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2: KINEMATICS

1. **(PSPM 00/01)**
   The motion of a particle is described by the following equation

   $$x = 3t^2$$

   where x is displacement and t is time. Sketch the displacement time graph of the equation.

2. **(PSPM 07/08)** A bullet is fired from a rifle with a muzzle velocity of 100ms^{-1} at 15^o above the horizontal. Calculate the horizontal range of the bullet. **(Ans:** $R = 510m$**)**.

3. **(PSPM 08/09)** A stone is thrown vertically upwards with initial velocity 24ms^{-1}. Calculate the

   (a) Displacement of the stone after 4.0s.

   (b) Velocity of the stone at 10m above the point of launch.

   (c) Time to reach maximum height.

   (Ans: $s = 17.5m$**;** $v = \pm 19.5ms^{-1}$**;** $t = 2.45s$**)**

4. **(PSPM 09/10)** A particle moving with uniform acceleration a has initial velocity u. With the aid of a velocity-time graph, show that the displacement s after time t is given by $s = ut + \frac{1}{2}at^2$.

5. **(PSPM 09/10)** A long jump athlete take-off at 25^o with the horizontal and achieves a jumping distance of $9.12m$

   (a) Calculate the initial take-off speed

   (b) Calculate the maximum height of the jump

   (c) Suggest two ways to increase the jumping distance.

   (Ans: 10.8ms^{-1}**; 1.06**m**)**

6. **(PSPM 10/11)** A drunken motorist who is moving at a constant velocity of $90kmh^{-1}$ passes a stationary police patrol car. The patrol car immediately gives a chase at a constant acceleration and catches up with the motorist after a distance of $10km$.

   (a) Calculate the time taken by the patrol car to catch up with the motorist.

   (b) Calculate the acceleration of the patrol car.

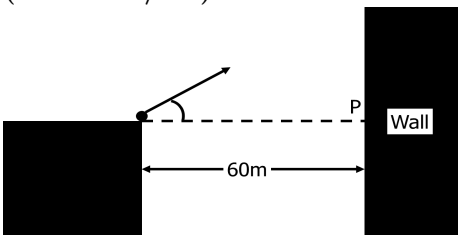
   (c) Calculate the velocity of the patrol car when it catches up with the motorist.

   (d) On the same axes, sketch and label graphs of displacement versus time for both the vehicles.

   (Ans: $t = 400s$**;** $a = 0.125ms^{-2}$**;** $v = 50ms^{-1}$**)**

7. **(PSPM 11/12)** A plane travels at three times the speed of sound. If the speed of sound is 343 ms^{-1}, how far it travels in 10minutes? **(Ans:** $s = 6.17 \times 10^5 m$**)**

8. **(PSPM 11/12)**



The figure above shows a balls being thrown from the top of a building towards a wall $60m$ away. The initial velocity is $20ms^{-1}$ at 40^o to the horizontal.

(a) How much time does it take to hit the wall?

(b) What is the distance between P and the position the ball strike the wall?

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(c) What is the speed of the ball when it strikes the wall?

(Ans: $t = 3.92s$**;** $s_y = -24.8m$**;** $v = 29.8ms^{-1}$**)**

9. **(PSPM 12/13)**

(a) A train initially at rest, accelerates uniformly until its speed reaches $8ms^{-1}$ in $25s$. For the next 200s, the train continues its journey with constant speed, before it slows down uniformly and comes to a complete stops in 20s.

i. Sketch a labels graph of speed versus time for the whole journey.

ii. Calculate the acceleration of the train for the three parts of the journey. **(Ans:** $0.32ms^{-2}$**;** $0ms^{-2}$**;** $0.4ms^{-2}$**)**

iii. Determine the total distance travelled by the train.**(Ans:** $1780m$**)**

(b) An object is thrown vertically downward at $5ms^{-1}$ from a height of $30m$. Calculate

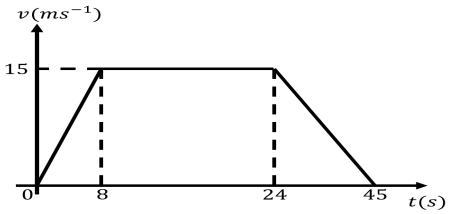
i. The speed of the object just before it hits the ground.**(Ans:** $24.77ms^{-1}$**)**

ii. the time taken by the object to reach the ground. **(Ans:** $2.02s$**)**

(c) A ball is thrown horizontally at $10ms^{-1}$ from a height of $15m$ above the ground. Calculate the horizontal range covered by the ball.**(Ans: 17.5m)**

10. **(PSPM 13/14)**

(a)



The figure above shows velocity-time graph of a motion along a straight line.

i. Calculate the average velocity and average acceleration of the entire motion.

ii. Sketch a labelled displacement-time graph of the motion.

(b) A bullet is fired vertically upwards with an initial speed of 600 ms^{-1}. Calculate the time interval, Δr for the bullet to be 800 m above ground.

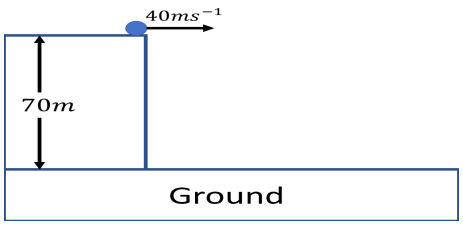
(c) i. Why is the displacement and velocity in a projectile motion can be analysed separately in the x and y-directions?

ii. A projectile is launched with a velocity of $45ms^{-1}$ at an angle of 60^o from the horizontal. Determine the time when the velocity makes an angle 30^o with the horizontal for first time.

11. **(PSPM 14/15)**

(a) Distinguish between distance and displacement.

(b)



The figure above shows a stone is thrown horizontally with initial velocity $40ms^{-1}$ from the top of $70m$ high building.

i. Sketch the path traversed by the stone to the ground and indicate the velocity components and resultant velocity of the stone l5 m from the ground.

ii. Calculate the resultant velocity of the stone 15 m from the ground. (**Ans:** $v_{res} = 51.73ms^{-1}$)

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iii. Sketch a graph of vertical acceleration versus time (a *vs* t) for the falling stone and label the value of acceleration.

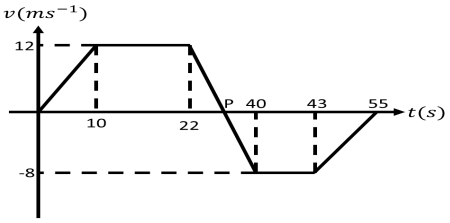
iv. Calculate the time of flight. (**Ans:** $t = 3.78s$)

v. Calculate the range.(**Ans:** $R = 151.2m$)

12. **(PSPM 15/16)**

(a) Describe a free falling body.

(b)



The figure above shows the velocity-time graph of a toy train moving on a straight track in $55s$.

i. Determine the time and acceleration at point P when the velocity is zero. (**Ans:** $t = 32.8s$; $a = -1.11ms^{-2}$)

ii. Is the total distance travelled by the train less than, equal or greater than its total displacement? Justify your answer using calculation. (**Ans:** $d > s$)

(c) A javelin is thrown with a speed of 55 ms^{-1} at an angle of 42^o with the horizontal. Calculate the velocity of the javelin after $5s$.(**Ans:** $v = 42.7ms^{-1}$)

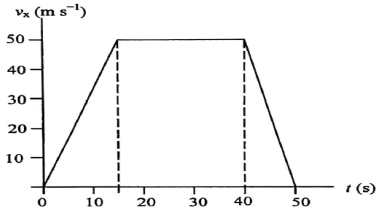
13. **(PSPM 17/18)**

(a) Define

i. average velocity

ii. instantaneous velocity

(b)



i. The figure above shows a part of car performance data.

A. Calculate the total distance travelled by the car. (**Ans:** $d = 1875m$)

B. Draw a graph of its acceleration against time between $t = 0s$ and $t = 50s$. Show your calculation.

(c) A ball on the field was kicked with an initial velocity of $16.5ms^{-1}$ at an angle of 35^o above the horizontal line. After passing a maximum height, the ball hit the goal post bar at a height of $3m$ from the ground.

i. Determine the time taken by the ball to hit the bar. (**Ans:** $t = 1.53s$)

ii. Calculate the distance of the goal post from the footballer. (**Ans:** $d = 20.7m$)

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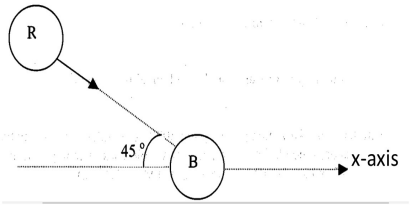
3: MOMENTUM & IMPULSE

1. **(00/01)**

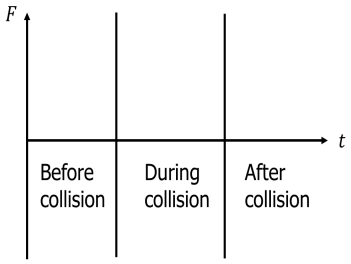


A red ball, R, of mass $0.1kg$ moving at velocity $0.8ms^{-1}$ at an angle of 45^o from the x-axis, collides with a blue ball, B, of mass $0.2kg$ at rest as shown in the figure above. After the collision, ball R moves with velocity $0.5ms^{-1}$ at angle 20^o from the x-axis, whilst ball B moves at an angle of θ from the axis x-axis. Calculate the momentum of R and B before and after the collision, and determine the magnitude and direction of the velocity of B after the collision. **(Ans:** $v_B = 0.2ms^{-1}$ **at an angle of** 78^o **from the x-axis)**

2. **(PSPM 05/06)** A body P of mass m moves with velocity u collides and sticks to a stationary body Q of mass $3m$.

   (a) State two physical characteristics of the collision.

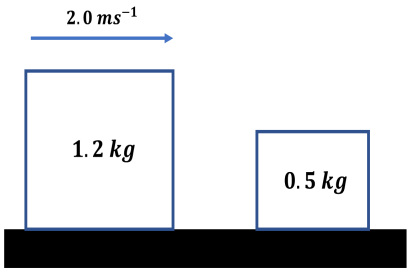
   (b) Determine the total kinetic energy after collision in terms of m and u. [**Ans:** $E_k = [0.125mu^2]$



   (c) Copy the figure above and sketch on the same axes, the changes in the force F on body Q with time t before, during and after collision.

3. **(PSPM 07/08)**

   (a) Explain the principle used to determine whether a collision between two bodies is elastic or inelastic.



   (b) A 1.2 kg object moving at initial velocity 2.0 ms^{-1} collides elastically with a stationary 0.5 kg object as shown in the figure above. Calculate

      i. the velocity of each object after the collision. [**Ans:** $v_i = (0.824, 2.82)ms^{-1}$]

      ii. the impulsive force if their contact time is 0.3 s. [**Ans:**$F = -4.70N$]

   (c) State ONE physical property of a material that is used as car bumper. Explain your answer.

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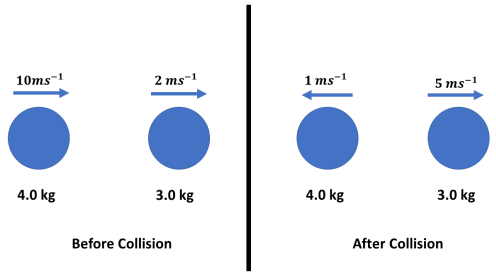
4. **(PSPM 08/09)**



The figure above shows the velocities of two metal balls of mass 4.0 kg and 3.0 kg before and after a collision. Determine the type of the collision.

5. **(PSPM 10/11)** A 50 g marble is released from a height of 1 m above the floor. Calculate its momentum just before hitting the floor. [**And:** $p = 0.222 kgms^{-1}$ downward]

6. **(PSPM 11/12)** An 8 g bullet moving at 50 ms^{-1} strikes a wooden block. The bullet undergoes uniform deceleration and stopped 12 cm inside the block. Calculate the

   (a) time taken for the bullet to stop [**Ans:** $t = 4.81 \times 10^{-3} s$]

   (b) impulse on the block [**Ans:** $J = -0.4 kgms^{-1}$

   (c) average force on the block [**Ans:** $F_{av} = -83.2N$]

7. **(PSPM 12/13)** Two identical balls with speed $4ms^{-1}$ and $2ms^{-1}$ collide head-on and stick together. Calculate their speed after the collision. [**Ans:** $1ms^{-1}$]

8. **(PSPM 13/14)** What is meant by impulse?

9. **(PSPM 14/15)**

   (a) State the principle of conservation of momentum.

   (b) A $6.25kg$ trolley moving with the velocity $5.5ms^{-i}$ hits a stationary $1.2kg$ trolley. After the collision the trolleys stick together and move with a constant velocity. Calculate

      i. the velocity after the collision [**Ans:** $4.6ms^{-1}$]

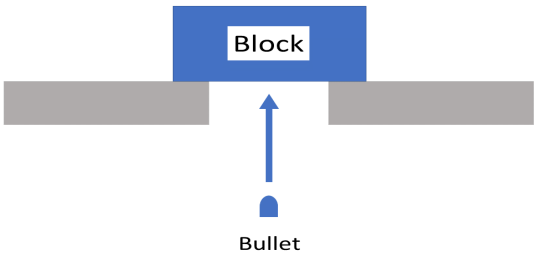
      ii. the loss of kinetic energy [**Ans:** $15.7J$]

10. **(PSPM 15/16)**

    (a) How is force related to momentum?

    (b) State a physical quantity used to indicate the difference between elastic and inelastic collision.

11. **(PSPM 16/17)**



The figure above shows a $12g$ bullet shot vertically into a $5kg$ block and lifting it upwards to a maximum height of $4mm$. The bullet travelled for $1ms$ in the block before stopping completely. Calculate the

(a) the speed of the block and the bullet just after the collision.

(b) impulse on the block

(c) depth of the bullet embedded in the block

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12. **(PSPM 17/18)**

    (a) State **one (1)** similarity and **one (1)** difference between elastic collision and inelastic collision.

    (b) A tennis player hits a $0.06kg$ ball horizontally approaching at $50ms^{-1}$ perpendicularly to his racquet's surface. He returns the shot at $40ms^{-1}$ in the opposite direction.

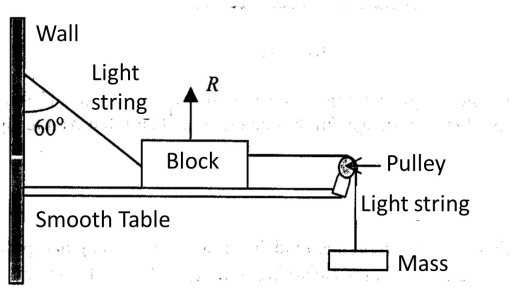
    i. Calculate the impulse to the ball by the racquet? [**Ans:** $5.4Ns$]

    ii. How much work does the racquet do on the ball? [**Ans:** $27J$]

    iii. If the ball hits the plane of the racquet at an angle, will the impulse delivered to the ball increase, decrease or remain the same? Explain. [**Ans:** Decrease]

4: FORCES

1. **(PSPM 00/01)**



(a) The diagram above shows a pulley system with weighted blocks attached by light strings. If the weight of the block is $30N$, calculate the magnitude of the reaction force, R. [$R = 30N$]

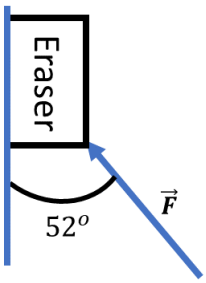
2. **(PSPM 05/06)** A block of mass $2kg$ is pushed along a horizontal surface with a force $F = 3.2N$. The block experiences an acceleration $a = 0.3ms^{-}2$. What is the coefficient of friction between the block and the horizontal surface? **(Ans:** $\mu = 0.133$**)**.

3. **(PSPM 05/06)** A man pulls a 45 kg block at constant velocity on a rough surface. The angle between the rope and the horizontal is 30^o and the coefficient of kinetic friction between the block and the surface is 0.6.

    (a) Sketch and label all the forces acting on the block.

    (b) Calculate the tension in the rope. **(Ans:** $T = 227N$**)**.

4. **(PSPM 06/07)**



The figure above shows a 0.2 kg eraser being pressed against a whiteboard by a force F inclined at 52^o to the whiteboard. The coefficient of static friction, μ, between the eraser and whiteboard is 0.3.

(a) Draw all the forces acting on the eraser.

(b) Calculate the force F needed just to keep the eraser from sliding down. [**Ans**: $F = 2.30N$]

(c) What will happen to the eraser if a stronger force $\vec{F_1}$ is exerted at the same angle? Give a reason for your answer.

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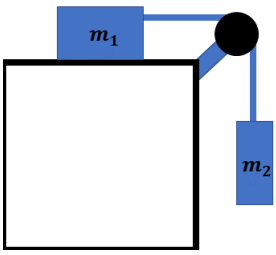
5. **(PSPM 09/10)**



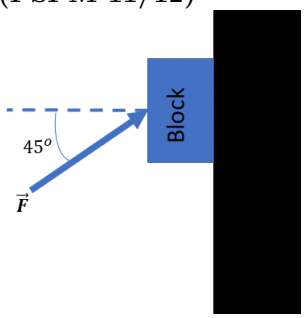
The figure above shows a block of mass $m_1 = 6.0kg$ on a horizontal surface with coefficient of kinetic friction, $\mu_k = 0.22$ is connected by a string through a pulley to another block of mass $m_2 = 3.0kg$. The system is released from rest.

(a) Draw the forces acting on the blocks when they are in motion.

(b) Calculate the acceleration of the blocks. [**Ans:** $|\vec{a}| = 1.82ms^{-2}$]

(c) Calculate the tension in the string. [**Ans:** $T = 23.9N$]

6. **(PSPM 11/12)**



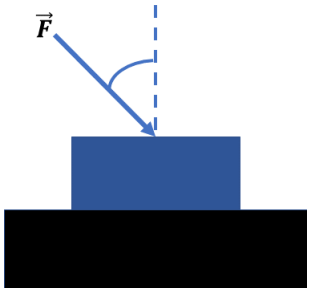
The figure above shows a $0.4kg$ block being pushed against a rough vertical wall by a force F at an angle 45^o with respect to the horizontal. The block remains stationary.

(a) Sketch a free body diagram of all the forces acting on the block.

(b) If the coefficient of static friction, $\mu_s = 0.20$, what is the magnitude of $\vec{F}$? [**Ans:** $|\vec{F}| = 4.62N$]

7. **(PSPM 12/13)**

(a) A 0.5 kg box is initially at rest on a smooth horizontal surface. It is acted upon by a horizontal force for a distance of 3 m. If the final speed of the box is $5ms^{-1}$, calculate the magnitude of the force. [**Ans:** $F = 2.08N$]

(b) 

The figure above shows a $2.0kg$ block is being pushed along a rough surface by a force $F = 30N$ at an angle 60^o from the normal.

i. Sketch a free body diagram for the block. Use common symbol for each force.

ii. If the block moves at constant acceleration $0.5ms^{-2}$, calculate the coefficient of friction. [$\mu = 0.72$]

8. **(PSPM 13/14)**

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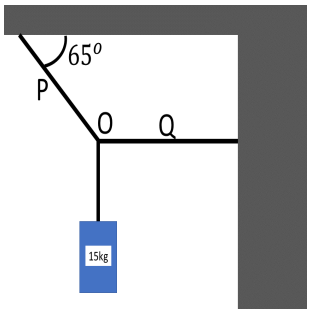
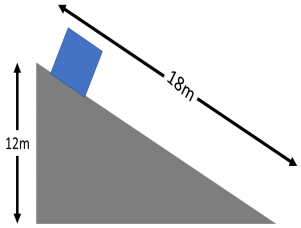
(a)



The figure shows a $15kg$ load held in equilibrium by ropes, P & Q fastened to the ceiling and the wall respectively.

i. Sketch a free body diagram at point O.
ii. Calculate the tension of ropes P and Q.

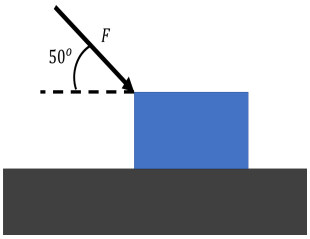
(b)



The figure shows a block held at rest at the top of a $18m$ long rough slope with a coefficient of kinetic friction of 0.19. The height of the box on the slope is $12m$. When released, the block slides down.

i. Calculate the final speed of the block at the bottom of the slope.
ii. If the mass of the block is increased, will the final speef of the block decrease, same or increase? Justify your answer.

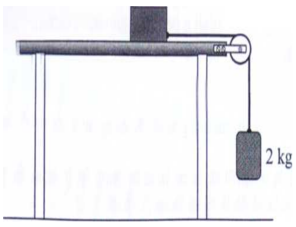
9. **(PSPM 14/15)**



The figure shows a $500N$, F acts on a stationary $25kg$ box lying on a rough surface. After $4s$, the speed of the box is $2ms^{-1}$. Calculate

(a) the frictional force on the box, [**Ans:** $F_f = 308.9N$]
(b) the coefficient of the kinetic friction between the box and the rough surface. [**Ans:** $\mu = 0.49$]

10. **(PSPM 15/16)**



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The figure shows a $2.5kg$ block connected to a $2kg$ load by a light string through a pulley of negligible mass. The coefficient of kinetic friction between the block and table is 0.18. When the system is released, calculate the

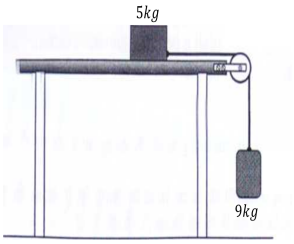
(a) acceleration of the block [**Ans:** $a = 3.38ms^{-2}$]

(b) tension in the string [**Ans:** $T = 12.86N$]

(c) total kinetic energy of the system after the block has moved $0.6m$ using the work-energy theorem.[**Ans:** $E_k = 9.12J$]

(d) final velocity, v_f of the block. [**Ans:** $v = 2.01ms^{-1}$]

11. **(PSPM 17/18)**



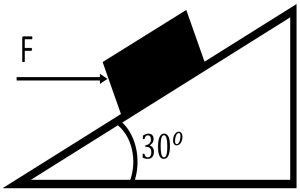
The figure shows a $5kg$ block placed on frictionless horizontal table, is conected to a $9kg$ hanging box by a string that passes over a pulley.

(a) Draw free-body diagram of both boxes

(b) Determine the magnitude of acceleration of both boxes [**Ans:** $a = 6.3ms^{-1}$]

(c) Determine the magnitude of tension in the string [**Ans:** $T = 31.5N$]

12. **(PSPM 17/18)**



The figure shows an object of mass $2.0kg$ placed on a rough plane inclined at 30^o with the horizontal. The coeffient of kinetic friction between the object and the plane surface is 0.25. A constant horizontal force of $F = 50N$ acts on the object and pushes it along the inclined plane with acceleration a.

(a) Draw free-body diagram of both boxes

(b) Determine the magnitude of acceleration of both boxes.

5: WORK, ENERGY & POWER

1. **(PSPM 00/01)**

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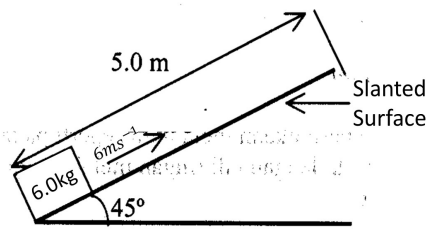
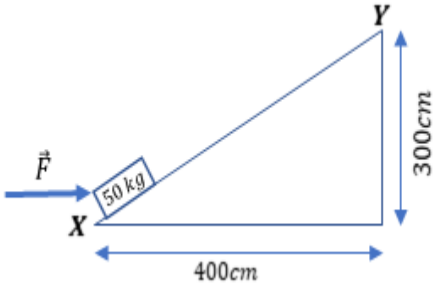


(a)

The diagram above shows a block of mass $6.0kg$ moving up the slope at $6ms^{-1}$ through a distance of $5.0m$ before it comes to a stop. Calculate the energy loss by friction. [$E_{loss} = 100J$]

2. **(PSPS 01/02)**



The figure above shows a horizontal force, $\vec{F}$, pushing a safe of mass $50kg$ on a smooth inclined plane from position X to position Y. If $|\vec{F}|$ is 400 N, calculate

(a) the work done to move the safe (in Joule) [**Ans:** $W = 128J$]

(b) the potential energy at position Y. [**Ans:** $E_{grav} = 1471.5J$]

3. **(PSPS 04/05)**
A Proton car has maximum power of $82kW$ and may attain maximum speed of $190kmh^{-1}$. Calculate the force of the car at maximum speed. [**Ans:** $F|_{max\ speed} = 1553.6N$]

4. **(PSPM 05/06)**
A $10.0J$ of work is needed to stretch an elastics spring by $2.0cm$. Calculate the work required to further extend the spring to $5.0cm$. [**Ans:** $W|_{5cm} = 52.5J$]

5. **(PSPM 06/07)**
A motorcycle overtakes a slow moving lorry by speeding up from $16ms^{-1}$ to $10ms^{-1}$ in $2s$. If the total mass of the rider and the motorcycle is 150 kg, calculate the required power. [**Ans:** $P|_{150kg} = 2550W$]

6. **(PSPM 09/10)**
A particle undergoes displacement $\vec{s} = -4\hat{i} - 5\hat{j}$ m when acted by a force, $\vec{F} = 3\hat{i} - 5\hat{j}$ N. Calculate the

(a) work done by the force. [**Ans:** $W = 13J$]

(b) average power if the force acts for 5 seconds. [**Ans:** $P = 2.6W$]

7. **(PSPM 10/11)**
A spring stretches by $4mm$ when a $1.5kg$ mass is suspended at its end. Calculate the spring constant. [**Ans:** $k = 3.68 \times 10^3 Nm^{-1}$]

8. **(PSPM 11/12)**

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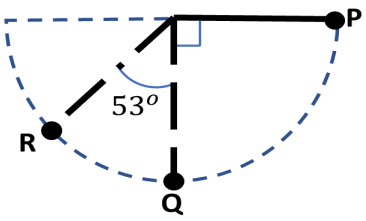
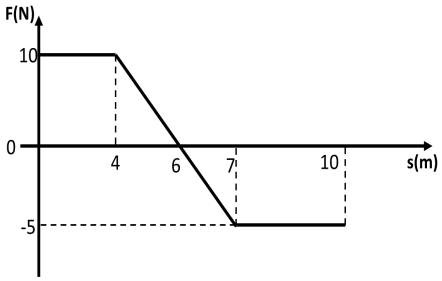


The figure above shows a $0.8kg$ pendulum bob being released from rest at P. The length of the string is $0.75m$. Calculate the

(a) work done by gravity on the bob at R. [**Ans:** $W = 2.35J$]

(b) speed of the bob at Q. [**Ans:** $v = 3.84ms^{-1}$]

9. **(PSPM 18/19)**



An object of mass $2.0kg$ travels along horizontal floor under the action of force F. The figure above shows the graph of F against the displacement s. The speed of the object at $s = 0$ is $10ms^{-1}$. Determine the speed of the object at $s = 10m$. [**Ans:** $11.5ms^{-1}$]

10. **(PSPM 18.19)**
A $2.0kg$ object is released vertically onto the top end of a vertical spring $30cm$ away. The spring constant is $2000Nm^{-1}$.

(a) Calculate the speed of the object just before striking the spring [**Ans:** $v = 2.43ms^{-1}$]

(b) Determine the maximum compression x. [**Ans:** $8.7 \times 10^{-2}m$]