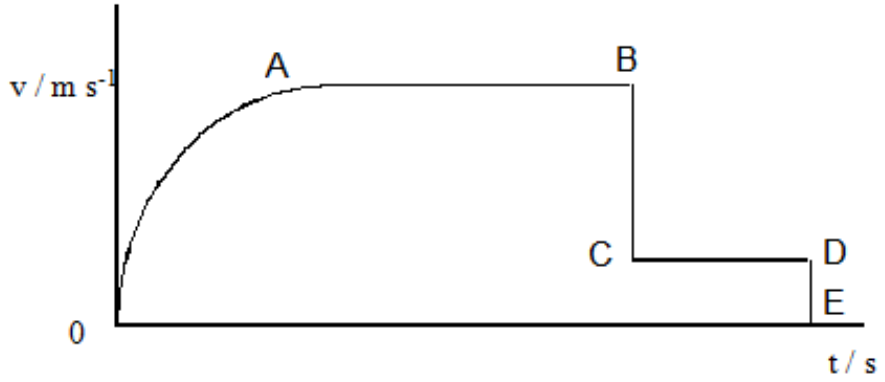


20. A 2 kg trolley is connected by string to a 1 kg mass as shown. A force of friction of 3.8 N acts on the vehicle.



(a) Calculate the acceleration of the trolley.
(b) Calculate the tension in the string.

21. The graph below shows how the speed of a parachutist varies with time after having jumped from a plane.

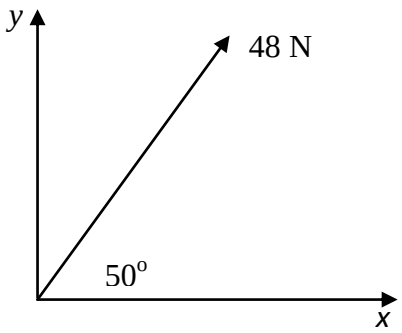


Describe the motion at each stage of the graph (with reference to the origin and letters) in terms of the forces acting upon the parachutist.

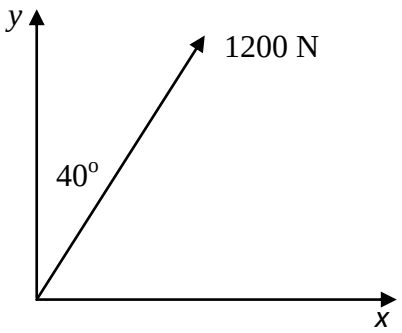
Resolution of Forces

22. What is the *x* component and *y* component in each of the following cases :

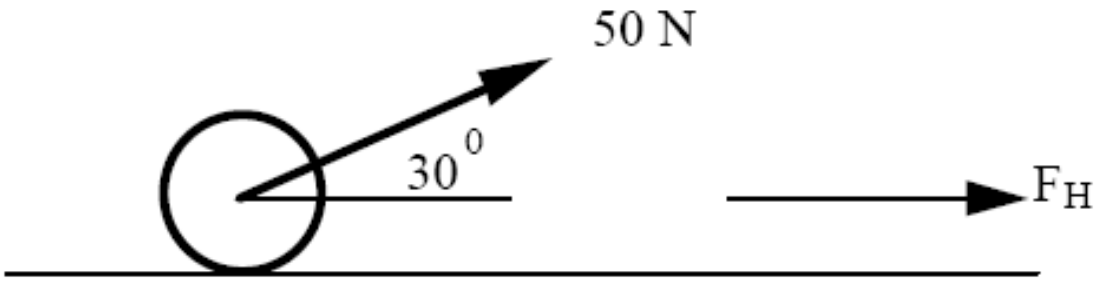
(a)



(b)

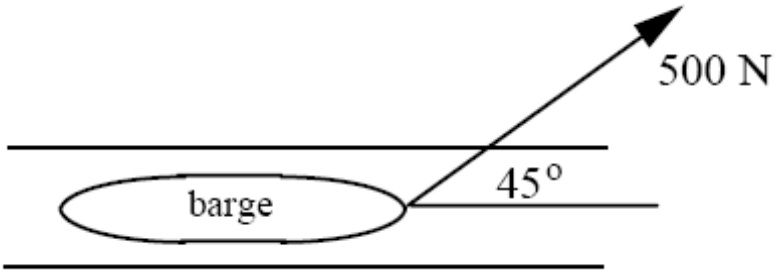


23. A man pulls a garden roller with a maximum force of 50 N.



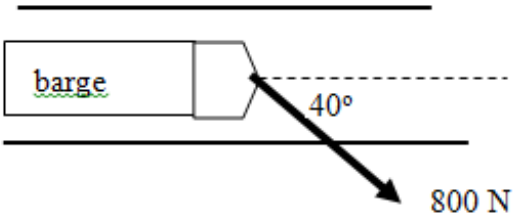
(a) Find his effective horizontal force.
(b) Without changing the force applied, explain how he could increase this effective force.

24. A barge is dragged along a canal as shown below.



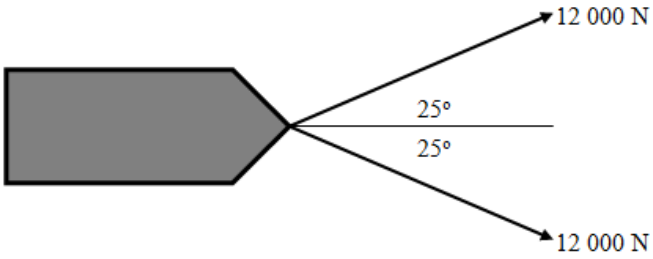
What is the component of the force parallel to the canal?

25. A barge of mass 1000 kg is pulled by a rope along a canal as shown.



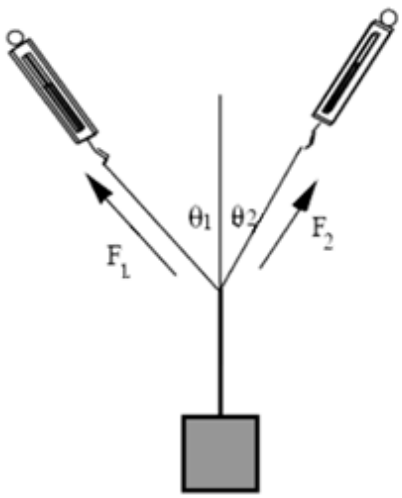
The rope applies a force of 800 N at an angle of 40° to the direction of the canal. The force of friction between the barge and the water is 100 N. Calculate the acceleration of the barge.

26. Two tugs are hauling a tanker as shown in the diagram below.

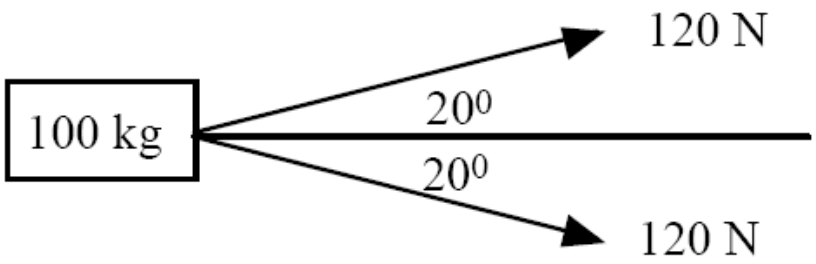


Find the magnitude of the resultant force.

27. The diagram opposite shows a block being supported by two spring balances. If F_1 applies a force of 4.4 N at 30° and F_2 applies a force of 6.4 N at 20°.
Use a scale diagram to find the mass of the block.



28. A crate of mass 100 kg is pulled along a rough surface by two ropes at the angles shown.



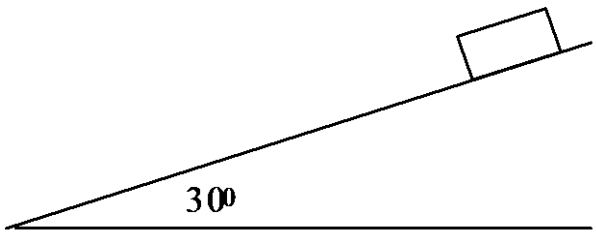
(a) If the crate is moving at a constant speed of 1 ms^{-1} what is the force of friction?
(b) If the forces were increased to 140 N at the same angle calculate the acceleration of the crate.

Components of Weight

29. A wooden block of mass 12 kg lies on a plane inclined at an angle of 25^o to the horizontal. What is the component of its weight (a) parallel to the slope
(b) perpendicular to the slope ?

30. The angle of the inclined slope in the previous question is gradually increased. The force of friction between the block and the plane is 70 N, at what angle would the block just begin to slide down the slope ?

31. A 2.0 kg block of wood is placed on a slope as shown.



The block remains stationary. What is the magnitude and direction of the frictional force on the block?

32. A car of mass 900 kg is parked on a hill. The gradient of the hill is 15^o to the horizontal. The hand brake on the car fails and the car runs down the hill, a distance of 50 m, until it crashes into a hedge. The average force of friction acting upon the car as it runs down the hill is 300 N.

(a) Calculate the component of the weight acting down the slope.
(b) Find the acceleration of the car.
(c) Calculate the speed of the car just before it hits the hedge.

33. What would be the acceleration of a vehicle of mass 4 kg on a 20^o slope if the friction force is 8 N ?

34. An air track is inclined at an angle of 5 ^{o} to the horizontal.
    (a) What is the acceleration of a vehicle of mass 400 g ?
    (b) What would be the acceleration if the mass of the vehicle was 600 g ?

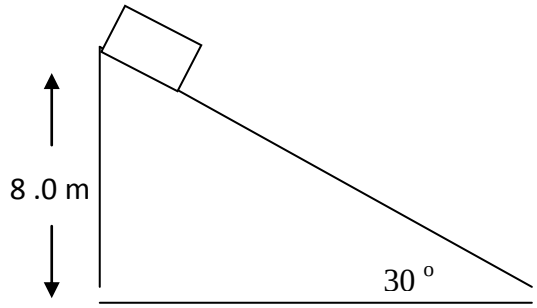
Work Done, Potential and Kinetic Energy

35. The diagram shows a 20 kg box at the top of an inclined plane. If the plane is friction free

    (a) What is the unbalanced force acting on the box as it slides down the slope ?

    (b) What is the acceleration of the box ?

    (c) What is the speed of the box as it reaches the foot of the slope ?



    Now try this alternative method. Ignore the answers to parts (a), (b) and (c) and find:

    (d) the gravitational potential energy of the box at the tope of the slope
    (e) the kinetic energy at the foot of the slope
    (f) the speed of the box at the foot of the slope.

36. A small ball of mass 0.20 kg is dropped from a height of 4.0 m above the ground. The ball rebounds to a height of 2.0 m.
    (a) Calculate the total loss in energy of he ball.
    (b) Calculate the speed of the ball just before it hits the ground.
    (c) Calculate the speed of the ball just after it leaves the ground.

37. A 20 kg stone falls from a 50 m high cliff top and reaches the ground travelling at 30 ms^{-1}.
    (a) How much energy is 'lost' during the stone's flight?
    (b) What happens to the 'lost' energy?

38. A 2.0 kg ball dropped down a 25 m deep well loses 100 J of energy because of air resistance. What is the speed of the ball when it strikes the water?

39. An air track vehicle is catapulted up a sloping track with an initial velocity of 60 cms^{-1}. If the track is at an angle of 2° to the horizontal, how far along the track will the vehicle travel before coming to rest ?

40. A winch driven by a motor is used to lift a crate of mass 50 kg through a vertical height of 20 m.
    (a) Calculate the size of the minimum force required to lift the crate.
    (b) Calculate the minimum amount of work done by the winch while lifting the crate.
    (c) The power of the winch is 2.5 kW. Calculate the minimum time taken to the lift the crate to the required height.

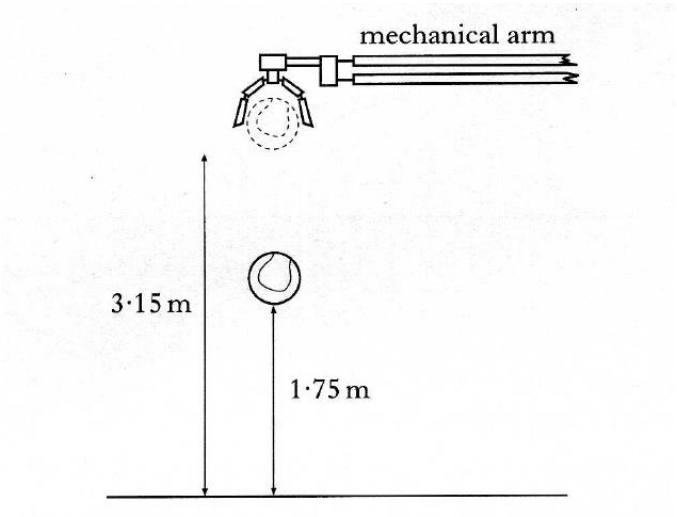
41. A train has a constant speed of 10 ms^{-1} over a distance of 2.0 km. The driving force of the train is 3.0 x 10^4 N.
Calculate the power developed by the train engine.

42. An arrow of mass 22g has a speed of 30 ms^{-1} as it strikes a target. The tip of the arrow goes 3.0 x 10^{-2} m in to the target.
(a) Calculate the average force of the target on the arrow.
(b) What is the time taken for the arrow to come to rest after striking the target, assuming the target exerts a constant force on the arrow?

43. The manufacturers of tennis balls require that the balls meet a given standard.

When dropped from a certain height on to a test surface, the balls must rebound to within a limited range of heights.

The ideal ball is one which, when dropped from rest from a height of 3.15 m, rebounds toa height of 1.75 m as shown below.



(a) Assuming air resistance is negligible, calculate

(i) the speed of an ideal ball just before contact with the ground
(ii) the speed of the ball just after contact with the ground.

(b) When a ball is tested six times, the rebound heights are measured to be

1.71 m, 1.78 m, 1.72 m, 1.76 m, 1.73m, 1.74m

Calculate

(i) the mean value of the height of the bounce
(ii) the random error in this value