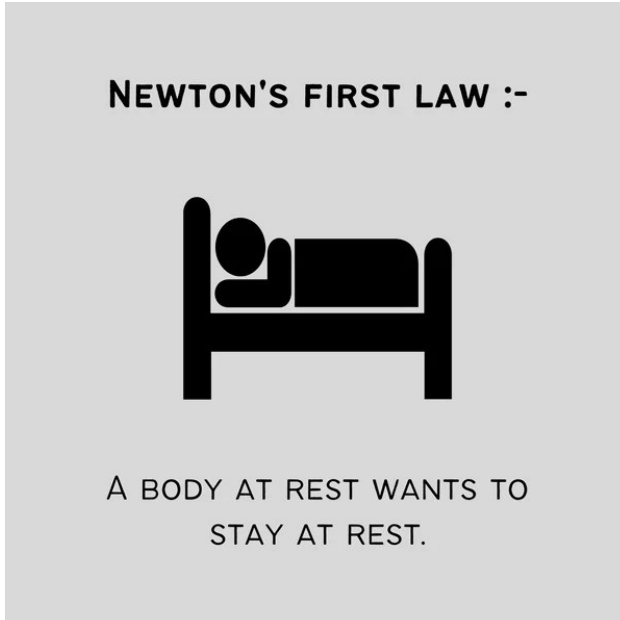

Grade 12 Physics
Kinematics Key

First Name: ____________________**KEY**________________________________

Last Name: ____

Directions:

- Please answer to 2 decimal points
- The test is designed to be completed in 75 minutes

For grading use only

Page:	2	3	4	5	6	7	8	Total
Points:	7	23	20	10	20	20	15	115
Score:								

Questions

1. (1 point) A car accelerates uniformly from rest to a speed of 25 m/s in 10 seconds. What is the car's acceleration?

   A. 1.5 m/s^2

   B. 2.5 m/s^2

   C. 3.5 m/s^2

   D. 4.5 m/s^2

2. (1 point) A projectile is launched with an initial velocity of 20 m/s at an angle of 30° above the horizontal. What is the maximum height it reaches?

   A. 10 m

   B. 15 m

   C. 20 m

   D. 25 m

3. (1 point) What is the force required to accelerate a 5 kg object at 3 m/s^2?

   A. 15 N

   B. 10 N

   C. 20 N

   D. 25 N

4. (1 point) An object moves in a circular path with a radius of 4 m at a constant speed of 8 m/s. What is the centripetal acceleration?

   A. 8 m/s^2

   B. 16 m/s^2

   C. 16 m/s^2

   D. 32 m/s^2

5. (1 point) A spring with a spring constant of 200 N/m is compressed by 0.1 m. What is the potential energy stored in the spring?

   A. 1 J

   B. 2 J

   C. 1 J

   D. 4 J

6. (1 point) A 10 kg object is dropped from a height of 20 m. What is its speed just before it hits the ground? (Assume no air resistance)

   A. 10 m/s

   B. 14 m/s

   C. 20 m/s

   D. 25 m/s

7. (1 point) A 3-ohm resistor is connected to a 12 V battery. What is the current flowing through the resistor?

   A. 2 A

   B. 4 A

C. 6 A
D. 8 A

8. (1 point) A 2 kg object is moving with a velocity of 5 m/s. What is its kinetic energy?
   A. 25 J
   B. 15 J
   C. 25 J
   D. 50 J

9. (1 point) A 50 N force is applied to a 10 kg object, causing it to accelerate. What is the object's acceleration?
   A. 2 m/s^2
   B. 5 m/s^2
   C. 5 m/s^2
   D. 10 m/s^2

10. (1 point) A block slides down a frictionless incline of 30°. What is the acceleration of the block along the incline?
    A. 3.3 m/s^2
    B. 5.0 m/s^2
    C. 7.5 m/s^2
    D. 9.8 m/s^2

Short Answer

11. A football with a mass of 0.4 kg is thrown with an initial velocity of 20 m/s at an angle of 30° above the horizontal.
    (a) (5 points) Calculate the time it will take for the football to reach its maximum height.
    (b) (5 points) Find the maximum height of the football.
    (c) (5 points) Determine the total time the football will be in the air before landing.
    (d) (5 points) Calculate the horizontal distance it will cover before landing.

Solution: (a) The time it will take for the football to reach its maximum height:

The vertical component of the initial velocity is given by:

$$v_{y0} = v_0 \sin\theta = 20 \sin 30^\circ = 10\, m/s$$

The time to reach the maximum height is calculated using:

$$t_{maxheight} = \frac{v_{y0}}{g} = \frac{10}{9.8} \approx 1.02\, seconds$$

(b) The maximum height of the football:

The maximum height is given by the equation:

$$h_{max} = \frac{v_{y0}^2}{2g} = \frac{10^2}{2 \times 9.8} = \frac{100}{19.6} \approx 5.10\, meters$$

(c) The total time the football will be in the air before landing:

The total time in the air is twice the time to reach the maximum height:

$$t_{total} = 2 \times t_{maxheight} = 2 \times 1.02 \approx 2.04\, seconds$$

(d) The horizontal distance the football will cover before landing:

The horizontal velocity is given by:

$$v_x = v_0 \cos\theta = 20 \cos 30^\circ \approx 17.32\, m/s$$

The horizontal distance is:

$$d = v_x \times t_{total} = 17.32 \times 2.04 \approx 35.3\, meters$$

12. A block of mass 4 kg rests on an inclined plane with an angle of 20° to the horizontal. The block is connected by a rope to a hanging block of mass 2 kg. The coefficient of friction between the block on the incline and the surface is 0.11.
    (a) (5 points) Calculate the normal force acting on the block on the incline.
    (b) (5 points) Find the frictional force acting on the block on the incline.
    (c) (5 points) Calculate the tension in the rope.
    (d) (5 points) Determine the acceleration of the system.

Solution: (a) The normal force acting on the block on the incline:

The normal force is calculated as:

$$F_N = m_1 g \cos\theta = 4 \times 9.8 \times \cos 20^\circ \approx 36.8\, N$$

(b) The frictional force acting on the block on the incline:

The frictional force is given by:

$$F_{friction} = \mu F_N = 0.11 \times 36.8 \approx 4.05\, N$$

(c) The tension in the rope:

First, calculate the force due to gravity acting on the hanging block:

$$F_{gravity} = m_2 g = 2 \times 9.8 = 19.6\, N$$

The net force on the system is:

$$F_{net} = F_{gravity} - F_{friction} - m_1 g \sin\theta = 19.6 - 4.05 - 4 \times 9.8 \times \sin 20^\circ$$

$$F_{net} \approx 19.6 - 4.05 - 13.4 = 2.15\, N$$

The tension in the rope is:

$$T = F_{net} = 2.15\, N$$

(d) The acceleration of the system:

The total mass of the system is:

$$m_{total} = m_1 + m_2 = 4 + 2 = 6\,kg$$

Using Newton's second law:

$$a = \frac{F_{net}}{m_{total}} = \frac{2.15}{6} \approx 0.36\,m/s^2$$

13. A canoe is traveling at a velocity of 60.0 km/h due south with respect to the water. Due to a current, the canoe ends up traveling at 30.0 km/h at an angle of 45° south of west with respect to the shore.
    (a) (5 points) Using vector components, calculate the velocity of the current.
    (b) (5 points) Find the direction of the current with respect to the southward direction.

Solution: (a) The velocity of the current:

We know the velocity of the canoe with respect to the shore is $\vec{v}_{canoe/shore} = 30.0\,km/h\,[S45°W]$, and the velocity of the canoe with respect to the water is $\vec{v}_{canoe/water} = 60.0\,km/h\,[S]$.

First, decompose both velocities into their vector components:

$$\vec{v}_{canoe/shore,x} = 30.0\,km/h \cdot \sin(45°) \approx 21.2\,km/h,$$

$$\vec{v}_{canoe/shore,y} = -30.0\,km/h \cdot \cos(45°) \approx -21.2\,km/h.$$

For the canoe with respect to the water, the components are:

$$\vec{v}_{canoe/water,x} = 0\,km/h,$$

$$\vec{v}_{canoe/water,y} = -60.0\,km/h.$$

Now calculate the velocity of the current using the equation:

$$\vec{v}_{current} = \vec{v}_{canoe/shore} - \vec{v}_{canoe/water}.$$

Substitute the components:

$$\vec{v}_{current,x} = 21.2 - 0 = 21.2\,km/h,$$

$$\vec{v}_{current,y} = -21.2 - (-60.0) = 38.8\,km/h.$$

Thus, the velocity of the current is:

$$\vec{v}_{current} = \langle 21.2, 38.8 \rangle\,km/h.$$

(b) The direction of the current with respect to the southward direction:

The direction of the current is given by:

$$\theta = \tan^{-1}\left(\frac{v_{current,x}}{v_{current,y}}\right) = \tan^{-1}\left(\frac{21.2}{38.8}\right) \approx 29.7°.$$

Thus, the current is directed $29.7°$ east of south.

Final answers:

- **(a) The velocity of the current is $\vec{v}_{current} = \langle 21.2, 38.8 \rangle \, km/h$.**
- **(b) The direction of the current is $29.7°$ east of south.**

14. A 0.050 kg yo-yo is swung in a vertical circle on the end of its 0.30 m long string. The yo-yo is at its slowest speed, just enough to complete the vertical circle.
    (a) (5 points) Calculate the minimum speed of the yo-yo required to complete the circle.
    (b) (5 points) Draw a labelled free-body diagram at the highest point of the vertical circle.
    (c) (5 points) What will the maximum tension in the string be when the yo-yo is swung at the minimum speed?
    (d) (5 points) Where will the maximum tension occur in the vertical circle? Draw a labelled free-body diagram showing the forces acting on the yo-yo at this point.

Solution: (a) The minimum speed required to complete the circle:

At the highest point of the vertical circle, the tension in the string is zero. The centripetal force is provided by the gravitational force:

$$F_{centripetal} = \frac{mv_{min}^2}{r}.$$

At the highest point, the gravitational force is equal to the centripetal force:

$$mg = \frac{mv_{min}^2}{r}.$$

Canceling out the mass m from both sides:

$$g = \frac{v_{min}^2}{r}.$$

Solving for v_{min}:

$$v_{min} = \sqrt{gr} = \sqrt{9.8 \times 0.30} = \sqrt{2.94} \approx 1.71 \, m/s.$$

(b) Free-body diagram at the highest point:

At the highest point, the forces acting on the yo-yo are:

- **The tension T in the string acting upward.**
- **The gravitational force mg acting downward.**

The free-body diagram would show these forces.

(c) The maximum tension in the string:

The maximum tension occurs at the lowest point of the vertical circle. The tension must balance the gravitational force and provide the centripetal force. The total tension is:

$$T_{max} = \frac{mv_{min}^2}{r} + mg.$$

Substitute the known values:

$$T_{max} = \frac{0.050 \times (1.71)^2}{0.30} + 0.050 \times 9.8.$$

$$T_{max} = \frac{0.050 \times 2.9241}{0.30} + 0.490 = 0.487 + 0.490 = 0.977\,N.$$

(d) The maximum tension occurs at the lowest point:

The maximum tension occurs at the lowest point of the vertical circle, where the forces acting on the yo-yo are:

- **The tension T acting upward.**
- **The gravitational force mg acting downward.**

The free-body diagram at this point would show the tension vector pointing upward and the gravitational force vector pointing downward.

Final answers:

- **(a) The minimum speed required to complete the circle is $v_{min} = 1.71\,m/s$.**
- **(b) The free-body diagram at the highest point shows tension upward and gravity downward.**
- **(c) The maximum tension in the string is $T_{max} = 0.977\,N$.**
- **(d) The maximum tension occurs at the lowest point, where the forces are tension upward and gravity downward.**

15. A 5 kg block rests on an inclined plane with a 30° angle. The block is connected by a rope to a 3 kg hanging block. The coefficient of friction between the 5 kg block and the plane is 0.15.
    (a) (5 points) Determine the gravitational force acting on the 5 kg block.
    (b) (5 points) Calculate the frictional force acting on the 5 kg block.
    (c) (5 points) Find the tension in the rope connecting the blocks.
    (d) (5 points) Calculate the acceleration of the system.

Solution: (a) The gravitational force acting on the 5 kg block:

The gravitational force acting on the block is given by:

$$F_{gravity} = mg = 5 \times 9.8 = 49\,N.$$

Thus, the gravitational force acting on the 5 kg block is $49\,N$.

(b) The frictional force acting on the 5 kg block:

The frictional force is calculated using the formula:

$$F_{friction} = \mu F_N,$$

where $\mu = 0.15$ is the coefficient of friction and F_N is the normal force.

The normal force can be found by:

$$F_N = mg\cos\theta = 5 \times 9.8 \times \cos 30^\circ \approx 5 \times 9.8 \times 0.866 = 42.5\,N.$$

Now calculate the frictional force:

$$F_{friction} = 0.15 \times 42.5 \approx 6.375\,N.$$

Thus, the frictional force acting on the 5 kg block is $6.375\,N$.

Final answers:

- **(a) The gravitational force acting on the 5 kg block is $49\,N$.**
- **(b) The frictional force acting on the 5 kg block is $6.375\,N$.**

16. A boat is crossing a river that is 200 m wide. The boat has a velocity of 8 m/s relative to the water, and the current in the river flows at a velocity of 3 m/s.
    (a) (5 points) Calculate the time it takes for the boat to cross the river.
    (b) (5 points) Determine the distance the boat will be displaced downstream while crossing.
    (c) (5 points) Calculate the angle at which the boat must head to travel directly across the river (i.e., without drifting downstream).

Solution: (a) The time it takes for the boat to cross the river:

To calculate the time it takes for the boat to cross the river, we use the formula:

$$Time = \frac{Width of the river}{Velocity of the boat relative to the water}.$$

Given that the width of the river is 200 m and the velocity of the boat relative to the water is 8 m/s:

$$Time = \frac{200}{8} = 25\,seconds.$$

Thus, the time it takes for the boat to cross the river is $25\,seconds$.

(b) The distance the boat will be displaced downstream:

The downstream displacement is calculated using the velocity of the current and the time it takes the boat to cross the river:

$$Displacement = Velocity of current \times Time.$$

Given that the velocity of the current is 3 m/s and the time taken to cross is 25 seconds:

$$Displacement = 3 \times 25 = 75\,m.$$

Thus, the boat will be displaced 75 m downstream while crossing the river.

(c) The angle at which the boat must head to travel directly across the river:

To travel directly across the river, the boat must head at an angle that compensates for the current. The angle θ is found using:

$$\tan\theta = \frac{Velocity of current}{Velocity of boat relative to the water}.$$

Substitute the given values:

$$\tan\theta = \frac{3}{8} \approx 0.375.$$

Solving for θ:

$$\theta = \tan^{-1}(0.375) \approx 20.56^\circ.$$

Thus, the boat must head at an angle of approximately 20.56° upstream to travel directly across the river.

Final answers:

- **(a) The time it takes for the boat to cross the river is $25\,seconds$.**
- **(b) The distance the boat will be displaced downstream is $75\,m$.**
- **(c) The angle at which the boat must head to travel directly across the river is 20.56° upstream.**