ST. LAWRENCE HIGH SCHOOL

A JESUIT CHRISTIAN MINORITY INSTITUTION

First Term Examination - 2018

Class :11 A

Sub :Physics F.M.:70

DURATION:3 Hrs15Mins DATE:03.08.2018

Section - I

1. MCQ Questions each of 1 mark.(Answer all the question) 1x14=14

i) The equation of state of a real gas is given by $\left(P+\frac{a}{V^2}\right)(V-b)=RT$. Where P and V stand for pressure and volume. Then $[ab]$ will be

a) ML^6T^{-2} b) ML^8T^{-2} c) ML^2T^{-2}. d) Can't be calculated without knowing the dimensions of R and T.

ii) A physical quantity A is related to four observables a, b, c and d as $A=\frac{a^2b^3}{c\sqrt{d}}$. If a, b, c and d changes by 1%, 2%, 3% and 4% respectively, then what will be the percentage change of A?

a) 5% b) 10% c) 7% d) 13%

iii) The number of significant digits in 0.020800 m is

a) 5 b) 6 c) 7 d) 2

iv) From the top of a building two balls A and B are thrown with same velocity one vertically upward and another vertically downward. If v_a *and* v_b are their velocities respectively at reaching the ground, then which one is correct? (neglect air rsistance)

a) $v_a > v_b$, b) $v_a < v_b$, c) $v_a = v_b$, d) it depends on their masses.

v) A body covers one third of its journey with speed V_1 next one third with speed V_2 and last one third with speed $V_1.V_2$. The average speed of the body is

a) $\frac{3V_1V_2}{1+V_1+V_2}$ b) $\frac{3V_1V_2}{V_1V_2+V_1+V_2}$ c) $\frac{3(V_1+V_2)}{V_1V_2+V_1+V_2}$ d) None of these.

vi) If you speed up a bicycle by pedaling it, then the frictional force by the road on the wheels of the bicycle acts

a) Along backward for front wheel and forward for back wheel.
b) Along backward for back wheel and forward for front wheel.
c) Along backward for both wheels
d) Along forward for both wheels.

vii) The angle between two vectors of same magnitude whose resultant vector has also the same magnitude is

a) 0^0 b)60^0 c) 120^0 d) 90^0

viii) A man can swim with speed 4km/h in still water. At what angle he should project himself w.r.t the bunk of the river to reach exactly opposite point of the river? (velocity of river is 2km/h)

a) 30^0 b) 45^0 c) 60^0 d) 90^0

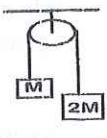
ix) For a projectile if R represents the maximum range and H represents the maximum height reached by the body when projected to get maximum range, then

a) H = 4R b) H = 2R c) R = 2H d) R = 4H

x) A cricket ball of mass 500g hits a cricket bat perpendicularly with velocity 20m/s and then gets reflected back with velocity 30m/s. The impulse exerted by ball on bat will be

a) 50 N.s b) 25 N.s c) 1 N.s d) 0.5 N.s

xi) Two masses are attached by a mass-less inextensible thread via a frictionless pulley as shown in the figure. If they are released then the acceleration of 2M mass will be



a) $\frac{g}{3}$ b) $\frac{g}{2}$

c) $3g$ d) g, as frictionless pulley will allow 2m mass to have free fall.

xii) For a particle executing uniform circular motion (i.e. moving with uniform speed), which option is correct?

a) The linear velocity remains unchanged.
b) The linear acceleration remains unchanged.
c) The magnitude of linear acceleration remains unchanged.
d) The magnitude of linear acceleration changes with time.

xiii) 8.9 N horizontal force is applied on a body of mass 1.8kg, which is kept on a horizontal rough surface. If the coefficients of static and kinetic friction are $\mu_s = 0.6$ *and* $\mu_k = 0.5$, then the frictional force the body experiences is ($g = 10m/s^2$) –

a) Zero b) 10.8 N c) 9.0N d) 8.9 N

xiv) To a driver going east in a car with a velocity of 40km/h , a bus appears to move towards north with a velocity of $40\sqrt{3}\ km/h$. What is the actual velocity of the bus?

a) 42km/hr b) 50km/hr c) $75\sqrt{3}$ km/hr d) 80km/hr

Section – II

Group – A

Answer the following question in brief. (Alternatives are to be noted) **1x4=4**

(For this group, mathematical explanation and diagrams are needed where applicable)

1. According to quantum mechanics, the energy of a photon particle can be written as $E = \frac{hc}{\lambda}$. Where, 'c' is speed of light in vacuum, 'λ' is the wave length. Determine the dimension of Plank's constant 'h'.

   Or

   The displacement of a body is a function of time as $S = 5t^3 - 4t^2$.What will be the instantaneous velocity at 2s?
2. Determine the unit vector of resultant of two vectors $\vec{A} = 2\hat{\imath} - 3\hat{\jmath} + 5\hat{k}$ and $\vec{B} = 5\hat{\imath} + 3\hat{\jmath} - 5\hat{k}$.
3. Two bodies of masses 5kg and 10 kg are placed back to back on a smooth horizontal surface. If a horizontal force of magnitude 21 N is applied to the system s.t. the bodies move together then what will be the acceleration of 5kg mass?
4. Write down the expression for the range of a particle in projectile motion clearly mentioning the symbols used.

Group – B

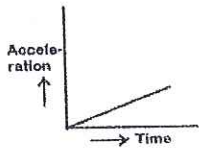
Answer the following questions in short. (Alternatives are to be noted) **2x5 = 10**

(For this group, mathematical explanations and diagrams are needed where applicable)

5. If 20 vernier division of a vernier calipers coincide with 19mm of main scale, what will be the vernier constant in mm?
6. Draw the velocity versus time curve of a particle in 1D motion whose displacement is given as $S = at^3 + bt$. *a and* b are constants.

   Or

   The acceleration versus time curve of a particle in 1D motion is shown in the figure. What will be the maximum power of 't' in the expression of its displacement? 't' represents time.



7. Find the vector which have magnitude of 6 units in the direction of resultant of two vectors $2\hat{\imath} - 4\hat{\jmath} + \hat{k}$ and $5\hat{\imath} - \hat{\jmath} - \hat{k}$.

   Or

   A stone is thrown horizontally at a velocity 18m/s from the top of a building. It touches the ground at a distance 90m from the foot of the building. Calculate the height of the building.
8. Determine the recoil velocity of a gun of mass 4kg when a bullet of mass 6g emerges out with velocity 500m/s from it.

   Or

   Find out the tension of the string T when masses are placed on a smooth plane.

9. A piece of stone comes to rest after being displaced by 20m on a rough surface. If the initial velocity of the stone was 1m/s, then determine the coefficient of kinetic friction of the stone-surface system.

   Or

   The displacement of a body undergoing a force $\vec{F} = \hat{\imath} - 0.5\,\hat{\jmath} + 3\hat{k}$ is $\vec{S} = 2\hat{\imath} - 2\hat{\jmath} - \hat{k}$. What is the work done on the body by the force? What can you conclude on your result?

Group – C

Answer the following questions. (Alternatives are to be noted) **3x9=27**

(For this group, mathematical explanations and diagrams are needed where applicable)

10. The frequency of vibration of a stretched string depends upon – its length 'l', its mass per unit length 'm' and the tension in the string 'T'. Find out the expression for the frequency by dimensional analysis. 3
11. What is the significance of slope of i) Displacement versus time curve and ii) velocity versus time curve ? Draw the velocity versus time curve of a particle in 1D motion whose acceleration is infinite. 1+1+1

12. What do you mean by null vector or zero vector? What is its importance? Determine the angle between two vectors $\hat{\imath}+\hat{\jmath}$ and $\hat{\imath}-\hat{\jmath}$. 1+1+1

Or

For any three vectors $\vec{A}, \vec{B}$ *and* $\vec{C}$, prove that $\vec{A}\times(\vec{B}+\vec{C})+\vec{B}\times(\vec{C}+\vec{A})+\vec{C}\times(\vec{A}+\vec{B})=\vec{0}$. Two vectors $\vec{P}$ and $\vec{Q}$ are such that $|\vec{P}\times\vec{Q}|=\vec{P}.\vec{Q}$. then determine the angle between them. 2+1

13. What do you mean by impulse of force and impulsive force? Derive Newton's first law from second law. ½+ ½+2

Or

A body of mass 5kg initially at rest explodes and breaks into three fragments of masses in the ratio 1: 1: 3. The two pieces of equal mass fly off perpendicular to each other with a speed $20\sqrt{2}$ m/s .what will be the velocity of the heavier fragment? 3

14. What do you mean by limiting frictional force? Draw a curve to show the variation of frictional force with applied force indicating limiting frictional force. Define angle of friction. 1+1+1

Or

The upper half of an inclined plane is smooth (frictionless) and the lower half is rough. It is making an angle θ with the horizontal direction. If an object when released from the top of the inclined plane comes to rest exactly at the foot of the inclined plane, then prove that $\mu = 2\tan\theta$. Where μ is coefficient of kinetic friction of the rough portion of inclined plane. 3

15. Prove graphically that , $S = ut + \frac{1}{2}at^2$. 3
16. What is the origin of frictional force? Pulling a roller is easier than pushing it – why? 1+2
17. A body falling freely under gravity passes two points 30m apart in 1sec. Find from what point above the upper point it began to fall. ($g = 10\ m/s^2$) 3
18. A particle P is moving along a straight line with velocity 3m/s and another Q with velocity 4m/s at an angle 30^0 to the path of P. find the velocity of Q relative to P. 3

Group – D

Answer the following questions. (Alternatives are to be noted)

(For this group, mathematical explanations and diagrams are needed where applicable)

19. Can a particle with nonzero acceleration have uniform speed -- explain? To a person moving eastwards with a velocity 5km/h, rain appears to fall vertically downward with a speed $5\sqrt{3}$km/h. Find the actual speed and direction of the rain. 1+2+2

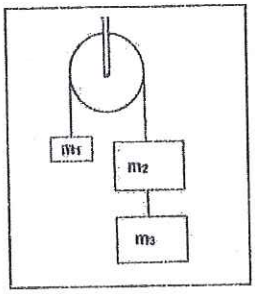
Or

For a body in projectile motion, derive the expression for i) the time of flight ii) maximum height attained iii) horizontal range. 1+2+2

20. A ball X is thrown along the horizontal direction with some initial velocity from the top of a building and at the same time, another identical ball Y is dropped from the same point. Which one will reach the ground first --and why? A man rows directly across a flowing river in time t_1 and rows an equal distance down the stream in time t_2. If 'u' be the speed of the man in still water and 'v' be that of stream, then show that $t_1 : t_2 = \sqrt{u+v} : \sqrt{u-v}$. 1+4

Or

Define angle of repose. Three masses are attached by an inextensible mass less string as shown in the figure via a frictionless pulley. If they are now released, then find out the tension in the string in between masses m_2 and m_3. (given $m_2+m_3>m_1$) . 1+4



21. The diagonals of a parallelogram are given as $3\hat{\imath}+\hat{\jmath}+2\hat{k}$ and $\hat{\imath}-3\hat{\jmath}+4\hat{k}$. Find its area. Establish the equation of motion of a body that is sliding down on a rough inclined plane of inclination 'θ' 3+2

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07.08.18

ST. LAWRENCE HIGH SCHOOL

Model Answer

Pre-Test Exam – 2018

Sub: Physics **Class: XI-A1** **F. M. : 70**

Duration: 3hrs 15 min

Section – I

1. MCQ

i) c) ML^2T^{-2}.

ii) d) 13%

iii) a) 5

iv) c) $v_a = v_b$,

v) b) $\frac{3V_1V_2}{V_1V_2+V_1+V_2}$

vi) Along backward for front wheel and forward for back wheel.

vii) c) 120^0

viii) c) 60^0 .

ix) d) R = 4H

x) b) 25 N.s

xi) $\frac{g}{3}$

xii) The magnitude of linear acceleration remains unchanged.

xiii) d) 8.9 N. [As applied force (8.9N) is less than the limiting frictional force $(0.5 \times 1.8 \times 10)N$]

xiv) d) 80km/hr

Section – II

Group – A

1. $[h] = \frac{[E][\lambda]}{[c]} = \frac{ML^2T^{-2}.L}{LT^{-1}} = ML^2T^{-1}$.

Or

Differentiating w.r.t time $v = \frac{dS}{dt} = 15t^2 - 8t$. So the instantaneous velocity at $t = 2sec$ will be –

$v = (15 \times 4 - 8 \times 2)m/sec = 44m/sec$.

2. Clearly the resultant vector will be $\vec{R} = \vec{A} + \vec{B} = 7\hat{\imath}$. Hence the unit vector of this resultant vector will be '$\hat{\imath}$'.
3. Acceleration of both the bodies will be same with value $a = \frac{21}{15}m/s^2 = 7/5m/s^2$.
4. $R = \frac{u^2 sin2\theta}{g}$.

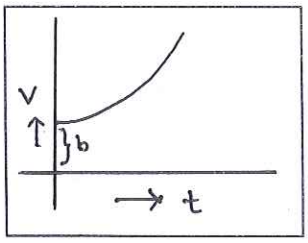
Group – B

5. 20 v.s.r coincide with 19mm

1 v.s.r.....19/20 mm

So, V.C = $\left(1 - \frac{19}{20}\right)mm = \frac{1}{20}mm = 0.05mm = 0.005\ cm$

6. Differentiating w.r.t time we get, $v = \frac{dS}{dt} = 3at^2 + b$. So the initial velocity is 'b' m/s.



And $acceleration = \frac{dv}{dt} = 6at$

Clearly, the acceleration is a function of time and that increases in time, hence velocity will increase rapidly. So the variation of velocity w.r.t t will be –

Or

The curve shows, a is changing linearly with t.

So, let $a = kt$

i.e. $\frac{dv}{dt} = kt$. Integrating we get, $v = kt^2 + c_1$. i.e. $\frac{ds}{dt} = kt^2 + c_1$. Integrating we get, $s = kt^3 + c_1t + c_2$. So, maximum power of 't' in the expression of 's' is '3'.

7. Resultant of $2\hat{\imath} - 4\hat{\jmath} + \hat{k}$ and $5\hat{\imath} - \hat{\jmath} - \hat{k}$ is $\vec{R} = 2\hat{\imath} - 4\hat{\jmath} + \hat{k} + 5\hat{\imath} - \hat{\jmath} - \hat{k} = 7\hat{\imath} - 5\hat{\jmath}$. So the unit vector of $\vec{R}$ will be, $\hat{R} = \frac{7\hat{\imath}-5\hat{\jmath}}{\sqrt{7^2+5^2}} = \frac{1}{\sqrt{74}}(7\hat{\imath} - 5\hat{\jmath})$. Then the required vector in the direction of this unit vector will be –

$=6 \times \hat{R} = \frac{6}{\sqrt{74}}(7\hat{\imath} - 5\hat{\jmath})$.

Or

For horizontal motion : Time taken to cover 90m horizontally is $= \frac{90}{18} sec = 5sec.$[as no change in velocity along this direction]. So, during 5sec the body was falling.

For vertically downward motion: Height of the building = distance travelled by the body vertically in 5 sec,

$= \frac{1}{2}.g.5^2 = 125m$ (if g=10m/s^2). [H = 122.5m, if g=9.8 m/s^2].

8. $V = -\frac{m}{M}.v = -\frac{6}{4000} \times 500 \frac{m}{s} = -\frac{3}{4} m/s \quad or\ 75cm/sec$

So the gun will move back with velocity ¾ m/s or 75cm/s.

Or

The common acceleration of the system, $a = \frac{20}{(20+5)} = \frac{4}{5}\ m/s$

By FBD of 5kg mass, $20 - T = 5 \times \frac{4}{5}$. solving, we get, $T = 16N$

9. As the stone is coming to rest because of frictional force, so by energy conservation,

$Initial\ K.E = work\ done\ by\ frictional\ force$

i.e. $\frac{1}{2}mu^2 = \mu_k mg \times s$

or, $\mu_k = \frac{u^2}{2sg} = \frac{1}{2.20.10} = 0.0025$

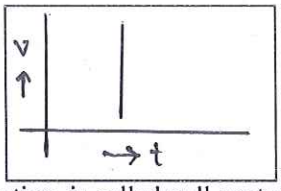
Or

Work done , $w = \vec{F}.\vec{S} = 2 + 1 - 3 = 0.$

So, the force is a no-work force for the body.

Group – C

10. Refer to standard text book.
11. i) slope of disp – time curve indicates the velocity of the body.
ii) slope of velocity versus time curve indicates the acceleration of the body.
The velocity versus time curve of a particle in 1D motion whose acceleration is infinite, will be as shown in the figure.



12. The unique vector in the vector space with zero magnitude and with no specific direction, is called null vector.
Importance : it is the identity element of the vector space w.r.t the operation addition.

$Let \vec{A} = \hat{\imath} + \hat{\jmath}$ and $\vec{B} = \hat{\imath} - \hat{\jmath}$. Then $\vec{A}.\vec{B} = 0$. So the angle between them is 90^0.

Or

L.H.S : $\vec{A} \times (\vec{B} + \vec{C}) + \vec{B} \times (\vec{C} + \vec{A}) + \vec{C} \times (\vec{A} + \vec{B})$

$= \vec{A} \times \vec{B} + \vec{A} \times \vec{C} + \vec{B} \times \vec{C} + \vec{B} \times \vec{A} + \vec{C} \times \vec{A} + \vec{C} \times \vec{B}$

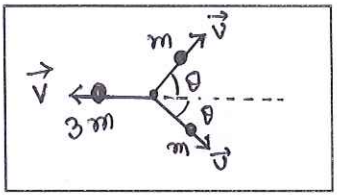
$= \vec{A} \times \vec{B} - \vec{A} \times \vec{B} + \vec{B} \times \vec{C} - \vec{B} \times \vec{C} + \vec{C} \times \vec{A} - \vec{C} \times \vec{A}$

$= \vec{0} + \vec{0} + \vec{0} = \vec{0} = R.H.S\ (Proved)$

13. Refer to standard text book.

Or

As two small fragments have same mass, they will move symmetrically w.r.t the heavier. So the diagram will be as shown in the figure. Let they make θ^o angle each as shown in the figure. Also let the masses as m, m & $3m$ and their velocities as $v, v\ and\ V$ respectively.Then from the linear momentum conservation –



Along X – axis :

$m.v\cos\theta + m.v\cos\theta + 3m.V = 0$ [$as\ initiall\ momentum\ is\ 0\ along\ both\ the\ axes$]

Solving, $V = -\frac{2 \times 20\sqrt{2}}{3} cos\theta$ ..... (1)

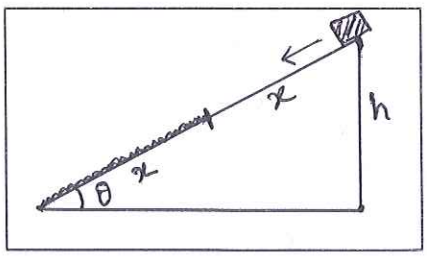
Also $\theta + \theta = 90^o$. i.e. $\theta = 45^0$. Putting this value in equation – 1, $V = -\frac{40}{3} m/s$.

So, the heavier mass will move along –X axis with velocity $\frac{40}{3} m/s$.

14. Refer to standard text book.

Or

Referring to the diagram, by energy conservation –



Potential energy at the top = energy lost due to friction.

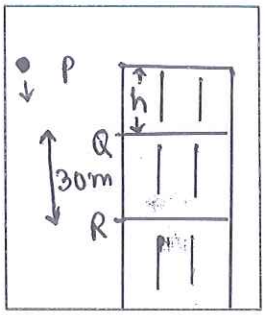
So, $m.g.2x.sin\theta = \mu.m.g.cos\theta \times x$

Solving, $\mu = 2tan\theta$.

15. Refer to standard text book.
16. Refer to standard text book.

While pushing, a component of the applied force gets added up with the weight of the body [if pushed from an inclined direction], thereby increasing the weight of the body and hence increasing the frictional force.

17. Let the body is dropped from the point P, it travels QR path in 1 sec as shown in the figure. Also let, velocity of the body at Q is u and P is at a height h above Q.



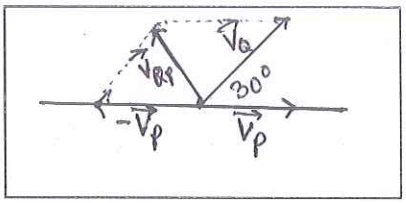
Then for QR path: $s = ut + \frac{1}{2}gt^2$ gives, $30 = u.1 + \frac{1}{2}.10.1.$

Solving, $u = 25m/s.$

So, for PQ path: $u^2 = 0^0 + 2.10.h$

Solving, $h = \frac{u^2}{20} = \frac{625}{20} m/s = 31.25\ m$. [putting u from the previous eqn]

18. The velocity of Q relative to P is $\vec{V}_{QP} = \vec{V}_Q - \vec{V}_P = \vec{V}_Q + (-\vec{V}_P)$.



From the diagram, the angle between $\vec{V}_Q$ *and* $(-\vec{V}_P)$ will be $180^0 - 30^0 = 150^0$.

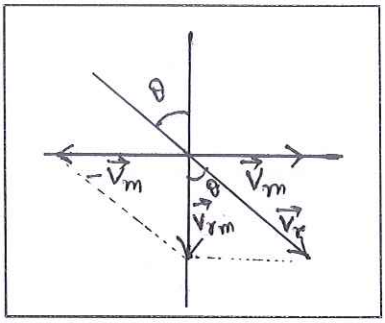
So, $|\vec{V}_{QP}| = \sqrt{3^2 + 4^2 + 2.3.4.cos180^0} = \sqrt{25 - 12\sqrt{3}}\ m/s$

{ as, $|\vec{V}_Q| = 4\ m/s$ and $|\vec{V}_P| = 3\ m/s$ }

Group – D

19. Yes, in circular motion the body possesses centripetal acceleration although the speed of the body remains constant.

As rain appears to fall vertically downward, its actual direction will be as shown in the figure.



Also given, $V_{rm} = 5\sqrt{3}km/h$ and $V_m = 5km/h$. Then, from the diagram, $V_r^2 = V_m^2 + V_{rm}^2$.

Solving, $V_r = 10km/h$. Again, $Sin\theta = \frac{5}{10}$, which gives $\theta = 30^0$.

Hence, rain is actually falling to the back of the parson making 30^0 angle with vertical direction with a speed 10km/h.

Or

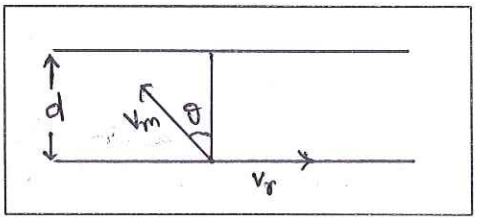
Refer to standard text book.

20. Both will reach the ground at same time. As it is thrown horizontally, no component of that horizontal velocity will be added up with vertically downward velocity, hence the vertically downward motion for both the cases are exactly similar.

Let, to cross the river directly, the man project himself at an angle θ as shown in the figure.

Referring to the diagram, $uCos\theta$ will lead the person to cross the river directly, so $t_1 = \frac{d}{uCos\theta}$.

And $uSin\theta$ will balance the motion of the river, so, $uSin\theta = v$



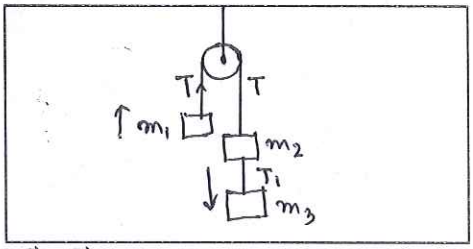
While rowing down the stream, $t_2 = \frac{d}{u+v}$.

Now, $Sin\theta = \frac{v}{u}$ gives , $Cos\theta = \sqrt{\frac{(u+v)(u-v)}{u^2}}$

Then, $t_1 : t_2 = \frac{d}{uCos\theta} : \frac{d}{u+v} = \sqrt{u+v} : \sqrt{u-v}.$

Or

Referring to the diagram,



FBD of m_1 gives, $T - m_1 g = m_1 a$

FBD of m_2 gives $T_1 + m_2 g - T = m_2 a$

FBD of m_3 gives $m_3 g - T_1 = m_3 a$

Eliminating T *and* a from the above equations, we get

$T_1 = \frac{2m_1 m_3}{m_1 + m_2 + m_3} . g.$

21. Let, $\vec{A} = 3\hat{\imath} + \hat{\jmath} + 2\hat{k}$ and $\vec{B} = \hat{\imath} - 3\hat{\jmath} + 4\hat{k}$. Then sides will be, $\vec{A} + \vec{B}$ and $\vec{A} - \vec{B}$. Then the sides are, $4\hat{\imath} - 2\hat{\jmath} + 6\hat{k}$ and $2\hat{\imath} + 4\hat{\jmath} - 2\hat{k}$. Then the area of the parallelogram will be – $\left|(\vec{A} + \vec{B}) \times (\vec{A} - \vec{B})\right|$

$$= \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ 4 & -2 & 6 \\ 2 & 4 & -2 \end{vmatrix} = \left|-20\hat{\imath} + 26\hat{\jmath} + 20\hat{k}\right| = \sqrt{400 + 676 + 400} = 38.42\ unit^2$$

Referring to the diagram, the equation of motion will be,

$mgSin\theta - \mu_k mgCos\theta = ma.$