Physics Revision Exercises

"What's behind and in front of you are nothing compared to what's within you."
Mahatma Ghandi

Some of you may not have done well for the Common Test. You may have lost a battle but the war continues. So you need to review your performance of the test and identify your strengths and areas for improvements so that you continue to learn. This process of reflection is so critical in the learning cycle but is yet most often ignored. So be quick and reflect now! After which, discuss with your Physics tutor your action plan. The prescription of help will be more effective.

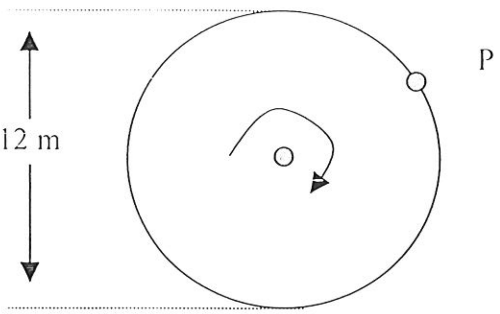
Diligent practice is a key to mastery. Hence, you are encouraged to pace yourself to the revision schedule below. Your tutor will be prepared to assist you only if you do your part.

Date	Topics for revision	Tutorial
Week 3	Circular Motion	Gravitational Field
Week 4	Gravitational Field	Physics of Fluids
Week 5	Gravitational Field	Physics of Fluids
Week 6	Kinematics	Oscillation
Week 7	Newton's Laws	Oscillation
Week 8	Physics of Fluids	Waves
Week 9	Physics of Fluids	Superposition
Week 10	Linear Momentum	Superposition

Forces
Work, Energy, Power

Circular Motion Week 3

1. A grinding wheel of diameter 0.12 m spins horizontally about a vertical axis, as shown in the diagram below. P is a typical grinding particle bonded to the edge of the wheel.



a. If the rate of rotation is 1200 revolutions per minute, calculate

(i) the angular velocity, [126 $rads^{-1}$]
(ii) the acceleration of P, [947 ms^{-2}]
(iii) the magnitude of the force acting on P if its mass is 1.0×10^{-4} kg. [9.47×10^{-2} N]

b. The maximum radial force at which P remains bonded to the wheel is 2.5N. Calculate the angular velocity at which P will leave the wheel if its rate of rotation is increased. [645 $rads^{-1}$]

2. At one instant, the rotational speed of a disc in a CD player is 300 revolutions per minute.

a. Calculate the angular velocity of the disc. [31.4 $rads^{-1}$]

b. Sketch a graph to show how the acceleration, a, of a point on the disc varies with its radial distance, r, from the axis of rotation when the disc is moving with constant angular velocity.

c. P and Q are two points on the disc, 30 mm and 50 mm respectively from the axis of rotation.

(i) Calculate the difference in the linear speeds of the two points. [0.628 ms^{-1}]

(ii) What is the difference in the angular velocities of the two points?

$V_1 = r_1 \omega$
$V_2 = r_2 \omega$
$V_2 - V_1 = (r_2 - r_1)\omega$

3. A record is played at 45 revolutions per minute, and then at 33 $^1/_3$ revolutions per minute. Find the ratio of the centripetal accelerations of a point on the rim of the record. [1.82]

4. The reading of a speedometer fitted to the front wheel of a bicycle is directly proportional to the angular velocity of the wheel. A certain speedometer is correctly calibrated for use with a wheel of diameter 66 cm but, by mistake, is fitted to a 60 cm wheel. Explain whether the indicated linear speed would be greater or less than the actual speed and find the percentage error in the readings. [10%]

5. Refer to Q32 (TYS). $v = r\omega$

<u>MCQ (TYS) – page 79</u>

Q6

Q17

Q19

Q20

Q21 to Q27

Gravitational Field **Week 4 - 5**

1. A space capsule is travelling between the Earth and the Moon. Using the data below, find the distance from the Earth at which it is subjected to zero resultant force. (Consider only the gravitational fields of the Earth and the Moon.)

Mass of the Earth = 6.0×10^{24} kg

Mass of the Moon = 7.4×10^{22} kg

Distance between the centres of the Earth and the Moon = 3.8×10^{8} m

[3.4×10^{8} m]

(a) (i) State Newton's law of gravitation. Give the meaning of any symbol you use.

(ii) Define *gravitational field strength*.

(iii) Use your answers to **(i)** and **(ii)** to show that the magnitude of the gravitational field strength at the Earth's surface is GM / R^2, where M is the mass of the Earth, R is the radius of the Earth and G is the gravitational constant.

(b) A communications satellite occupies an orbit such that its period of revolution about the Earth is 24 h. Show that the radius, R_o, of this orbit is given by

$$R_o = 574\sqrt[3]{GM}\,,$$

$\frac{mv^2}{r} = \frac{GMm}{r^2} = mr\omega^2$

where G and M have the same meanings as in **(a)(iii)**.

$\frac{GMm}{r^3} = m\left(\frac{2\pi}{T}\right)^2$

Escape velocity

2. Given that the Earth's radius is 6.4×10^{6} m and the acceleration due to free fall is 9.8 ms^{-2}, determine the velocity with which a rocket must be fired from the Earth's surface so as to escape the influence of the Earth's gravitational field. (Hint: To escape completely from the Earth's gravitational field, the rocket has to be infinitely far from the Earth in theory.) [1.1×10^{4} ms^{-1}]

3. A spherical hollow is made in a lead sphere of radius R, such that its surface touches the outside surface of the lead sphere on one side and passes through its centre on the opposite side as shown in the diagram below. With what force, according to Newton's Law of universal gravitation, will the lead sphere attract a small sphere of mass m, which lies at a distance d from the centre of the lead sphere on the straight line connecting the centres of the spheres and of the hollow?

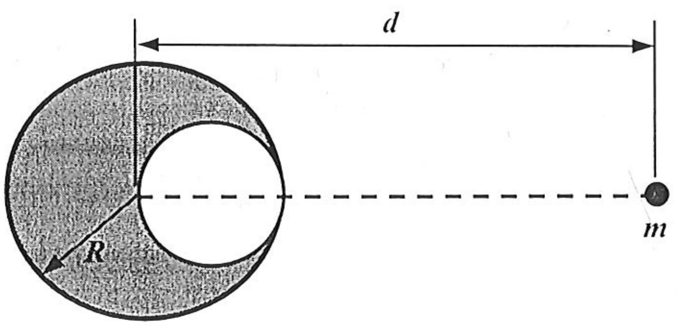
$\frac{mv^2}{r} = \frac{GMm}{r^2}$

$\frac{v^2}{r} = \frac{GM}{r^2}$

$r = \frac{GM}{r^2}$

$v = \sqrt{\frac{GM}{r}}$

$\frac{GM}{r^2} = 9.8$



Kinematics Additional Exercises Week 6

1. A ball is projected vertically upwards from ground level at the surface of a planet where the acceleration due to gravity is 5.0 m s^{-2}. If the ball reaches a maximum height of 40 m, what is its velocity 6.0 s after it was thrown? (Assume frictional forces are negligible.)

   A 10 m s^{-1} upwards
   B 10 m s^{-1} downwards
   C 20 m s^{-1} upwards
   D 30 m s^{-1} downwards

2. A small smooth sphere is released from rest just below the surface of the liquid in a tall vessel of large diameter. The sphere, whose density exceeds that of the liquid, is observed until it reaches its terminal speed. During the period of observation, its acceleration is

   A upward and decreasing
   B upward and increasing
   C downward and decreasing
   D zero

3. A particle is projected with a velocity of 10 ms^{-1} at an angle 60° to the horizontal. If at a point A, its direction of motion is 30°, the velocity at that point is

   A 5.8 ms^{-1}
   B 8.7 ms^{-1}
   C 10.0 ms^{-1}
   D 11.5 ms^{-1}

4. A physics student climbs a 50 m cliff that overhangs a calm pool of water. She throws 2 stones vertically upward 1.0 s apart and observes that they cause a single splash. The first stone has an initial velocity of 20 m s^{-1}.

   (a) At what time after the release of the first stone do the 2 stones hit the water? [3]
   [5.83s]

   (b) What initial velocity must the second stone have, if the 2 stones are to hit the water simultaneously? [2]
   [-13.3m/s]

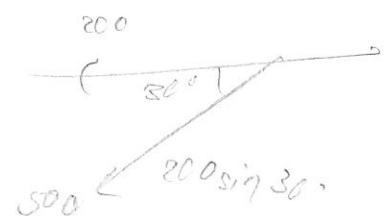
   (c) What is the velocity of each stone at the instant they hit the water? [3]
   [34.0 m/s]

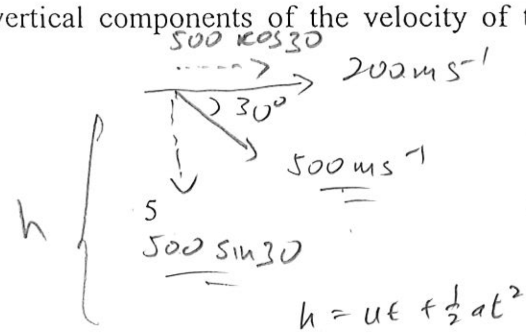
5. A fighter plane flies horizontally at a constant speed of 200 ms^{-1}. It carries a cannon inclined at an angle of 30° below the horizontal.

   (a) If it takes 10 s for the projectile which has a muzzle velocity of 500 ms^{-1} (with respect to the plane) to reach a target, find the height at which the plane is flying. [3]
   [2990 m]

   (b) How far ahead of the target must the pilot fire the cannon to get a direct hit? [2]
   [6330 m]

   (c) Find the horizontal and vertical components of the velocity of the projectile just before it hits the target. [4]
   [348, 633 m/s]





$h = ?$ $a = 9.81 \downarrow$

$u_v = 500 \sin 30 \downarrow$

$h = ut + \frac{1}{2}at^2$ $t = 10s$ $\downarrow +ve$

Newton's Laws **Week 7**

1. A force of 5.0 N is applied to a body of mass 3.0 kg. What is the acceleration of the body? [1.7 m s^{-2}]

2. In a catapult, a stone of mass 50 g is accelerated to a speed of 8.0 m s^{-1} from rest over a distance of 30 cm. What average force is applied by the rubber of the catapult? [5.3 N]

3. A box of mass 5.0 kg is pulled along a horizontal floor by a force P of 25 N, applied at an angle of 20° to the horizontal. A frictional force F of 20 N acts parallel to the floor.
   (a) Draw a labelled free-body diagram of the box.
   (b) Calculate the acceleration of the box. [0.70 m s^{-2}]

Things to ponder...

In the above problems:

1. What is the key equation here?

   In what situation(s) would you use it?

   What is the physical principle applied?

2. What are the key equation(s) here?

   Why do you think the force is "average"?

   Is there another approach to solving this question? Work it out.

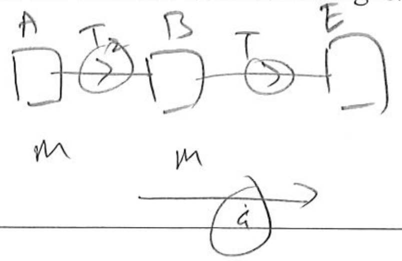
3. What questions do you ask when drawing the free-body diagram?

   How do you decide which forces exist?

   Can you apply concepts of net force and/or equilibrium?

   What technique do you apply to form the equation(s)?

4. A railway engine pulls two carriages of equal mass with uniform acceleration. The tension in the coupling between the engine and the first carriage is T. Deduce the tension in the coupling between the first and second carriages.

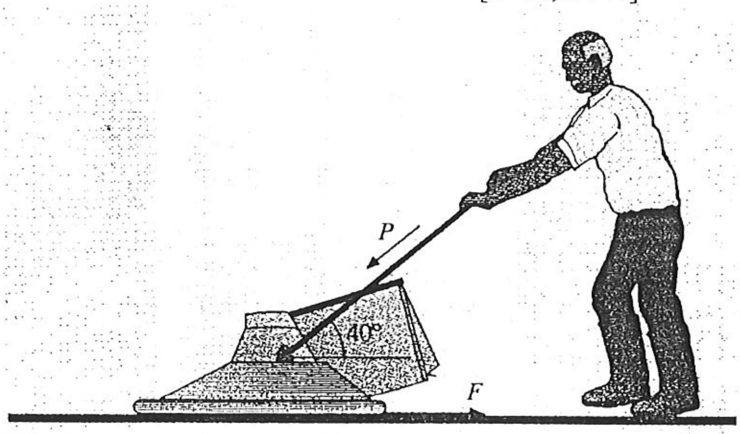


Things to ponder...

4. Is there another free-body diagram that you can use?
If yes, work out the answer again.

5. A gardener pushes a lawnmower of mass 18 kg at constant speed. To do this requires a force ***P*** of 80 N directed along the handle, which is at an angle of 40° to the horizontal (see diagram below).
   (a) Calculate the horizontal retarding force ***F*** on the mower.
   (b) If this retarding force were constant, what force applied along the handle, would accelerate the mower from rest to 1.2 m s^{-1} in 2.0 s?

[61 N, 94 N]



Option F- Physics of Fluids **Week 8 - 9**

1. Given that the density of seawater is 1030 kgm^{-3}, the submarine has a volume of $250m^3$ and mass 25000 kg, using the Principle of Floatation, find the proportion of the submarine that is under the sea.

2. (i) A steel ball bearing of volume 3.0×10^{-5} m^3 and density 7800 kgm^{-3} is dropped into a long jar of glycerine of viscosity 1.50 $kgm^{-1}s^{-1}$. Given that the viscous force experienced by the ball bearing follows Stoke's Law can be written as

$$F_v = 6\pi r \eta v$$

Calculate the terminal velocity attained by the ball bearing, ignoring the upthrust. [3]

(ii) Given that the density of glycerine is 1260 kgm^{-3}, calculate the upthrust exerted by the liquid glycerine on the steel ball in part (i).

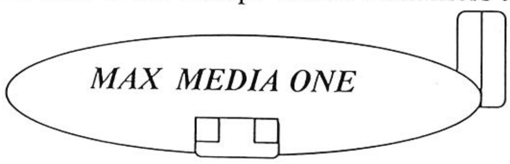
Write down an equation (in symbolic form, without numerical evaluation) for terminal velocity, V_t, when upthrust is not negligible.

Hence derive the following expression for the terminal velocity, V_t

$$V_t = \frac{2\,(\rho_{steel} - \rho_{glycerine})gr^2}{9\eta}$$

where ρ_{steel} = density of steel
$\rho_{glycerine}$ = density of glycerine
r = radius of ball bearing
η = viscosity of glycerine [4]

3. Airships also known as blimps are still being used nowadays for media broadcasting and advertising. Blimps are filled with helium and are propelled by fans. The blimp buoyancy and orientation are controlled by pumping air into or out of containers found under the exterior skin of the blimp. These containers are also known as ballonets.



(a) A blimp has a volume of 5750 m^3 and a mass of 4300 kg when empty.
(i) Calculate the weight of the blimp when filled with helium.
(Density of helium gas = 0.177 kgm^{-3}) [1]

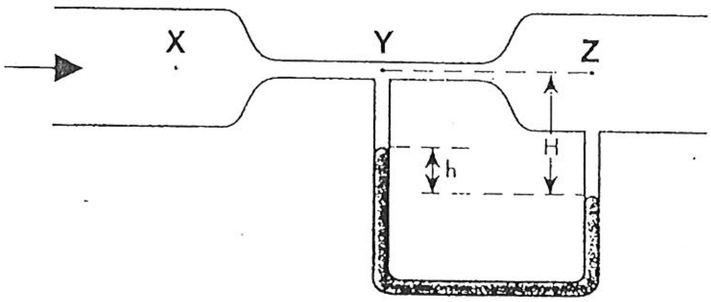
(ii) What additional load is it able to carry when the entire volume is filled with helium? (Density of air = 1.29 kgm^{-3}) [2]

(b) The exterior skin of the blimp is rigid, so that the blimp's total volume does not change. State and explain the effect on the position of the blimp when air is pumped into the ballonets. [2]

(c) Given that the drag force F, acting on the blimp when it is cruising at 1.20 ms^{-1} is given by $F = 26.9 \rho v^2$, where ρ is the density of air, calculate the power exerted by the fans when the blimp is traveling at this speed. [3]

4. A party is in progress in a small swimming pool. All the guests climbed into a large rubber boat, and are having an argument about Archimedes' Principle. Jack claims that if all leave the boat, and float in the pool instead, the water level will rise. On the other hand, Rose says that the water level will fall. What do you think will happen to the water level? Explain your answer. [5]

5. In the figure below, a horizontal pipe has a cross-sectional area of 5.0×10^{-4} m^2 at Y and 30×10^{-4} m^2 at Z. A powerful pump at X pumps water which flows smoothly along the pipe. The water leaves the pipe at Z with a velocity of 2.0 ms^{-1}.
Density of water = 1.00×10^3 kg m^{-3} and density of mercury = 13.6×10^3 kg m^{-3}.



(i) Determine the velocity of water at Y.
(ii) Calculate the pressure difference between Y and Z.
(iii) Hence, find the difference in level h of the mercury columns in the manometer.
[6]

6. The windows in an office building are 4.0 m by 5.0 m. On a stormy day, air is blowing at 30 m/s past a window on the 53rd floor. Calculate the net force on the window. The density of air is 1.23 kg/m^3.

30 ms^{-1}
0 ms^{-1}

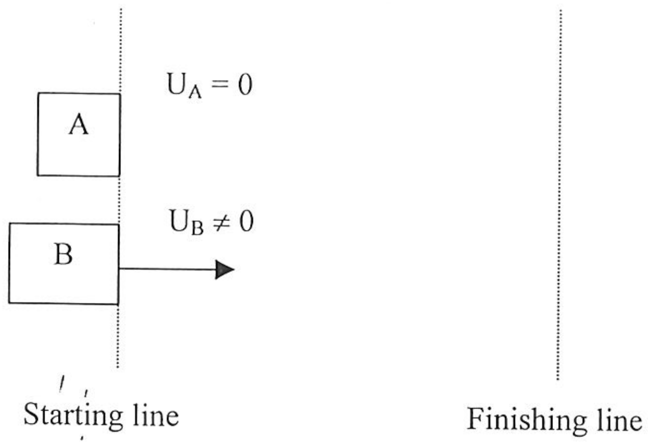
The End

Solutions

(1) 9.72%
(2) 4.21 ms^{-1}, 0.371 N
(3) (a) (i) 52.2 kN (ii) 20.6 N (c) 60.0 W
(5) (i) 12.0 ms^{-1} (ii) -70 kPa (iii) 0.525 m
(6) 11.1 kN

Linear Momentum **Week 10**

1. Identical constant forces push two identical masses *A* and *B* continuously from a starting line to a finish line. If *A* is initially at rest and *B* is initially moving to the right, which mass has the larger change in momentum?



2. Consider these situations:

(*i*) a ball moving at speed v is brought to rest;

(*ii*) the same ball is projected from rest so that it moves at speed v;

(*iii*) the same ball moving at speed v is brought to rest and then projected backward to its original speed.

In which case(s) does the ball undergo the largest change in momentum?

1. (*i*)
2. (*i*) and (*ii*)
3. (*i*), (*ii*), and (*iii*)
4. (*ii*)
5. (*ii*) and (*iii*)
6. (*iii*)

3. Suppose a ping-pong ball and a bowling ball are rolling toward you. Both have the same momentum, and you exert the same force to stop each. How do the time intervals to stop them compare?

1. It takes less time to stop the ping-pong ball.
2. Both take the same time.
3. It takes more time to stop the ping-pong ball.

4. A cart moving at speed v collides with an identical stationary cart on an airtrack, and the two stick together after the collision. What is their velocity after colliding?

1. v
2. 0.5 v
3. zero
4. –0.5 v
5. –v
6. need more information

5. A person attempts to knock down a large wooden bowling pin by throwing a ball at it. The person has two balls of equal size and mass, one made of rubber and the other of putty.The rubber ball bounces back,while the ball of putty sticks to the pin.Which ball is most likely to topple the bowling pin?

1. the rubber ball
2. the ball of putty
3. makes no difference
4. need more information

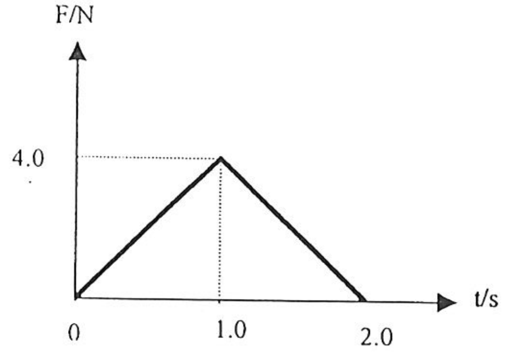
6. A compact car and a large truck collide head on and stick together. Which undergoes the larger momentum change? Which vehicle undergoes the larger acceleration during the collision?

1. car
2. truck
3. The momentum change is the same for both vehicles.
4. Can't tell without knowing the final velocity of combined mass.

7. A car accelerates from rest. It gains a certain amount of kinetic energy and Earth

1. gains more kinetic energy.
2. gains the same amount of kinetic energy.
3. gains less kinetic energy.
4. loses kinetic energy as the car gains it.

8a A body of mass 1.0 kg initially at rest is acted upon by a force which varies with time as shown below:



Find the speed of the body after 1.0 s. Draw a labelled graph of how its velocity varies with time from t = 0 s to t = 2.0 s. [4]

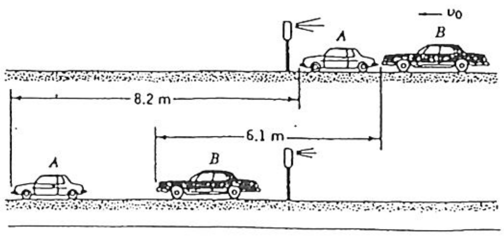
b A man of mass 80 kg jumps down to a concrete patio from a window ledge 0.50 m above the ground. He neglects to bend his knees, so that his motion is arrested in a time of 0.013 s. With what average force does this jump jar his bone structure? [3]

c Two cars *A* and *B* slide on icy road as they attempt to stop at a traffic light. The mass of *A* is 1100 kg and the mass of *B* is 1400 kg. The kinetic friction between the locked wheels of each car and the road is 13% of the car's weight. Car *A* succeeds in coming to rest at the light, but car *B* cannot stop and rear-ends car *A*. After the collision, *A* comes to rest 8.2 m ahead of the impact point and *B* 6.1 m ahead (see figure below). Both drivers had their brakes locked throughout the incident.

(i) From the distances each car moved after the collision, find the speed of each car immediately after impact. [5]

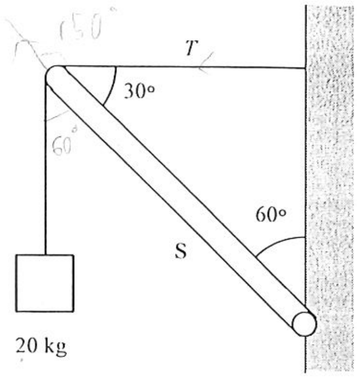
(ii) Use conservation of momentum to find the speed at which car *B* struck car *A*. [4]

(iii) On what grounds can the use of momentum conservation be criticized here? [1]



Q8 2.0 m/s; 19.3 kN; 4.57 m/s; 3.94m/s;

Forces Term IV



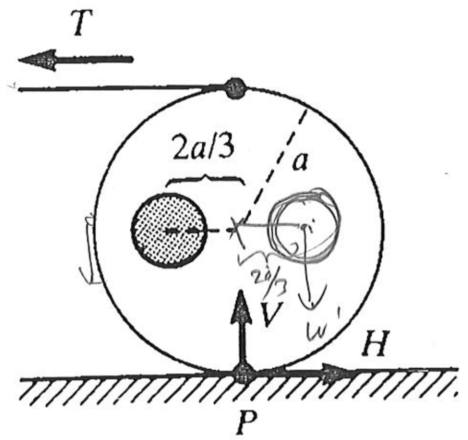
1. The system shown in the figure is in equilibrium. A mass of 20.0 kg hangs from the end of the weightless strut S. The lower end of S is attached to the wall with a hinge. The tension T in the cable is

   A 113 N
   B 196 N
   C 226 N
   D 340 N

2. A raindrop of mass m is falling vertically through the air with a steady speed v. It experiences a retarding force kv due to the air, where k is a constant. The acceleration of free fall is g.
   Which expression gives the kinetic energy of the raindrop?

   A $\frac{mg}{k}$ B $\frac{mg^2}{2k^2}$ C $\frac{m^3g^2}{2k^2}$ D $\frac{m^3g^2}{k^2}$

3. A uniform cylinder of radius a resting on a horizontal table originally had a weight of 80 N. After an off-axis cylindrical hole was drilled through it as shown, it weighed 65 N. The axes of the two cylinders are parallel.



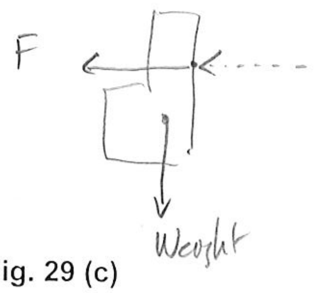
Assuming that the cylinder does not slip on the table, what is the tension T in the cord to keep it from moving?

$15\left(\frac{2a}{3}\right) = Ta$

$T =$

A. 10 N
B. 0 N
C. 15 N
D. 5 N

4.



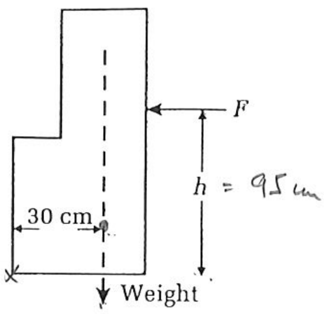


Fig. 29 (c)

Fig. 29 (c) illustrates aside view of a piano whose weight, 2500 N acts along a vertical line 30 cm from the front of the piano.

Two men try to push the piano across the floor by applying a horizontal force F to the back of the piano at a distance h above the ground. When h is less than 95 cm the piano slides across the floor. When h is greater than 95 cm the piano begins to tip.

Draw a free-body force diagram of the piano as it begins to tip.

Calculate the magnitude of the force F for h = 95 cm. [4]

[75 kN]

5. The diagrams below show a human arm lifting a brick. In position A, the effort in the biceps muscle is at right angles to the lower arm and in position B the arm is stretched out so that the angle has become 135°. All dimensions are in mm and forces in N.

(a) Calculate the effort in the biceps muscle in each position (A and B).

[190, 269 N]

(b) For position A **(Fig. 5.1)**

1. Sketch the lower arm and indicate with **R** the vertical force that the upper arm exerts (at the elbow joint) on the lower arm to keep it in equilibrium.
2. Calculate the magnitude of **R**. [160 N]

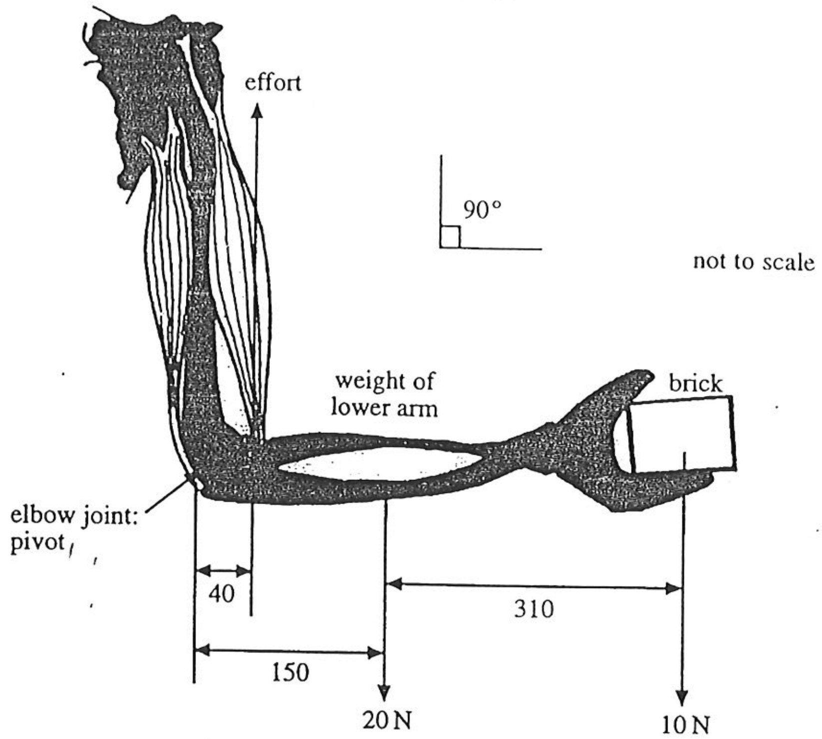
(c) For position B **(Fig. 5.2)**, the direction of **R** is shown acting at an angle θ to the horizontal. Calculate the magnitude of force **R** and the value of the angle θ.

[248 N, 40.1°]

become 135°. All dimensions are in mm and forces in N.

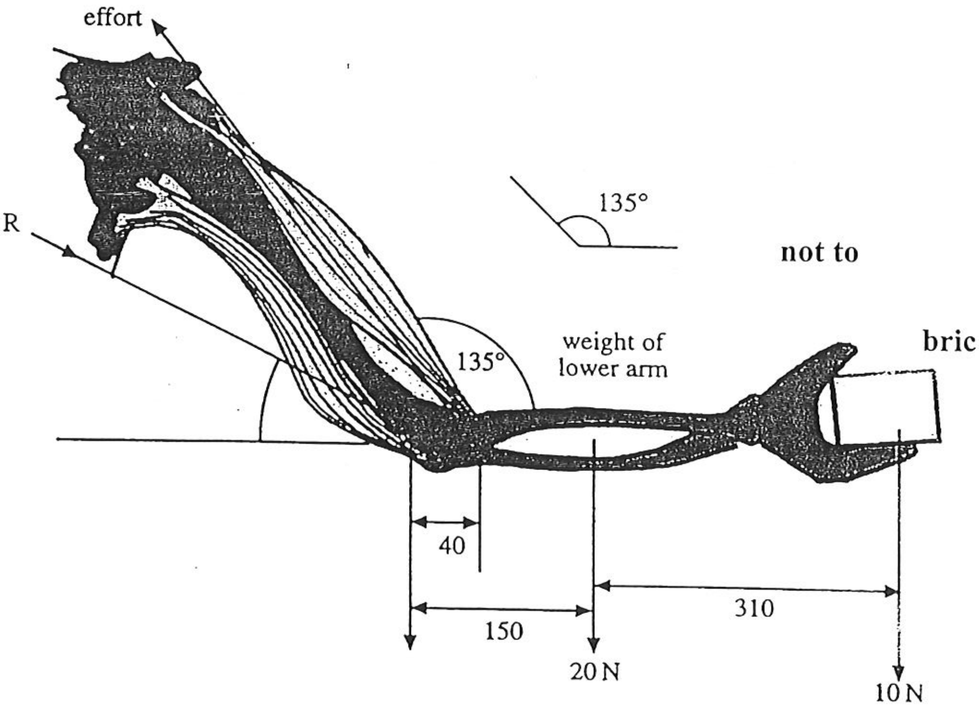
POSITION A

Fig. 5.1



POSITION B

Fig. 5.2



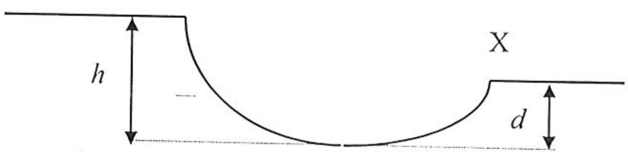
Work, Energy and Power **Term IV**

1. A box weighing 200 N is lifted 2.0 m vertically by pushing it up a ramp with a force of 35.0 N along the ramp. If 76 % of the work supplied is used to move the box and 24 % of the work supplied is used to overcome the friction, what is the length of the ramp?

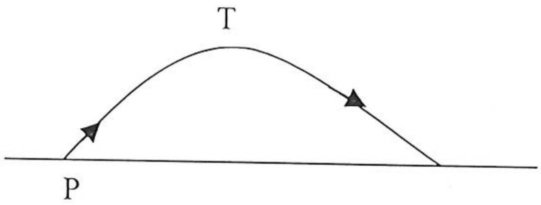
   A 8.7 m
   B 9.2 m
   C 11.4 m
   D 15.0 m

2. A skier starts from rest at the top of a hill and follows the path as shown in the diagram. Assuming no friction, what will be his speed at point X?

   A $\sqrt{2gh}$
   B $\sqrt{2gd}$
   C $\sqrt{2g(h-d)}$
   D mgd



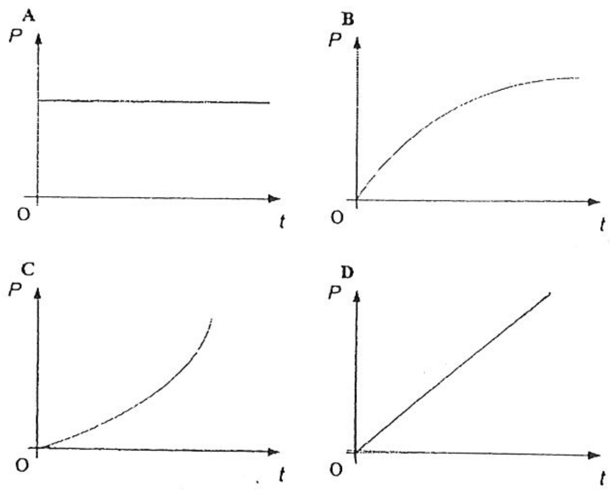
3. In the absence of air resistance, a stone is thrown from P and follows a parabolic path in which the highest point reached is T.



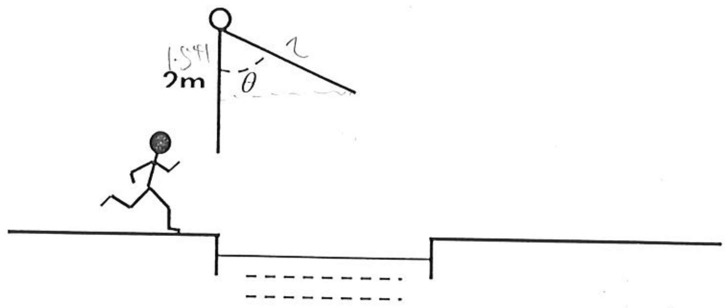
   The total energy of the stone is

   A zero at T
   B greatest at T
   C the same at P as at T
   D greatest at P

4. A constant force is applied to a body which is initially stationary but free to move in the direction of the force. Assuming that the effects of friction are negligible, which of the following graphs best represents the variation of P, the power supplied, with time t?



5 In the process of crossing an obstacle course, a 65-kg student running at 5.0 ms^{-1} grabs a hanging rope of length 2.0 m, and swings out over a pit of water. He releases the rope when his speed is 2.0 ms^{-1}. What is the angle θ when he releases the rope?

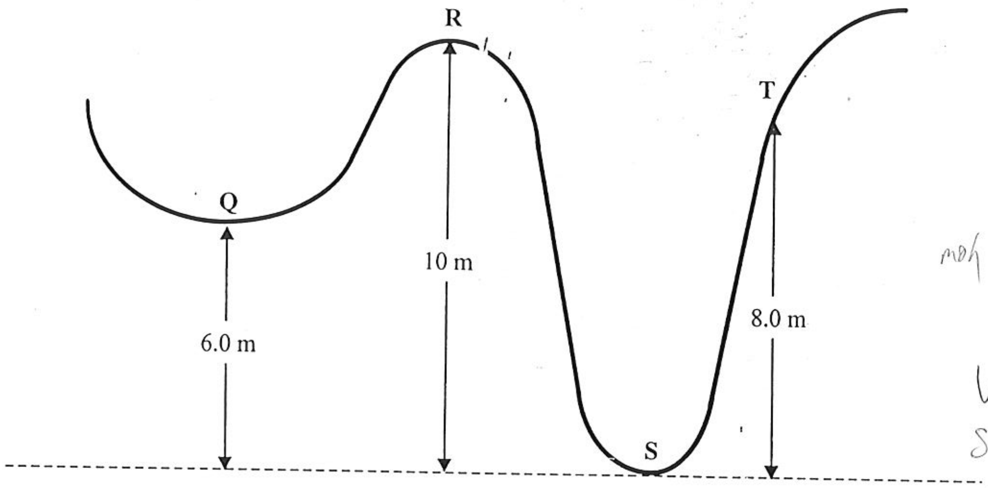


A 50°

B 58°

C 62°

D 69°



mgh

$v = u + at$

$s = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2as$

6. With reference to the above diagram, a small truck can be placed at various positions on the frictionless big dipper track and be given various initial speeds.

(a) If the truck is released from **R** and allowed to move to the right, what would be its speed at S and at T?

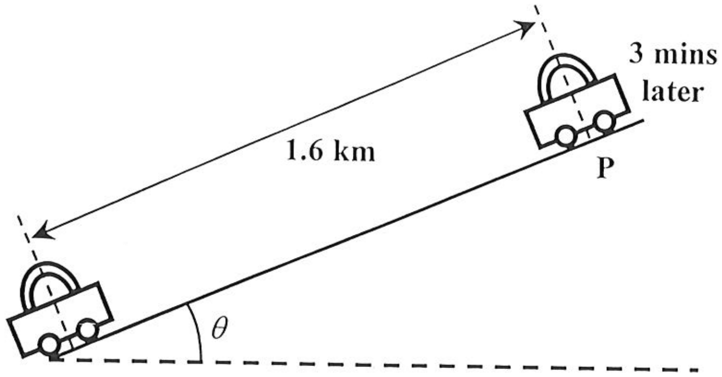
The truck is now given an initial velocity to the right when it is at **Q**.

(b) What should the initial speed of the truck be, in order for it to reach S?

(c) Describe the change in energy as the truck moves from **Q** to S.

7. (a) By reference to equations of motion, derive an expression for the kinetic energy E_k of an object of mass m moving at speed v.

(b) A car of mass 1200 kg starts from rest at the foot of a hill inclined at an angle θ to the horizontal, where $\sin\theta = \frac{1}{5}$.



3.0 minutes later, the car has a speed of 20.0 ms^{-1} and has travelled a distance of 1.6 km (see diagram above) to reach **P**. The frictional forces resisting the motion are constant and of magnitude 210 N.

Calculate, in this time,

(i) the increase of potential energy of the car;

(ii) the increase of kinetic energy of the car;

(iii) the work done against frictional forces; and

(iv) the average power of the engine of the car.

[Q6. 14 m/s; 6.26 m/s; 8.9 m/s]
[Q7. 3.8 x 10^6 J; 2.4 x 10^5 J; 3.4 x 10^5 J; 24 kW]

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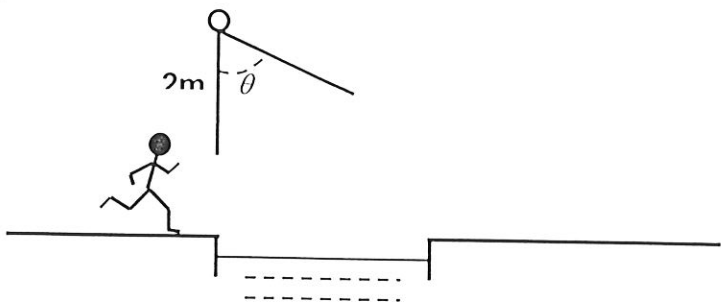
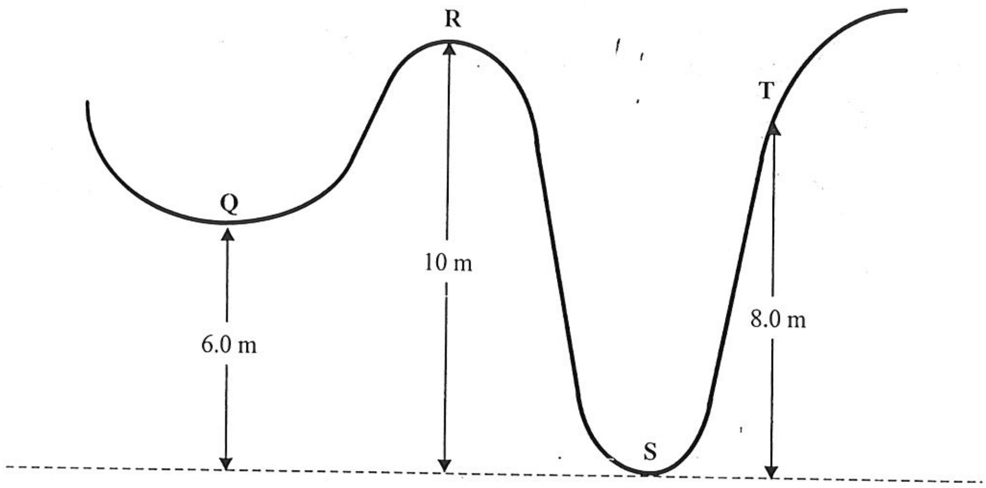


A 50° 58° 62° 69°



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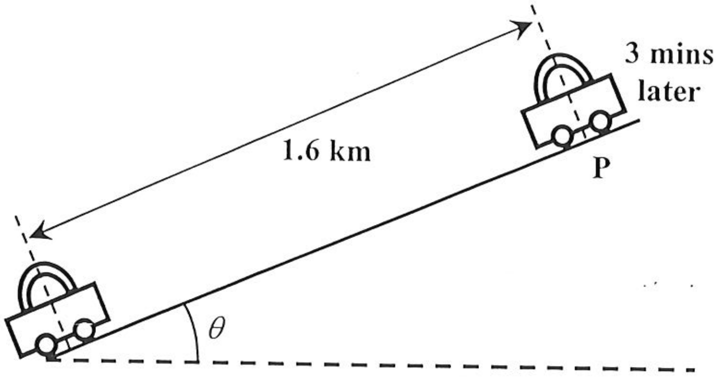

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