Engineering Mechanics

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Homework 1

Problem 1

Determine the magnitude of the resultant force $\mathbf{F_R} = \mathbf{F_1} + \mathbf{F_2}$ and its direction, measured counterclockwise from the positive x axis.

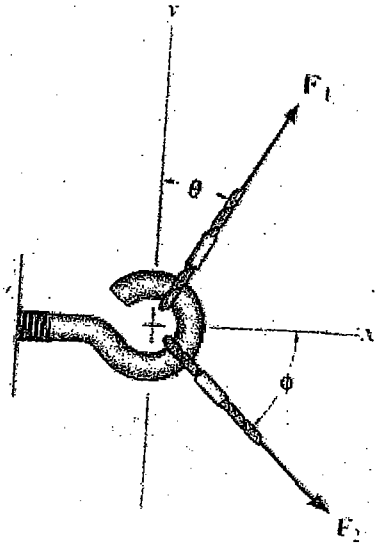
Given:

$F1 = 250$ N

$F2 = 375$ N

$\theta = 30°$

$\varphi = 45°$



Problem 2

Determine the magnitude of the resultant force $F_R = F_1 + F_2$ and its direction measured counterclockwise from the positive u axis.

Given:

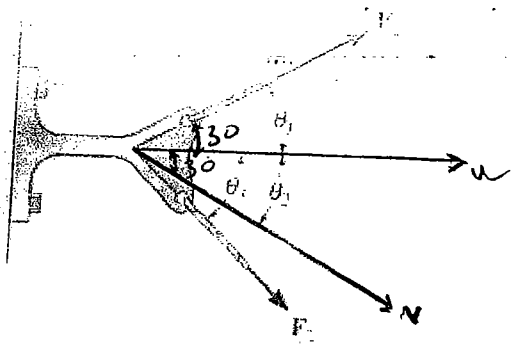
$F1 = 25$ N

$F2 = 50$ N

$\theta_1 = 30°$

$\theta_2 = 30°$

$\theta_3 = 45°$



Problem 3

Determine the components of the **F** force acting along the u and v axes.

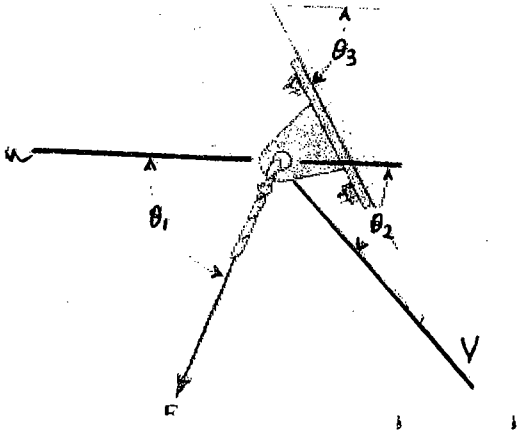
Given:

$\theta_1 = 70°$

$\theta_2 = 45°$

$\theta_3 = 60°$

$F = 250$ N



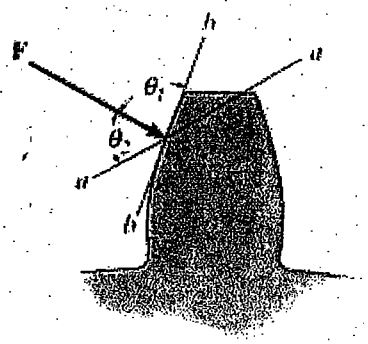
Problem 4

The component of force **F** acting along line *aa* is required to be *30 N*. Determine the magnitude of **F** and its component along line *bb*.

Given:

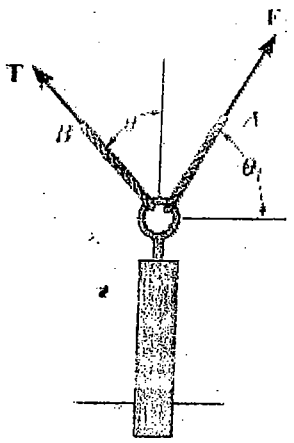
$\theta_1 = 80°$

$\theta_2 = 60°$



Problem 5

The post is to be pulled out of the ground using two ropes *A* and *B*. Rope *A* is subjected to force of *600 N* and is directed at angle $\theta_1 = 60°$ from the horizontal. If the resultant force acting on the post is to be *1200 N*, vertically upward, determine the force **T** in rope *B* and the corresponding angle θ.



Homework 1

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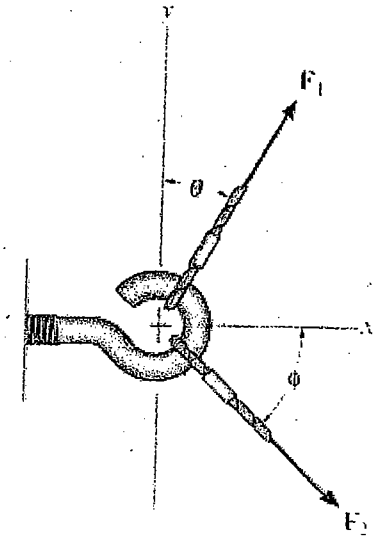

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Determine the magnitude of the resultant force $\mathbf{F_R} = \mathbf{F_1} + \mathbf{F_2}$ and its direction measured counterclockwise from the positive u axis.
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$F1 = 25$ N

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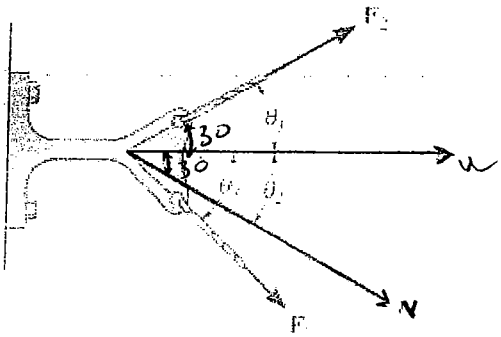

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Determine the components of the F force acting along the u and v axes.
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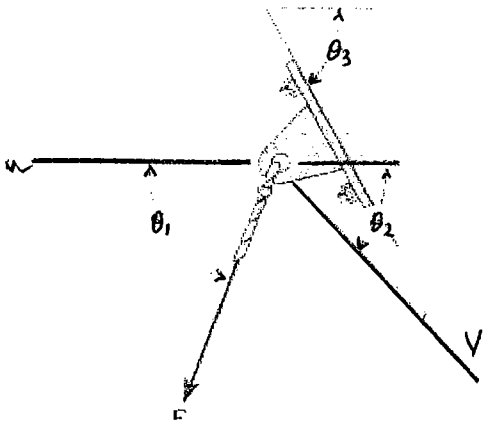
$F = 250$ N



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The component of force **F** acting along line *aa* is required to be *30 N*. Determine the magnitude of **F** and its component along line *bb*.

Given:

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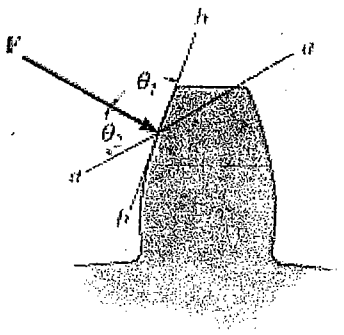

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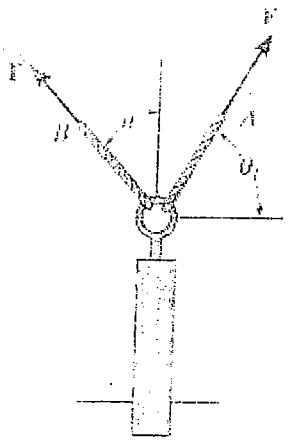
The post is to be pulled out of the ground using two ropes *A* and *B*. Rope *A* is subjected to force of *600 N* and is directed at angle $\theta_1 = 60°$ from the horizontal. If the resultant force acting on the post is to be *1200 N*, vertically upward, determine the force **T** in rope *B* and the corresponding angle θ.



Homework 2

Problem 1
Determine the magnitude of the resultant force and its direction, measured counterclockwise from the positive x axis.
Given:

$F1 = 850$ N

$F2 = 625$ N

$F3 = 750$ N

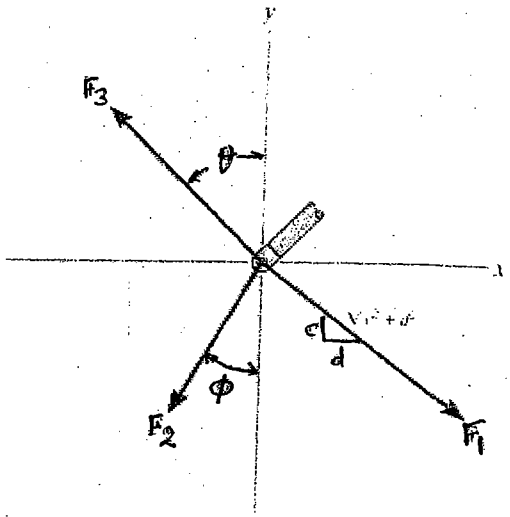
$\theta = 45°$

$\varphi = 30°$

$c = 3$

$d = 4$

ANS:
$F_R = 546$ N
$\beta = 252.6°$



Problem 2
Three forces act on the bracket. Determine the magnitude and direction θ of **F1** so that the resultant force is directed along the positive x' axis and has a magnitude of **1KN**.
Given:

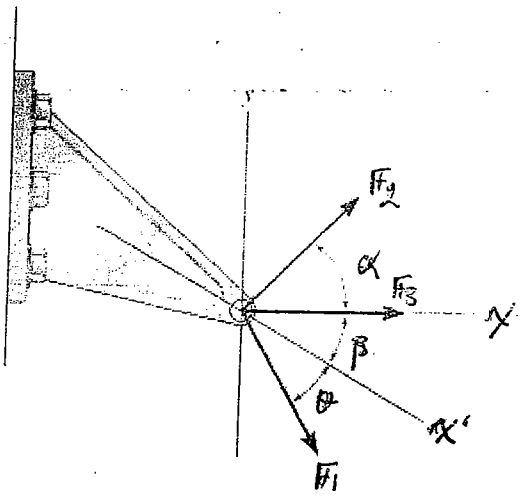
$F2 = 450$ N

$F3 = 200$ N

$\alpha = 45°$

$\beta = 30°$

ANS:
$F_1 = 838$ N
$\theta = 37°$



Problem 3
Determine the magnitude and direction, measured counterclockwise from the positive x' axis, of the resultant force of the three forces acting on the bracket.
Given:

$F1 = 300$ N

$F2 = 200$ N

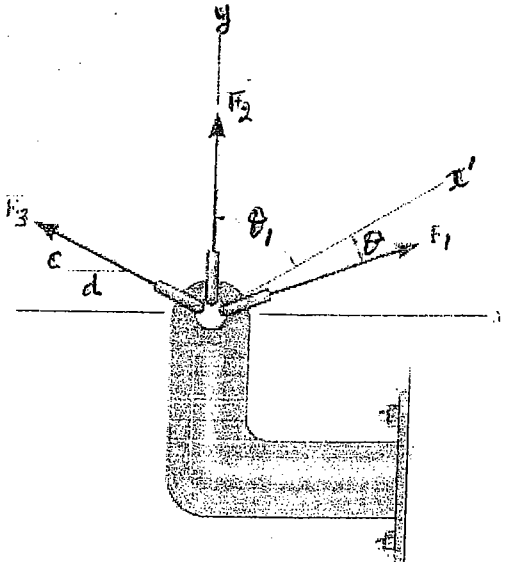
$F_3 = 180$ N

$\theta = 10°$

$\theta_1 = 60°$

$c = 5$ $d = 12$

ANS: $F_R = 389$ N
$\phi = 72.7°$ $\psi = 42.7°$

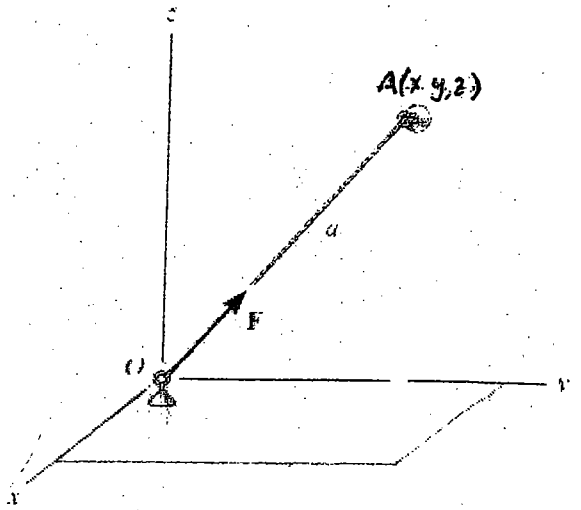


Homework 3

Problem 1

The cable *OA* exerts force $\mathbf{F} = \{40\mathbf{i} + 60\mathbf{j} + 70\mathbf{k}\}$ N on point *O*. If the length of the cable is $L = 3m$, what are the coordinates (x, y, z) of point *A*?

ANS: (1.2 , 1.8 , 2.1)



Problem 2

Determine the position $(x, y, 0)$ for fixing cable *BA* so that the resultant of the forces exerted on the pole is directed along its axis, from *B* toward *O*, and has magnitude of 1 kN. Also, what is the magnitude of force F_3?

Given:

$F1 = 500$ N

$F2 = 400$ N

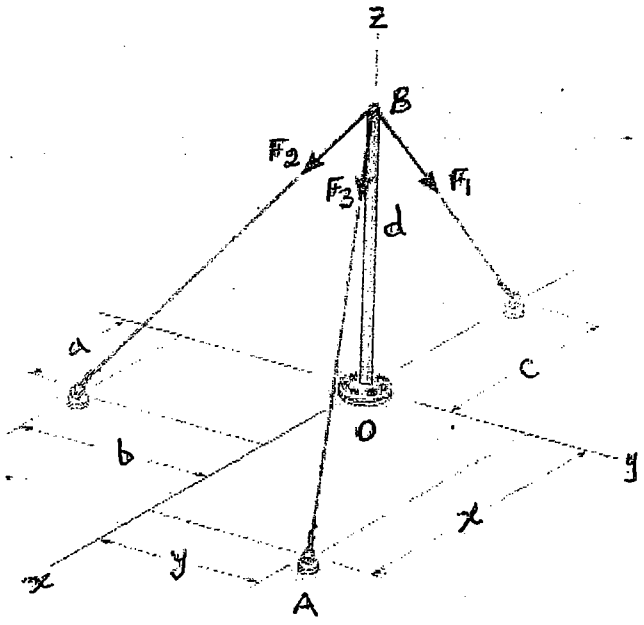
$a = 1$ m

$b = 2$ m

$c = 2$ m

$d = 3$ m

ANS: $F_3 = 380$ N



Homework 4

Problem 1

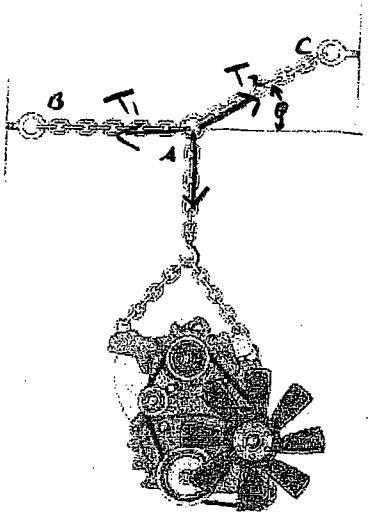
Determine the maximum weight of the engine that can be supported without exceeding a tension of T1 in chain *AB* and T2 in chain *AC*.

Given:

θ = 30°

T_1 = ~~4.5 kN~~ 450 N

T_2 = ~~4.8 kN~~ 480 N



ANS: W = 240 N

Problem 2

The unstretched length of spring *AB* is δ= 2m. If the block is held in the equilibrium position shown, determine the mass of the block at *D*.

Given:

a = 3 m

b = 3 m

c =4 m

k_{AB} = 30 N/m

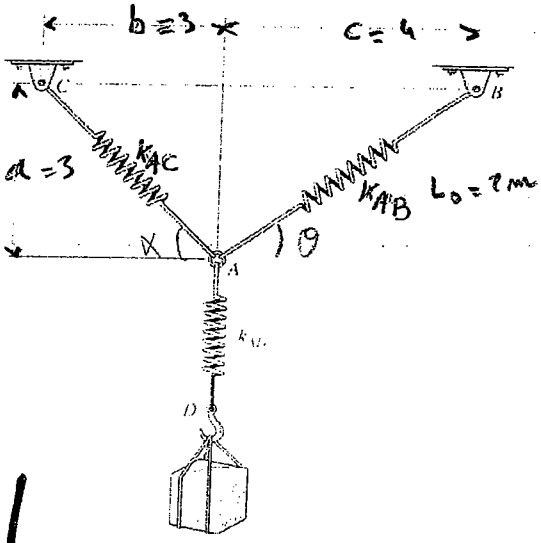
k_{AC} = 20 N/m

k_{AD} = 40 N/m

ANS.

$F_{AC} = 101.8$ N

$m_D = 12.8$ kg



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Problem 3

Determine the force in each cable and the force **F** needed to hold the lamp of mass *M* in the position shown. *Hint:* First analyze the equilibrium at *B*; then, using the result for the force in *BC*, analyze the equilibrium at *C*.

Given:

M = 4 kg

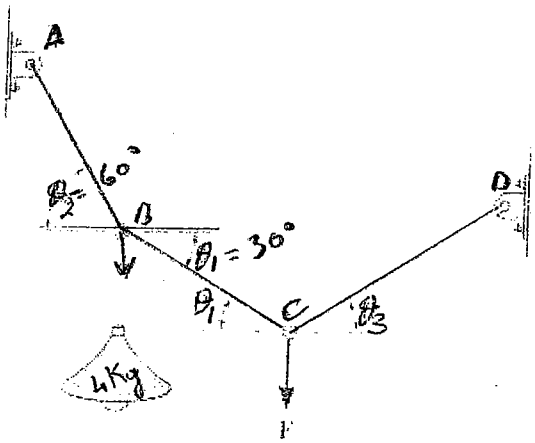
θ_1 = 30°

θ_2 = 60°

ANS:

$T_{CD} = 39.24$ N

$F = 39.24$ N



$\theta_3 = 30°$

Problem 4

The 30-kg block is supported by two springs having the stiffness shown. Determine the unstretched length of each spring.

Given:

$M = 30$ kg

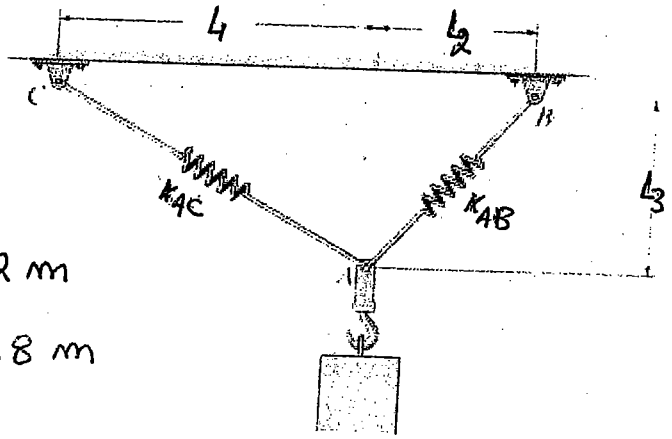
$l_1 = 0.6$ m

$l_2 = 0.4$ m

$l_3 = 0.5$ m

$k_{AC} = 1.5$ kN/m

$k_{AB} = 1.2$ kN/m



ANS:

$L_{AB} = 0.452$ m

$L_{AC} = 0.658$ m

Problem 5

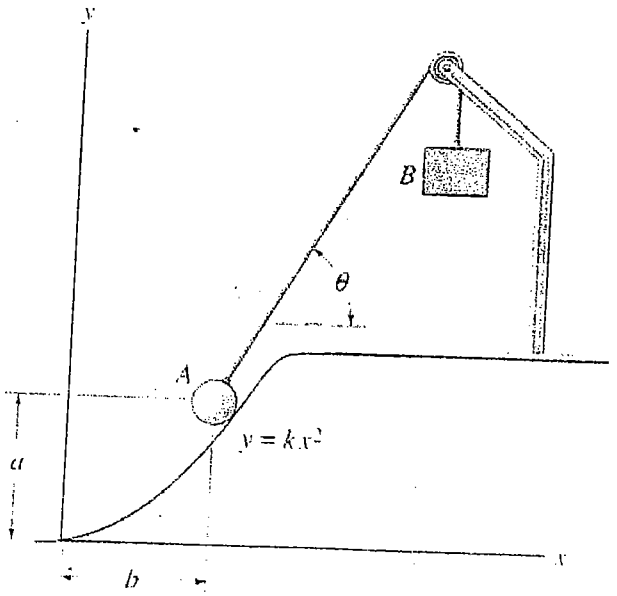
A 4-kg sphere rests on the smooth parabolic surface. Determine the normal force it exerts on the surface and the mass m_B of block B needed to hold it in the equilibrium position shown.

Given:

$a = 0.4$ m

$b = 0.4$ m

$\theta = 60°$



ANS. $F_N = 19.66$ N

$m_B = 3.58$ kg

Homework 5

Problem 1

Determine the magnitude and directional sense of the resultant moment of the forces at *A* and *B* about point *P*.

Given:

F_1 = 40 kN

F_2 = 60 kN

θ_1 = 30°

θ_2 = 45°

a = 5 m

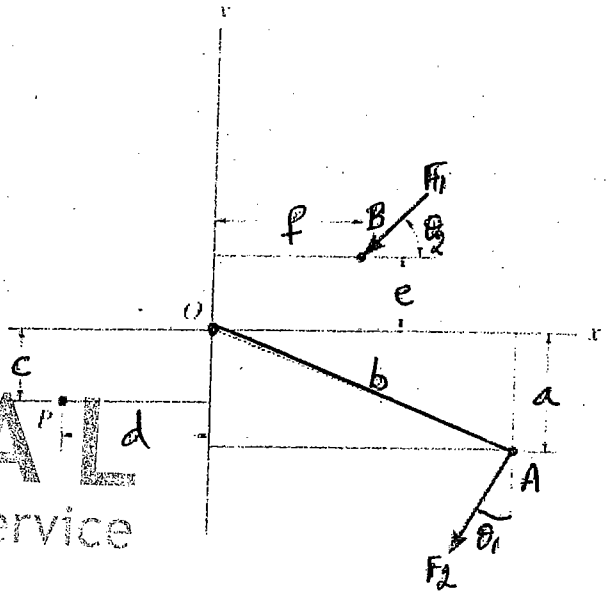
b = 13 m

c = 3 m

e = 3 m

d = 6 m

f = 6 m



Problem 2

Determine the angle θ (0 <= θ <= 90 deg) so that the force **F** = 100N develops a clockwise moment *M = 20 N.m* about point *O*.

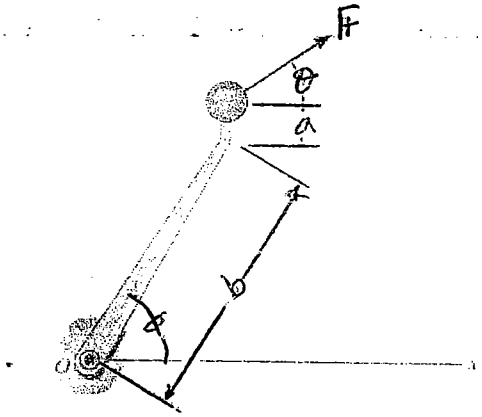
Given:

φ = 60°

b = 300 mm

a = 50 mm

ANS: θ = 28.6°



Problem 3

Determine the magnitude and directional sense of the moment of the forces about point *P*.

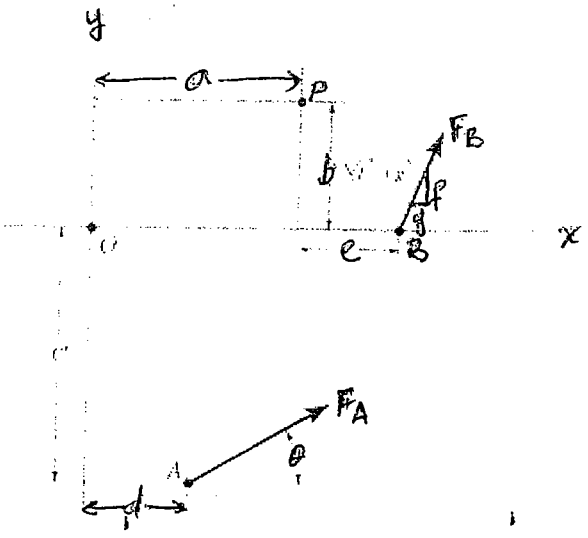
Given:

FA = 400 N

FB = 260 N

θ = 30°

a = 4 m



$b = 3$ m

$c = 5$ m

$d = 2$ m

$e = 2$ m

$f = 12$

$g = 5$

ANS: $M_o = 3.57$ (positive C.C.W)

Problem 4

A force **F** = 40N is applied to the wrench. Determine the moment of this force about point *O*. Solve the problem using both a scalar analysis and a vector analysis.

Given:

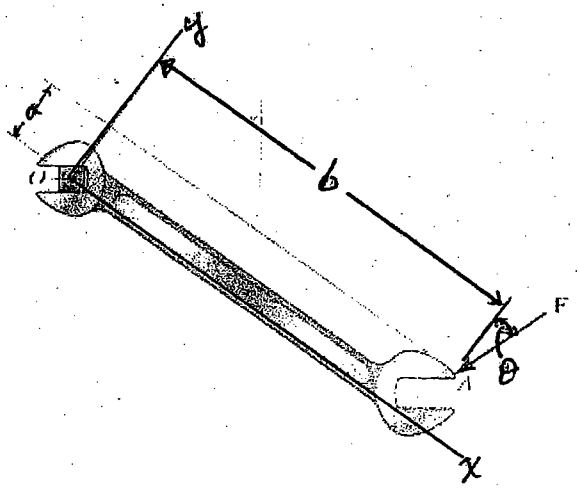
$F = 40$ N

$\theta = 20°$

$a = 30$ mm

$b = 200$ mm

ANS: $|M_o| = 7.11$ Nm



Problem 5

Determine the direction θ ($0° \le \theta \le 180°$) of the force **F** = 200 N so that it produces (a) the maximum moment about point *A* and (b) the minimum moment about point *A*. Compute the moment in each case.

Given:

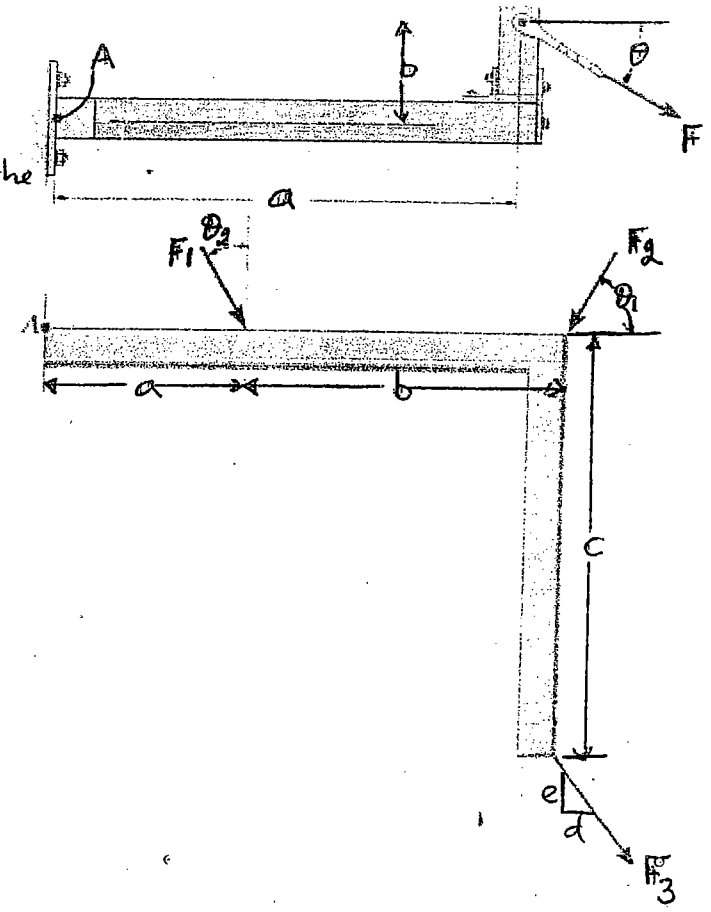
$a = 2.0$ m

$b = 0.5$ m

Max. moment occurs when the force is ⊥ to the line between A and the point of application of the force.

$M_{max} = F\sqrt{a^2+b^2}$

$\theta = 90 - \tan^{-1}\left(\frac{200}{30}\right)$



Problem 6

If the resultant moment about point *A* is *M = 4800 N.m* clockwise, determine the magnitude of **F**3 if

F1 = 300 N and *F2* = 400 N.

Given:

$\theta_1 = 60°$ $\quad a = 2m$ $\quad c = 4m$

$\theta_2 = 30°$ $\quad b = 3m$ $\quad d = 3$

$e = 4$

Homework 6

Problem 1
Replace the force at *A* by an equivalent force and couple moment at point *P*.
Given:

F = 375 N

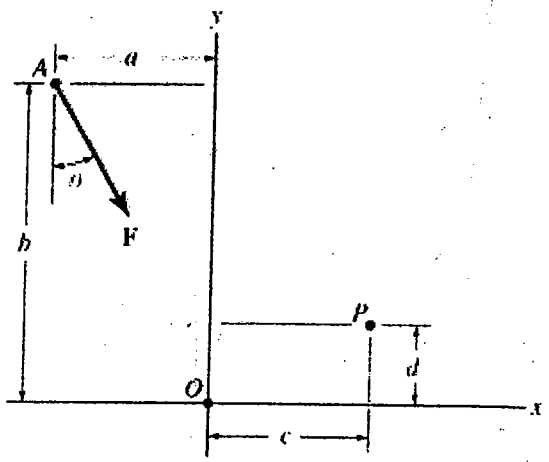
a = 2 m

b = 4 m

c = 2 m

d = 1 m

θ = 30 °



Problem 2
Replace the force system by an equivalent resultant force and couple moment at point *P*.
Given:

F1 = 60 kN

F2 = 85 kN

F3 = 25 kN

θ = 45 °

a = 2 m

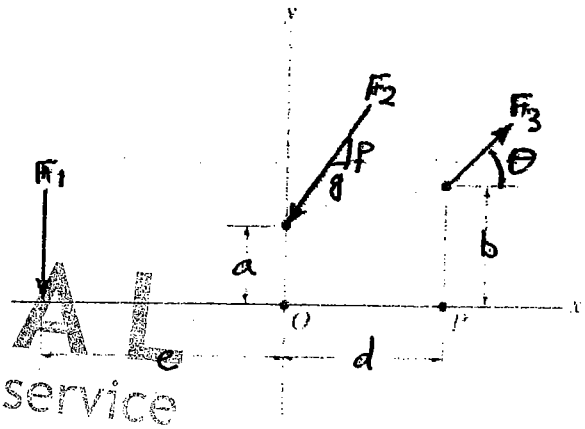
b = 3 m

c = 6 m

d = 4 m

e = 3

f = 4



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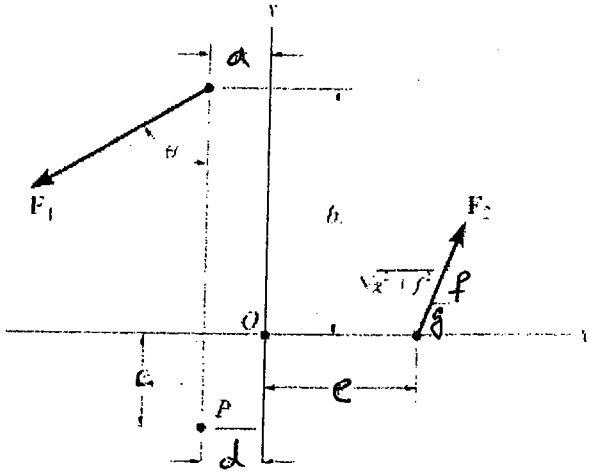
Replace the force system by an equivalent force and couple moment at point *P*.
Given:

F1 = 430 kN

F2 = 260 kN

θ = 60 °



$a = 2$ m

$b = 8$ m

$c = 3$ m

$d = a$

$e = 5$ m

$f = 12$

$g = 5$

Problem 4

Replace the loading system acting on the post by an equivalent resultant force and couple moment at point *P*.

Given:

F1 = 30 kN

F2 = 40 kN

F3 = 60 kN

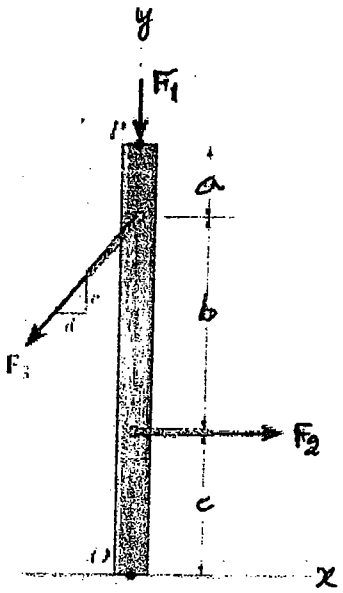
$a = 1$ m

$b = 3$ m

$c = 2$ m

$d = 3$

$e = 4$



Problem 5

Replace the loading on the frame by a single resultant force. Specify where the force acts , measured from end *A*.

Given:

F1 = 450 N $\theta = 60°$

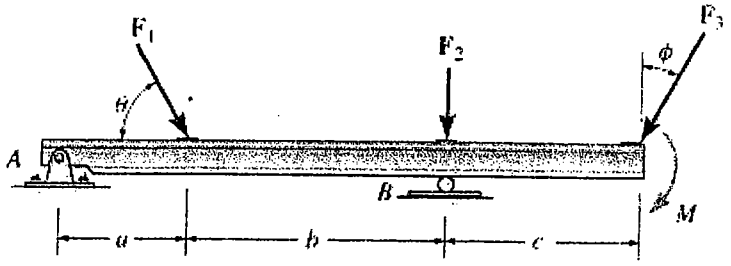
F2 = 300 N $M = 1500$ Nm

F3 = 700 N $\varphi = 30°$

$a = 2$ m

$b = 4$ m

$c = 3$ m



Homework 7

Problem 1
Determine the magnitude of the reactions on the beam at *A* and *B*. Neglect the thickness of the beam.
Given:

F1 = 600 N

F2 = 400 N

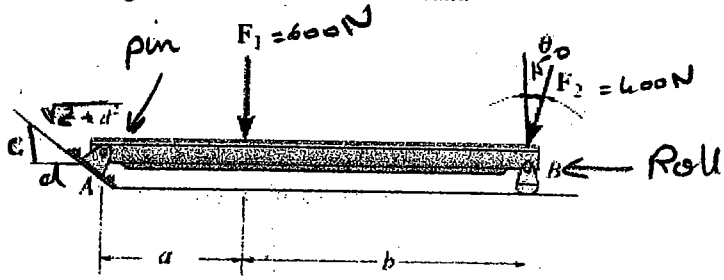
θ = 15°

a = 4 m

b = 8 m

c = 3

d = 4



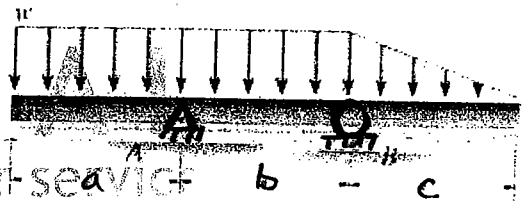
Problem 2
Determine the reactions at the supports.
Given:

w = 250 kN/m

a = 6 m

b = 6 m

c = 6 m



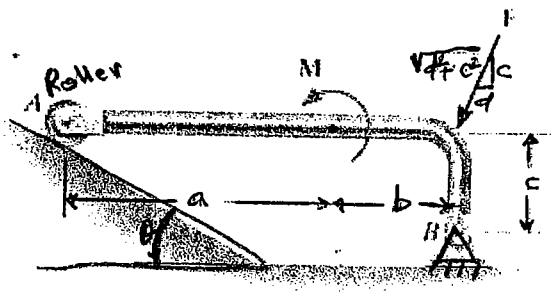
Problem 3
Determine the reactions at the roller *A* and pin *B*.
Given:

M = 800 kN.m *c* = 3 m

F = 390 kN *d* = 5

a = 8 m *e* = 12

b = 4 m θ = 30°

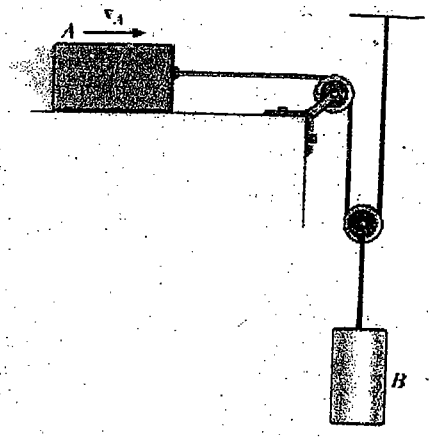


Energie and work

Problem 1

The block A of weight $W_A = 20N$ (≈2kg) rests on a surface for which the coefficient of kinetic friction is $\mu k = 0.3$. Determine the distance the cylinder B of weight $W_B = 50M$ (≈5kg) must descend so that A has a speed $V_A = 2$ m/s starting from rest.

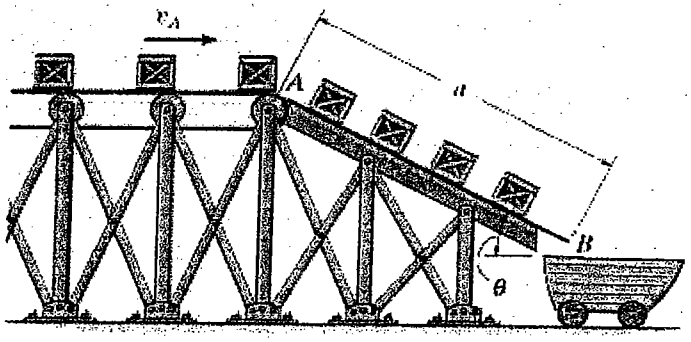
(Ans:)



Problem 2

The conveyor belt delivers crate each of mass $M = 12$ kg to the ramp at *A* such that the crate's velocity is $V_A = 2.5$ m/s, directed down *along* the ramp. If the coefficient of kinetic friction between each crate and the ramp is $\mu_k = 0.3$, determine the speed at which each crate slides off the ramp at *B*. Assume that no tipping occurs. Given a = 3m, θ=30°.

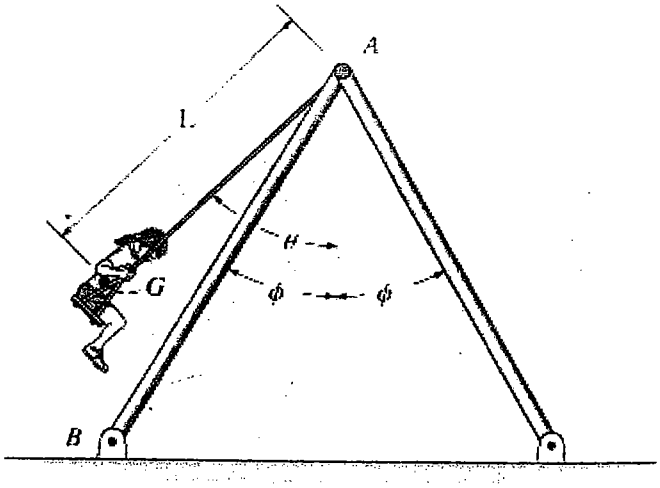
(Ans: $V_B = 4.52$ m/s)



Problem 3

The girl has mass M = 40 kg and center of mass at G. If she is swinging to a maximum height defined by θ = 60°. Determine the force developed along each of the four supporting posts such as AB at the instant θ = 0°. The swing is centrally located between the posts. Given:ϕ = 30°, L = 2 m.

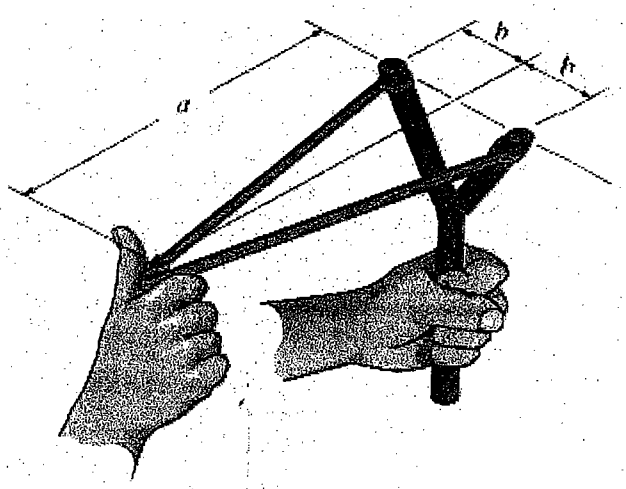
(Ans: $F_{AB} = 226.552$ N)



Problem 4

Each of the two elastic rubber bands of the slingshot has an unstretched length l = 200 mm. If they are pulled back to the position shown and released from rest, determine the maximum height the pellet of mass M = 25 g will reach if it is fired vertically upward. Neglect the mass of the rubber bands and the change in elevation of the pellet while it is constrained by the rubber bands. Each rubber band has a stiffness k = 50N/m. Given: a = 240 mm, b = 50 mm.

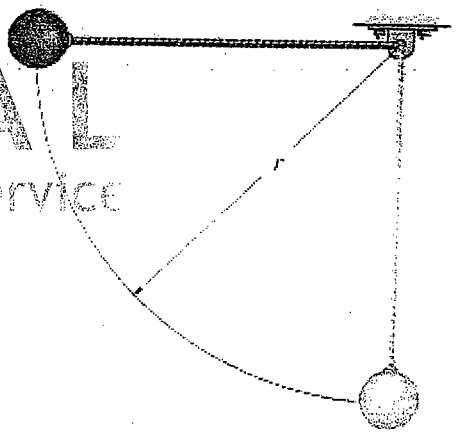
(Ans: h = 416mm)



Problem 5

The bob of the pendulum has a mass M = 0.2 kg and is released from rest when it is in the horizontal position shown. Determine its speed and the tension in the cord at the instant the bob passes through its lowest position. Given: r = 0.75 m

(Ans: V2 = 3.84 m/s , T = 5.89 N)



Problem 4

$$T_1 + V_1 = T_2 + V_2$$

$$\Delta L = \sqrt{(240)^2 + (50)^2} - 200 = 45.15 \text{ m}$$

$$2\left[\frac{1}{2}(50)(45.15 \times 10^{-3})^2\right] = 25 \times 10^{-3} \times 9.81\, h$$

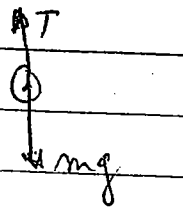
$$h = 4.16 \text{ m}$$

Problem 5

$$T_1 + V_1 = T_2 + V_2$$

$$0 + 0 = \frac{1}{2} m v_2^2 - mgL$$

$$v_2 = \sqrt{2gL} = 3.84 \text{ m/s}$$



$$\Sigma F_n = m a_n$$

$$T - mg = m\frac{v_2^2}{L}$$

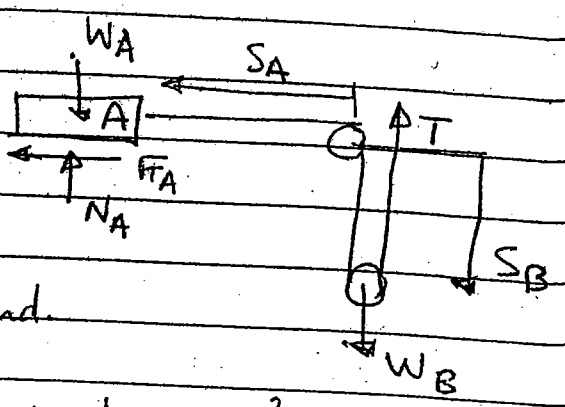
$$T = m\left(g + \frac{v_2^2}{L}\right) = 5.89 \text{ N}$$

Problem 1

$S_A + 2S_B = L$

$v_A = -2v_B$

$T_1 + U_{1-2} = T_2$



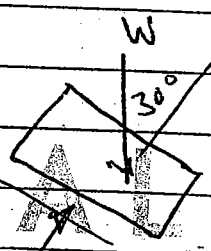
let d be the distance that W_B descend.

$$W_A d - 2W_B d\mu_K = \frac{1}{2} m_A v_A^2 + \frac{1}{2} m_B v_B^2$$

$$50d - (0.2)(20)(2)d = \frac{1}{2}(2)(2)^2 + \frac{1}{2}(5)\left(\frac{v_A}{2}\right)^2$$

$$d = 0.15\ m$$

Problem 2



$$\frac{1}{2} m v_A^2 + mg(3\sin 30) - \mu_k N(3) = \frac{1}{2} m v_B^2$$

$N = W\cos 30°$

$v_A = 2.5\ m/s$

Solve for $v_B = 4.52\ m/s$

Problem 3

$T_1 + V_1 = T_2 + V_2$

$0 - mgL\cos 60 = \frac{1}{2} m v^2 - mgL \Rightarrow v = 4.429\ m/s$

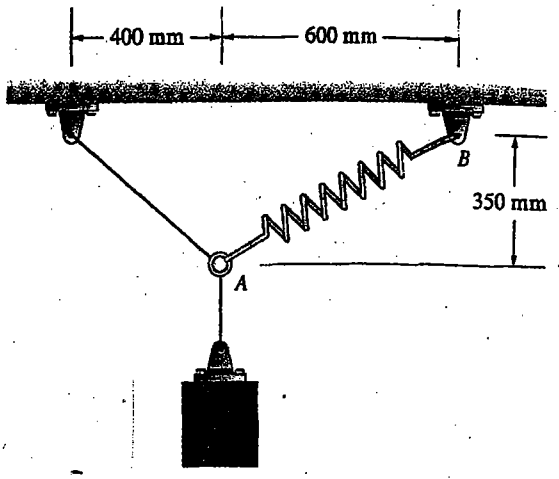
$\Sigma F = m\bar{a}$ $\left(a = \frac{v^2}{L}\right)$

$T - mg = m\left(\frac{v^2}{L}\right) \Rightarrow T = mg + m\frac{v^2}{L} = 784.8\ N$

$4F_{AB}\cos\phi - T = 0 \Rightarrow F_{AB} = \frac{T}{4\cos 20} = 226.552\ N$

GNE212 **November 20, 2009**
Test1

Problem 1 (30 points)

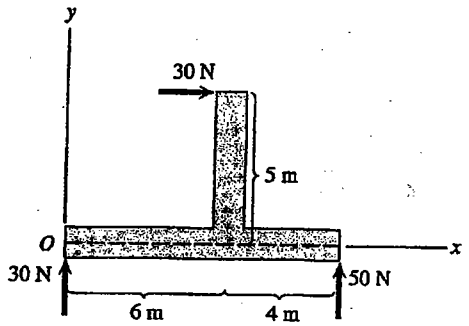


The unstretched length of the spring AB is 660 mm, and the spring constant k = 1000 N/m. What is the mass of the suspended object?

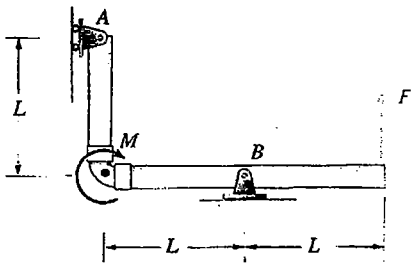
Problem 2 (28 points)

Reduce the system of forces by:

1. A single force F and a couple M at point O.
2. A single force. Where does the line of action of the force intersects the x-axis.



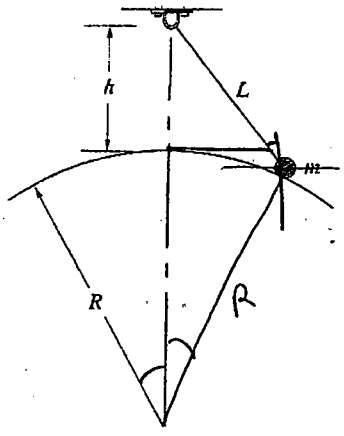
Problem 3 (28 points)



The beam is supported by a roller at A and pin at B. If F = 800 N, M = 200 N-m and L = 2 m. What are the reactions at A and B?

Problem 4 (14 points)

The small sphere of mass m is attached to a string of length L and rest on a smooth surface of a sphere of radius R. Determine the tension in the string in terms of m, L ,h and R.



If it takes a force **F** to pull the nail out, determine the smallest vertical force **P** that must be applied to the handle of the crowbar. *Hint:* This requires the moment of **F** about point *A* to be equal to the moment of **P** about *A*. Why?

Given:

F = 125 lb

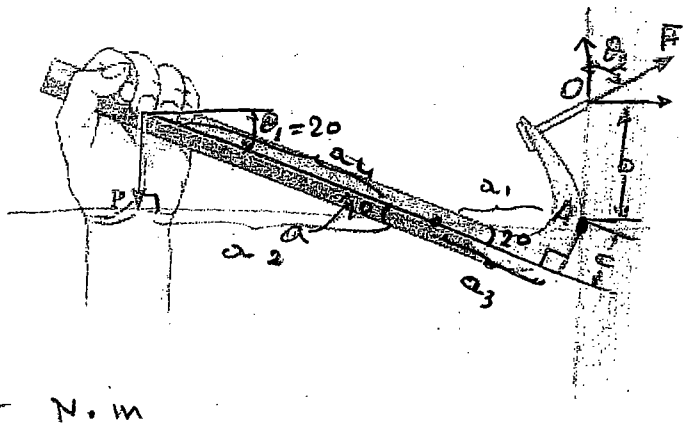
a = 14 in

b = 3 in

c = 1.5 in

θ_1 = 20 deg

θ_2 = 60 deg



$M_F = (F \cos 30)(3) = 324.75$ N·m

$M_P = (P \sin \theta_1)(d) =$

$d = a_1 + a_2$

$\cos 70 = \frac{c}{a_1} \rightarrow a_1 = \frac{c}{\cos 70}$

$\sin 70 = \frac{a_3}{c} \rightarrow a_3 = c \sin 70$

$a_4 = a - a_3$

$\cos 20 = \frac{a_2}{a_4} \rightarrow a_2 = a_4 \cos 20$

$M_F = M_P \Rightarrow P = 24.26$ lb

SOCIAL

#2

The force F acts on the end of the pipe at *B*. Determine (a) the moment of this force about point *A*, and (b) the magnitude and direction of a horizantal force, applied at *C*, which produces the same moment.

Given:

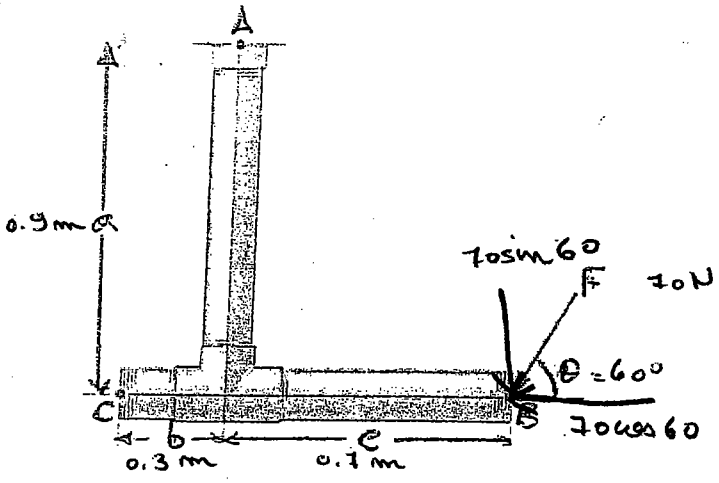
F = 70 N

a = 0.9 m

b = 0.3 m

c = 0.7 m

θ = 60 deg



a) Find the Moment about A:

$(70\cos 60)(0.9) \downarrow + (70\sin 60)(0.7) = 73.9\ N.m \curvearrowleft$

$M_A = 73.9\ N.m \downarrow$

b) The magnitude and direct°:

$(F_c)(0.9) = 73.9 \longrightarrow F_c = \frac{73.9}{0.9} = 82.2\ N$

Given: Find M_A??

F = 52 lb

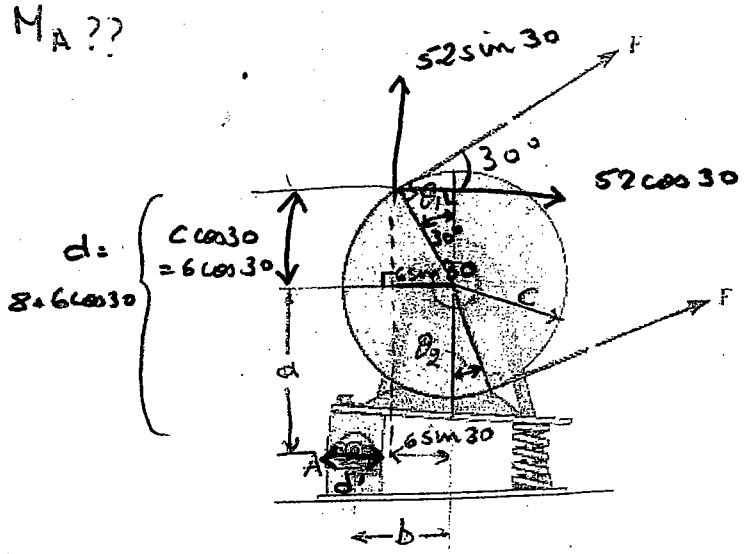
a = 8 in

b = 5 in

c = 6 in

θ_1 = 30 deg

θ_2 = 20 deg



$d = 8 + 6\cos 30$

$\zeta+$ $d' = b - 6\sin 30 = 5 - 6\sin 30$

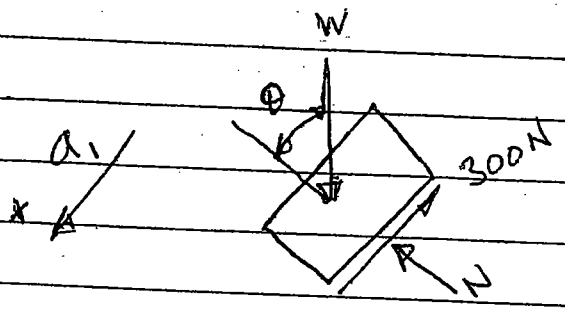
$M_1 = (52\sin 30)(5 - 6\sin 30) - (52\cos 30)(8 + 6\cos 30) = -542$ lb

$= 542$ lb ↓

$M_2 = -10$ lb ↓

Total Moment : $542 - 10 = 532$ lb in ↓

Problem 1



$\Sigma F = m a_1$

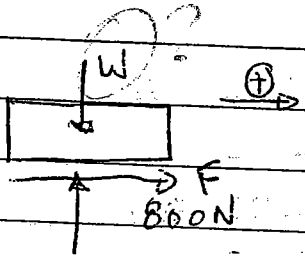
$W \sin\theta - 300 = 800\, a_1$ — mem eja a ? b ?

$a_1 = [8000 \sin 45 - 300]/800 \Rightarrow a_1 = 6.69\ m/s^2$

Kinematics! $S_1 = \sqrt{a^2+b^2} = 28.28\ m$

$v_1^2 = 2 a_1 S_1 = 2(6.69)(28.28) = 19.45\ m/s$

In water:



Is it a Formula ?

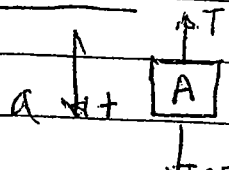
y we used the valu of m but we didn't use weight it's

$800 = m a_2 \Rightarrow a_2 = \frac{800}{800} = 1\ m/s^2$ →

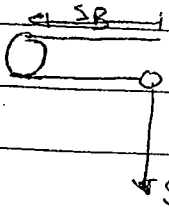
$v_2^2 - v_1^2 = 2 a_2 S_2$

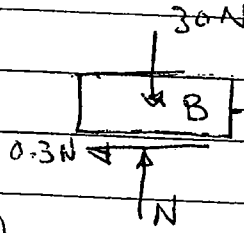
$v_2^2 = (19.45)^2 + 2(1)(1) \Rightarrow v_2 = 19.2\ m/s$

Problem 2



$25 - T = 2.5 a_A$ (1)





$\Sigma F_x = m a_B$

$-2T + 0.3N = 3 a_B$ (2)

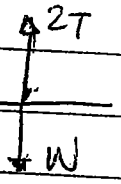
$\Sigma F_y = 0 \Rightarrow N = 30\ N$

$S_A + 2S_B = L \Rightarrow a_A = -2 a_B$ (3)

Solve (1), (2), and (3) $a_A = 6.30\ m/s^2$

$v = v_0 + at = 1 + (6.30)(2) = 13.4\ m/s$

Problem 3



① $2T - W = 0 \Rightarrow T = \frac{W}{2} = 200\ N$

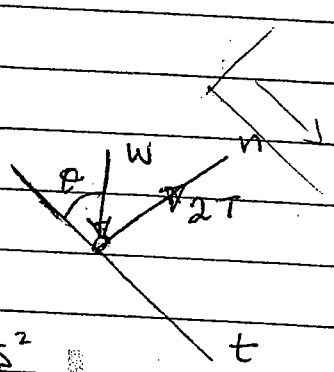
② $2T - W = ma \qquad a = \frac{dv}{dt} = \frac{d}{dt}(1.2t^2) = 2.4t$

$t = 25 \quad a = 4.8\ m/s^2$

$2T - 400 = (40)(4.8)$

$T = 296\ N$

Problem 4



$\Sigma F_t = ma_t$

$mg\cos\theta = ma_t$

$a_t = g\cos\theta = g\cos 60 = 4.905\ m/s^2$

$F_n = ma_n$

$2T - mg\sin 60 = \frac{mv^2}{r}$

$2T = 300\sin 60 + \frac{(30)(9)}{3} \Rightarrow T = 175\ N$

Problem 5

Limiting case $N = 0$

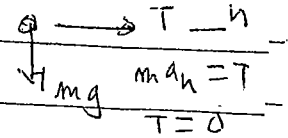
$\Sigma F_n = ma_n$

$mg = \frac{mv^2}{r} \Rightarrow v = \sqrt{rg} = \sqrt{100 \times 10} \simeq 31.3\ m/s$

Problem 6

Initial Tension: $T = 0, \quad v = 0, \quad a_n = 0$

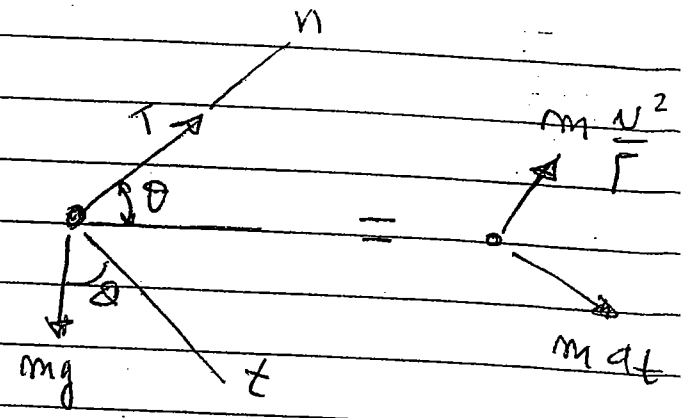
Point D:



$\Sigma F_n = m a_n$

$T - mg\sin 45 = m\frac{v^2}{r}$

$\Sigma F_t = m a_t$



$mg\cos 45 = m a_t \Rightarrow a_t = g\cos 45 = 6.937\ m/s^2$

Having:

$$v\frac{dv}{ds} = g\cos\theta \Rightarrow \int_0^v v\,dv = \int_0^{45^\circ} (g\cos\theta)\underbrace{2\,d\theta}_{ds = r\,d\theta}$$

$$\frac{v^2}{2} = 2g\sin\theta\Big|_0^{45} \Rightarrow v = 5.26\ m/s$$

$$T = mg\sin 45 + m\frac{(5.26)^2}{2} = 104\ N$$

Homework

Problem 1

Traveling with an initial speed *of 70km/h,* a car accelerates at 6000km/hr^2 along a straight road. How long will it take to reach a speed of *120km/h*? Also, through what distance does the car travel during this time?

Problem 2

The position of a particle along a straight line is given by $s = (0.3t^3 + -2.7t^2 + 4.5t)$ where t is in seconds. Determine its maximum acceleration and maximum velocity during the time interval $0 \leq t \leq 10$s.

Problem 3

A particle is moving along a straight line such that its acceleration is defined as $a = (-2v)$ m/s^2, where v is in meter per seconds .If v =20m/s when $s = 0$ and $t = 0$, determine the particle's velocity as a function of position and the distance the particle moves before it stops.

Problem 4

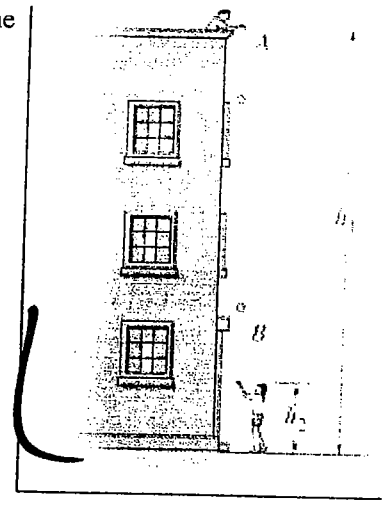
The acceleration of a particle as it moves along a straight line is given by $a = (2t - 1)$ m/s^2, where t is in seconds. If $s = 1m$ *and* v =2m/s *when* $t = 0$, determine the particle's velocity and position when $t = 6s$. Also, determine the total distance the particle travels during this time period.

Problem 5

Two particles *A* and *B* start from rest at the origin $s = 0$ and move along a straight line such that $a_A = (6t-3)$ and $a_B = (12t^2-6)$, where t is in seconds. Determine the distance between them at $t=4s$ and the total distance each has traveled in time $t=4s$.

Problem 6

Ball *A* is released from rest at a height of 12m at the same time that a second ball B is thrown upward 1.5m from the ground. If the balls pass one another at a height of 6m, determine the speed at which ball *B* was thrown upward..

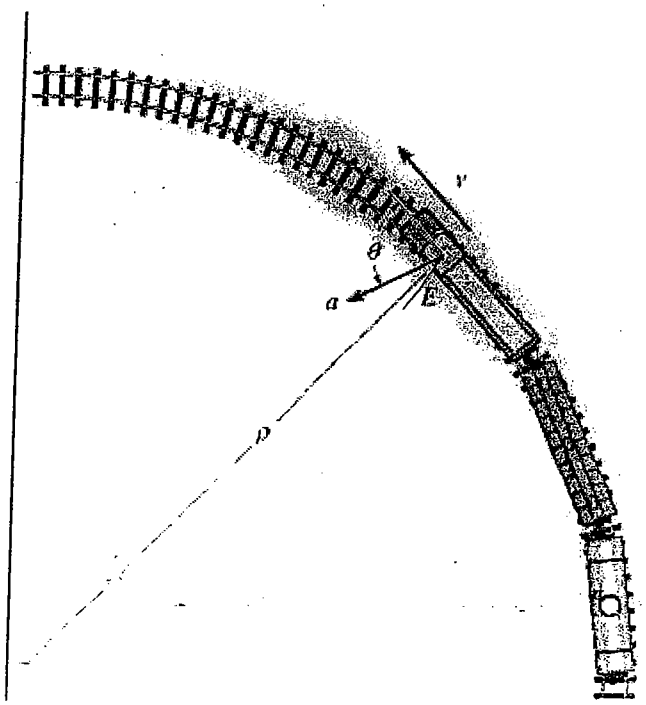


Problem 7

A particle *P* moves along the curve $y = (x^2 - 4)$ with a constant speed *of 5m/s*. Determine the point on the curve where the maximum magnitude of acceleration occurs and compute its value.

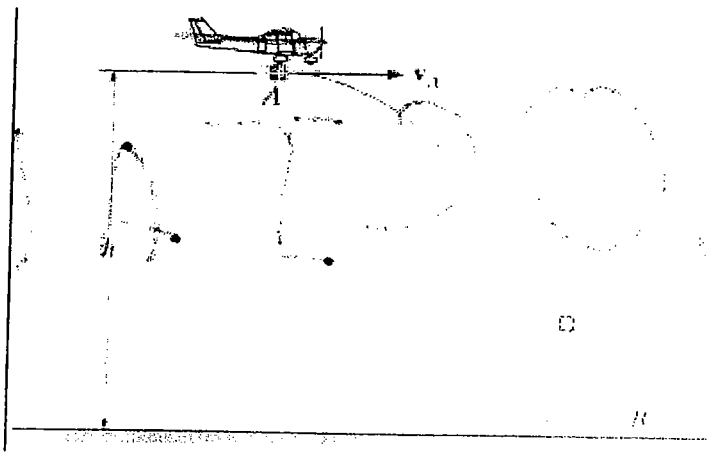
Problem 8

At a given instant the train engine at E has a speed *of 20m/s* and an acceleration of $14 m/s^2$ acting in the direction shown. Determine the rate of increase in the train's speed and the radius of curvature ρ of the path. The angle between a and v is equal to 75 degree



Problem 9

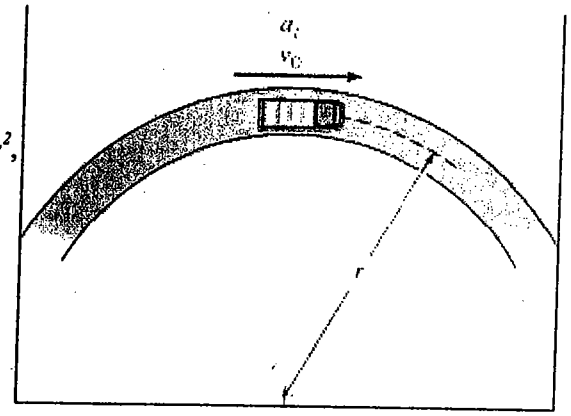
A package is dropped from the plane which is flying with a constant horizontal velocity $v_A = 50m/s$. Determine the normal and tangential components of acceleration and the radius of curvature of the path of motion (a) at the moment the package is released at A, where it has a horizontal velocity $v_A = 50m/s$, and (b) *just before* it strikes the ground at B. With h =500m.



Problem 10

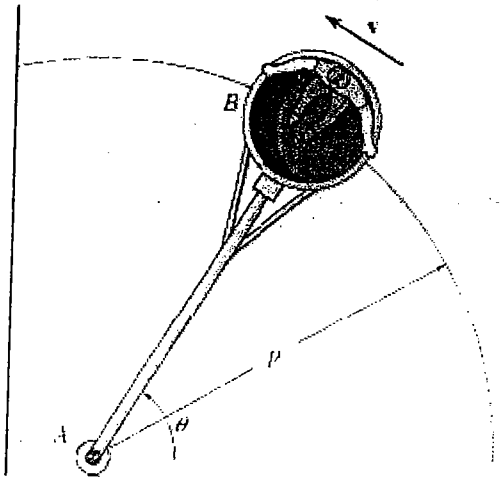
The truck travels in a circular path having a radius Of 50m at a speed of 4m/s. For a short distance from $s = 0$, its speed is increased by $a_t = (0.05s)\ m/s^2$, where s is in meters. Determine its speed and the magnitude of its acceleration when it has moved a distance s =10m.

Given r=50m



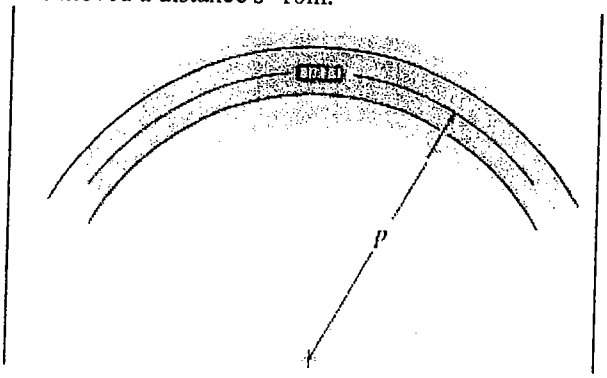
Problem 11

The car B turns such that its speed is increased by $dv_B/dt = (0.5e_r)m/s^2$, where t is in seconds. If the car starts from rest when $\theta = 0°$, determine the magnitudes of its velocity and acceleration when the arm AB rotates to $\theta = 30°$. Neglect the size of the car. Given: r=5m.



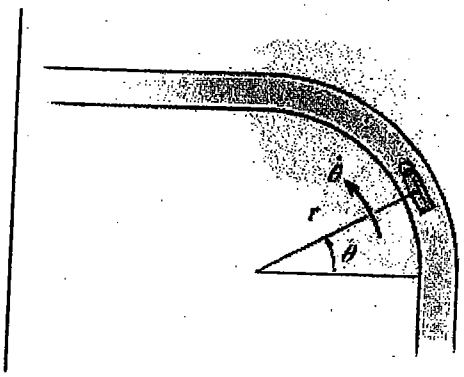
Problem 12

The truck travels at speed of 4m/s along a circular road that has radius of 50m. For a short distance from $s = 0$, its speed is then increased by $dv/dt = (0.05s)m/s^2$. Determine its speed and the magnitude of its acceleration when it has moved a distance s=10m.



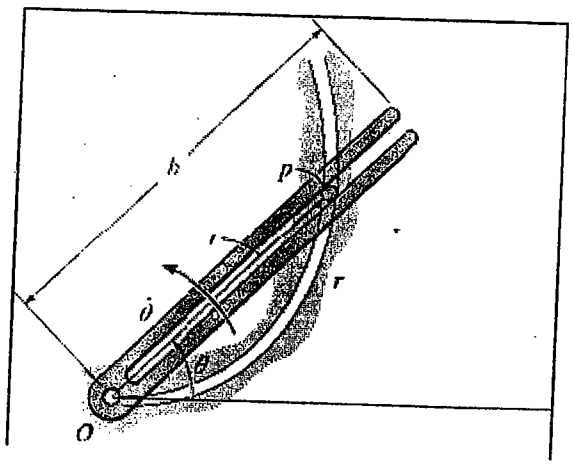
Problem 13

A truck is traveling along the horizontal circular curve of radius r=60m with speed of 20m/s which is increasing at the rate $3m/s^2$. Determine the truck's radial and transverse components of acceleration.



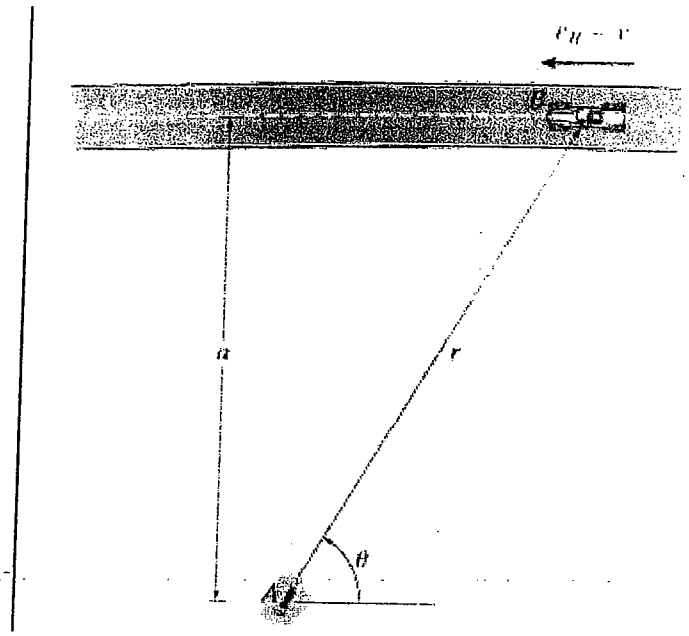
Problem 14

The slotted link is pinned at O, and as a result of the constant angular velocity $\theta' = 3rad/s$ it drives the peg P for a short distance along the spiral guide $r = 0.4\theta$ where θ is in radians. Determine the velocity and acceleration of the particle at the instant it leaves the slot in the link, i.e., when $r = 0.5$ m.



Problem 15

A cameraman standing at *A* is following the movement of a race car, *B*, which is traveling along a straight track at a constant speed 24m/s. Determine the angular rate at which he must turn in order to keep the camera directed on the car at the instant θ =60°. Given a=30m.



Dynamics Homework

Problem 1

$V_0 = 70\,km/h = \frac{70\times10^3}{3600} = 19.44\,m/s$

$a = \frac{6000\,km}{hr^2} = \frac{6000\times10^3}{(3600)^2} = 0.46\,m/s^2$

- $V = V_0 + at \Rightarrow v - v_0 = at$

$V_f = 120\,km/hr = \frac{120\times10^3}{3600} = 33.33\,m/s$

$\Rightarrow 33.33 - 19.44 = 0.46t \Rightarrow t = 30.2\,sec$

- $S = \frac{1}{2}at^2 + V_0t + S_0^{\,0}$

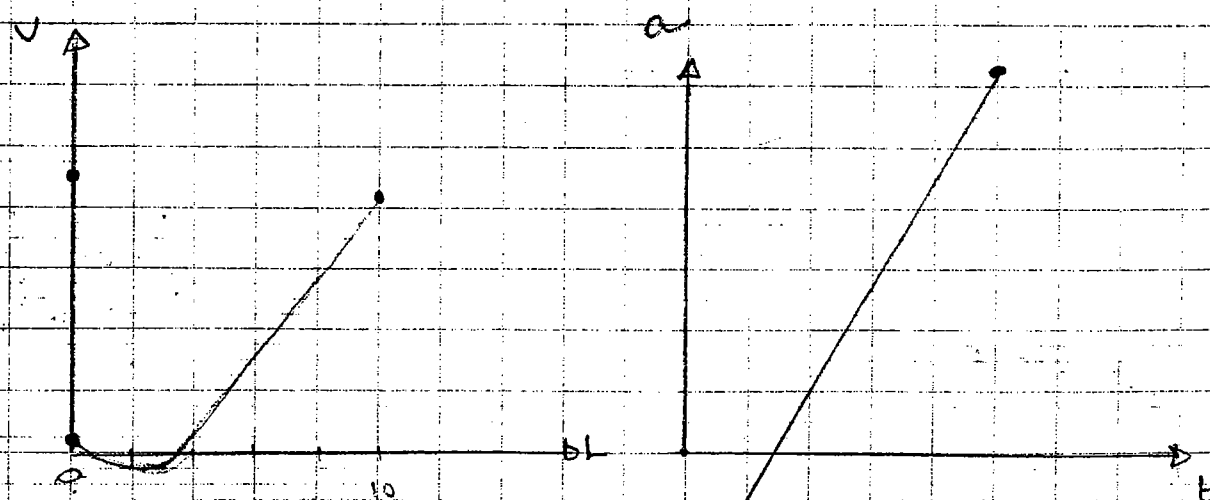
$= \frac{1}{2}(0.46)(30.2)^2 + 19.44(30.2) = 796.86\,m$

Problem 2

$S = 0.3t^3 - 2.7t^2 + 4.5t$

$V = 0.9t^2 - 5.4t + 4.5$

$a = 1.8t - 5.4$



$\Rightarrow$ max velocity at $t = 10\,sec$

$V = 40.5\,m/sec$

max acc. at $t = 10\,sec$

$a = 12.6\,m/sec^2$

Problem 3

$a = (-2v)\ m/s^2$

$t=0,\ s=0,\ v_0 = 20\ m/s$

$v\,dv = a\,ds \Rightarrow v\,dv = -2v\,ds$

$\frac{v\,dv}{-2v} = ds \Rightarrow \frac{dv}{-2} = ds$

$$-\tfrac{1}{2}\int_{20}^{v} dv = \int_0^s ds$$

$$-\tfrac{1}{2}[v - 20] = s$$

$$-\tfrac{1}{2}v + 10 = s$$

$$-\tfrac{1}{2}v = s - 10$$

$$\boxed{v = -2s + 20}$$

* particle stops when $v = 0$

$\Rightarrow 0 = -2s + 20$

$2s = 20 \Rightarrow s = 10\ m$

Problem 4

$t=0,\ S_0 = 1m,\ V_0 = 2m/s,\ a = (2t-1)\ m/s^2$

$a = \frac{dv}{dt} \Rightarrow dv = a\,dt \Rightarrow dv = (2t-1)\,dt$

$$\int_2^v dv = \int_0^6 (2t-1)\,dt$$

$$v - 2 = t^2 - t\Big]_0^6 = 36 - 6 = 30$$

$v = 32\ m/s$

$v = t^2 - t + 2$

$$\int_0^6 v\,dt = \int_1^s ds$$

$$\frac{t^3}{3} - \frac{t^2}{2} + 2t\Big]_0^6 = s - 1$$

$\Rightarrow s = 67m$

* $v = \frac{ds}{dt} \Rightarrow v\,dt = ds \Rightarrow \int_0^6 32\,dt = \int_1^s ds$

$32 \times 6 = s - 1 \Rightarrow s = 193\ m \Rightarrow \Delta s = 66m$

* total distance, $\Delta s = s - s_0 = 193 - 1 = 192\ m$

Problem 5

$t=0,\ v_0=0,\ s_0=0$

- $a_1 = 6t-3$; $a_2 = 12t^2-8$; at $t=4$?

$a\,dt = dv$

$\Rightarrow \int_2^4 (6t-3)\,t = \int_0^v dv$

$\Rightarrow 3t^2 - 3t\Big]_0^4 = v$

$48 - 12 = v \Rightarrow v_2 = 36\ m/s$

$v\,dt = ds$

$\Rightarrow \int_0^4 36t = \int_0^s ds$

$\Rightarrow 36 \times 4 = s_2 = 144\ m$

$\int_0^4 (12t^2-8)\,t = \int_0^v dv$

$\Rightarrow 4t^3 - 8t\Big]_0^4 = v$

$256 - 32 = v \Rightarrow v_1 = 224\ m/s$

$\int_0^4 224t = \int_0^s ds$

$224 \times 4 = s = 896\ m$

$\Rightarrow \Delta s = 896 - 144 = 752\ m$

Problem 6:

Ball A: $v_0 = 0$; $s_0 = 12m$; $s_f = 6m$

Ball B: $v_0 = ?$; $v_f = ?$; $s_0 = 1.5$; $s_f = 6m$

Ball A : $s_a = \frac{1}{2}at^2 + v_0 t + s_0$

$s_a = \frac{1}{2}at^2 + 12$

$v = at + v_0$

$v^2 = v_0^2 + 2as$

$at^2 = 2a(-6)$

$at^2 = -12$

$\Rightarrow$

Ball B: $s = \frac{1}{2}at^2 + v_0 t + s_0$

$6 = \frac{1}{2}at^2 + v_0 t + 1.5$

$4.5 = \frac{1}{2}at^2 + v_0 t$

- $v^2 = v_0^2 + 2a(4.5)$

$v^2 = v_0^2 + 9a$

$v^2 - v_0^2 = 9a$

- $v = at + v_0$

$\frac{1}{2}at^2 + 6 = \frac{1}{2}at^2 + v_0 t + 6$

$\frac{1}{2}at = \frac{1}{2}at + v_0$

$h = \frac{1}{2}at^2 = v^2 - 9a)t$

Problem 7

- $v = 5\ m/s$ (constant)
- S: $y = x^2 - 4$
- constant speed $\Rightarrow \dot{v} = 0 \Rightarrow a_T = 0$

$\Rightarrow a = a_n = \frac{v^2}{\rho} = v^2 \cdot \frac{1}{\rho}$

$* \frac{1}{\rho} = \frac{y''}{(1+y'^2)^{3/2}} = \frac{2}{(1+(2x)^2)^{3/2}}$

$= \frac{2}{(1+4x^2)^{3/2}}$

- $y = x^2 - 4$
- $y' = 2x$
- $y'' = 2$

$\Rightarrow a = a_n = 25 \cdot \frac{2}{(1+4x^2)^{3/2}} = \frac{50}{(1+4x^2)^{3/2}}$

$\text{deriv} = -\frac{3/2 (1+4x^2)^{1/2} (8x)(50)}{(1+4x^2)^3}$

$= -\frac{600x\sqrt{1+4x^2}}{(1+4x^2)^3}$ — always -ve

always +ve

$\Rightarrow$ deriv $= 0 \Rightarrow x\sqrt{1+4x^2} = 0$

$\Rightarrow \boxed{x = 0}$

$\Rightarrow$ at $x = 0$, $y = -4 \Rightarrow$ pt $(0, -4)$, the map of the acceleration is max.

$a = a_n = \frac{50}{1} = 50\ m/s^2$

Problem 8

$a_T = a\cos\theta = 14\cos 75^\circ = 3.62\ m/s^2$

$a_N = a\sin\theta = 14\sin 75^\circ = 13.52\ m/s^2$

$\because a_N = \frac{v^2}{\rho} \Rightarrow \rho = \frac{20^2}{13.52} = 29.59\ m$

Problem 10 :

$a_t = 0.05s$

$r = 50\ m$; $V_0 = 4\ m/s$

$S_0 = 0$ $S_f = 10\ m$ $\Rightarrow \Delta s = 10\ m$

* $a\,ds = v\,dv$

$$\Rightarrow \int_0^{10} 0.05s\,ds = \int_4^v v\,dv$$

$$\frac{0.05}{2}\left[s^2\right]_0^{10} = \frac{1}{2}\left[v^2\right]_4^v$$

$$2.5 = \frac{1}{2}\left[v^2 - 16\right]$$

$$5 = v^2 - 16 \Rightarrow v^2 = 21 \Rightarrow \boxed{v = 4.58\ m/s}$$

* $a_t = 0.05s = 0.05(10) = 0.5\ m/s^2$

$$a_n = \frac{v^2}{\rho} = \frac{v^2}{r} = \frac{4.58^2}{50} = 0.42\ m/s^2$$

$$\Rightarrow a = \sqrt{a_n^2 + a_t^2} = 0.65\ m/s^2$$

Problem 11 :

Problem 5

$\int dv = \int a\,dt$

$\int_0^v dv = \int_0^4 (6t - 3)\,dt$

$v = 3t^2 - 3t$

$\int v\,dt = \int ds$

$\int_0^s ds = \int (3t^2 - 3t)\,dt$

$s = t^3 - \frac{3}{2}t^2$

Let: $t = 4 \Rightarrow 4^3 - 24 = S$

$\Rightarrow S = 40m$

$\int dv = \int a\,dt$

$v = 12t - 8$

$\int_0^v dv = \int (12t - 8)\,dt$

$v = 4t^3 - 8t$

$\Rightarrow \int v\,dt = \int ds$

$\int_0^s ds = \int (4t^3 - 8t)\,dt$

$s = t^4 - 4t^2$

$s = 4^4 - 64$

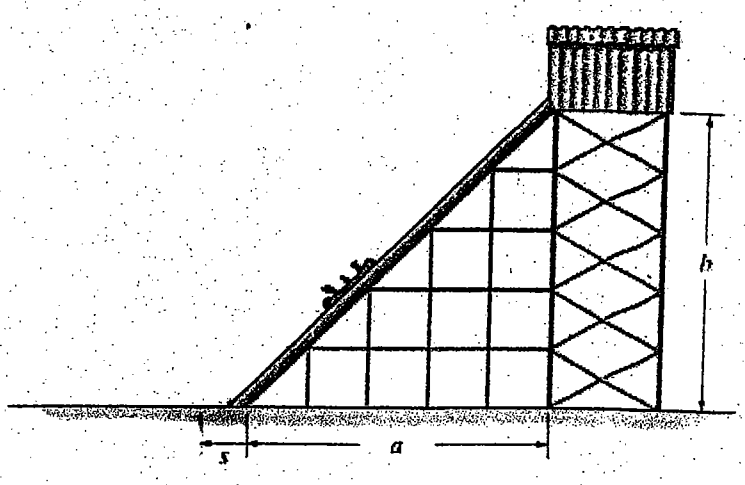
$s = 256 - 64$

$\Rightarrow s = 192m$

Kinetics

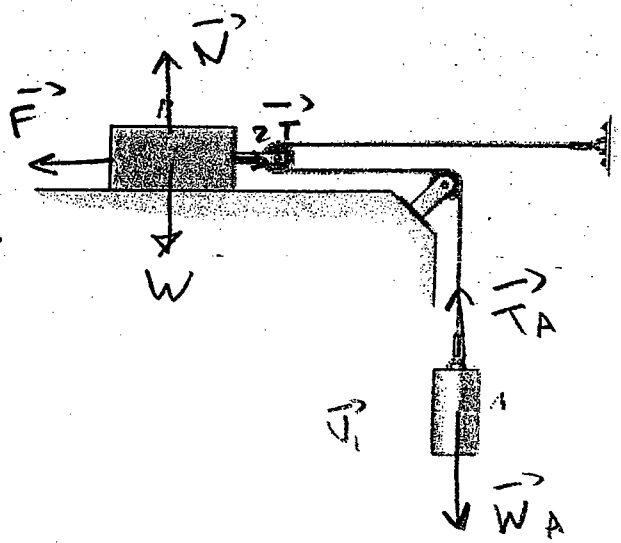
Problem 1

The water-park ride consists of a sled of weight *W =8-kN (≈800-kg)* which slides from rest down the incline and then into the pool. If the frictional resistance on the incline is F_r = 300N and in the pool for a short distance is F_r = 800N, determine how fast the sled is traveling when *s = 1m* (Ans:V_2=19.2 m/s)



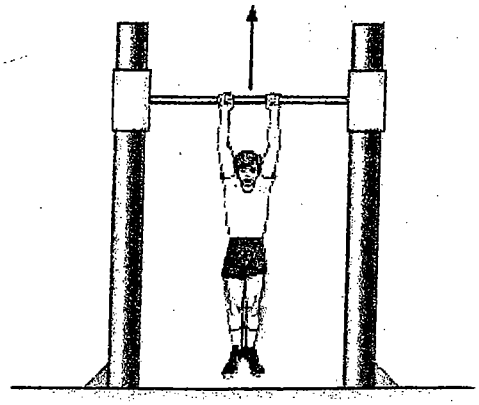
Problem 2

At a given instant block *A* of weight W_A = 25N is moving downward with a speed V_1 = 1m/s at t_o=0. Determine its speed at the later time *t = 2s*. Block *B* has weight W_B = 30N, and the coefficient of kinetic friction between it and the horizontal plane is μ_k = 0.3. Neglect the mass of the pulleys and cord. (Ans: V_A=13.4 m/s)



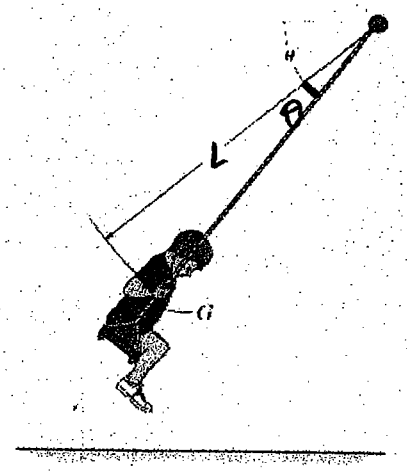
Problem 3

The boy has weight W = 400N (≈ 40kg) and hangs uniformly from the bar. Determine the force in each of his arms at time t =2s if the bar is moving upward with (a) a constant velocity of 1m/s and (b) a speed $v = 1.2t^2$ m/s.
(Ans: (a) T=200N; (b) T=298N)



Problem 4 60° L = 3 m

At the instant $\theta = \theta_1$ the boy's center of mass G has a downward speed $V_G = 3m/s$. Determine the rate of increase in his speed and the tension in each of the two supporting cords of the swing at this instant. The boy has a weight W = 300N (≈30Kg). Neglect his size and the mass of the seat and cords.
(Ans: T=175.8N , a_t= 4.91 m/s^2)

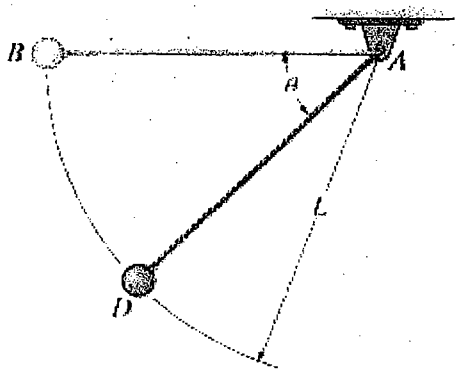


Problem 5 ρ = 100

If the crest of the hill has a radius of curvature ρ, determine the maximum constant speed at which the car can travel over it without leaving the surface of the road. Neglect the size of the car in the calculation. The car has weight W.
(Ans: V =31.3 m/s = 111.6 km/h)

Problem 6

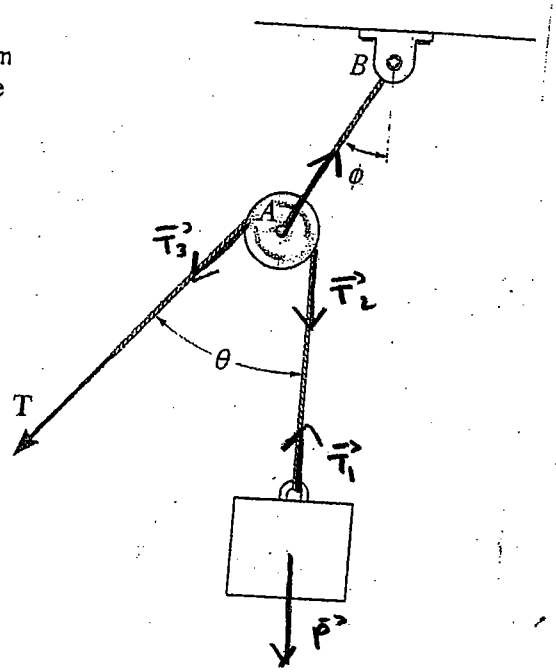
The pendulum bob *B* of mass *M* = 5 kg is released from rest when θ = 0°. Determine the initial tension in the cord and also at the instant the bob reaches point *D*, θ = 45°.Given: L = 2m. Neglect the size of the bob. (Ans: T= 0N; T_D = 104.1 N)



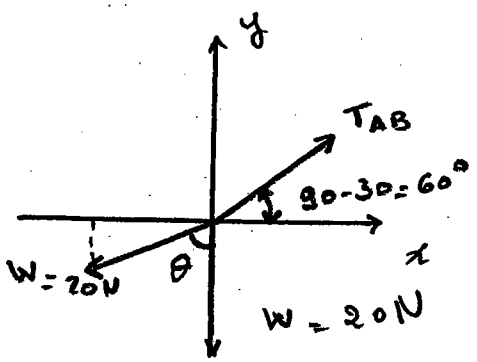
Prob 1

The block has weight W and is being hoisted at uniform velocity. Determine the angle θ for equilibrium and the required force in each cord.

Let $W = 20\ N$ & $\Phi = 30°$



Solution:



$\Rightarrow \Sigma F_x = 0 \Rightarrow T_{AB}\cos 60° - W\sin\theta = 0$

$\Uparrow \Sigma F_y = 0 \Rightarrow T_{AB}\sin 60 - W - W\cos\theta = 0$

we solve the sys of 2 equ. and 2 unknowns $\Rightarrow \theta$

$P = T_1 \rightarrow T_1 = T_2 = T_3 = P \Rightarrow \boxed{T_2 = T_3 = W}$

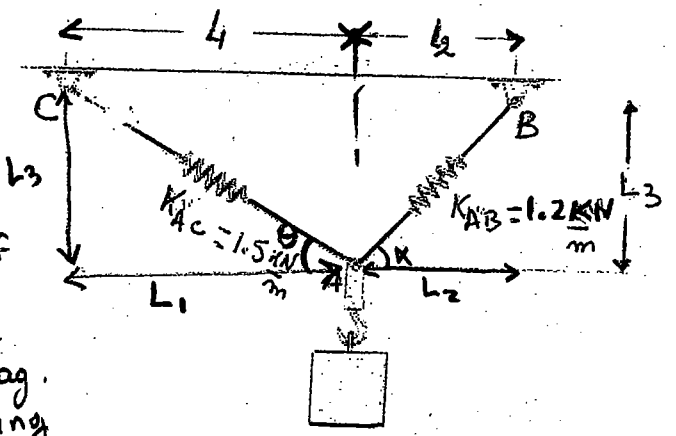
SOCIAL

Prob 2 (★★★☆☆ rated)

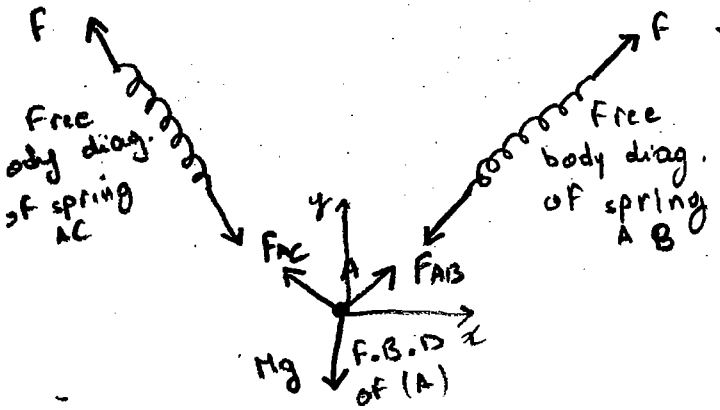
The block of mass M is supported by two springs having the stiffness shown. Determine the unstretched length of each spring.

Units Used: $M = 30\,kg$ $L_1 = 0.6\,m$ $L_2 = 0.4\,m$ $L_3 = 0.5\,m$

$kN = 10^3\,N$



Solution:



$$\tan\alpha = \frac{L_3}{L_2} = \frac{0.5}{0.4}$$

$$\Rightarrow \alpha = 51.34^\circ$$

$$\cos\alpha = \frac{L_2}{AB} \rightarrow AB = \frac{L_2}{\cos\alpha} \Rightarrow AB = 0.64\,m$$

same for AC $\Rightarrow AC = 0.78\,m$

D F.B.D of (A):

$\Sigma F_x = 0$ ($\cos\alpha = \frac{L_2}{AB}$, $\cos\theta = \frac{L_1}{AC}$)

$$F_{AB}\left(\frac{0.4}{0.64}\right) - F_{AC}\left(\frac{0.6}{0.78}\right) = 0$$

$\Sigma F_y = 0$ ($\cos 180$)

$$(30)(9.81) + F_{AB}\left(\frac{0.5}{0.64}\right) - F_{AC}\left(\frac{0.5}{0.78}\right) = 0$$

solve For F_{AB} and F_{AC}

D $F_{AB} = K\Delta L = K(L'_{AB} - L_{AB})$

$\Delta L = \frac{F_{AB}}{K_{AB}}$ ← stiffness

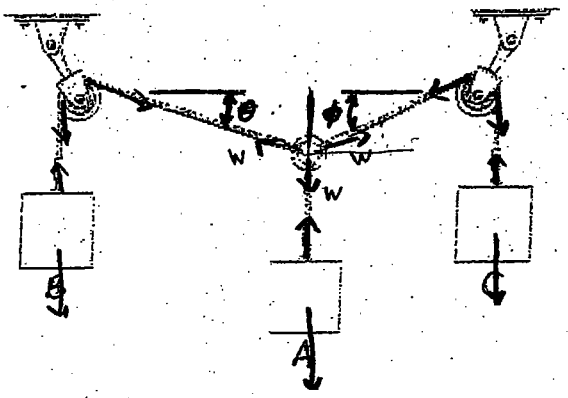
$\frac{F_{AB}}{K_{AB}} = 0.64 - L_{AB}$ Solve for L_{AB} $\Rightarrow L_{AB} = 0.45\,m$

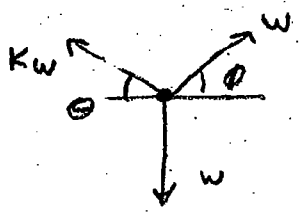
perform similar calculate to get L_{AC} $\Rightarrow L_{AC} = 0.65\,m$

$AC = 183.7\,N$, $F_{AB} = 226.13\,N$)

Prob 3

Three blocks are supported using the cords and two pulleys. If they have weights of $W_A = W_C = W$, $W_B = kW$, determine the angle θ for equilibrium.





$\Sigma F_x = 0 \quad W\cos\phi - KW\cos\theta = 0 \rightarrow (1)\ \cos\phi = K\cos\theta$

$\Sigma F_y = 0 \quad W\cos(90-\phi) + W + KW\cos(90-\theta) = 0 \rightarrow (2)\ \sin\phi = 1 - K\sin\theta$

$(1)^2 + (2)^2$

$$\begin{cases} \cos^2\phi = K^2\cos^2\theta \\ \sin^2\phi = (1 - K\sin\theta)^2 \end{cases}$$

$\cos^2\phi + \sin^2\phi = K^2\cos^2\theta + K^2\sin^2\theta - 2K\sin\theta + 1$

$K^2(\cos^2\theta + \sin^2\theta) - 2K\sin\theta = 0$

$K^2 - 2K\sin\theta = 0$

$K - 2\sin\theta = 0$

$\sin\theta = \frac{K}{2} \Rightarrow \theta = \sin^{-1}\left(\frac{K}{2}\right)$

Test 3 **Jan. 15, 2010**

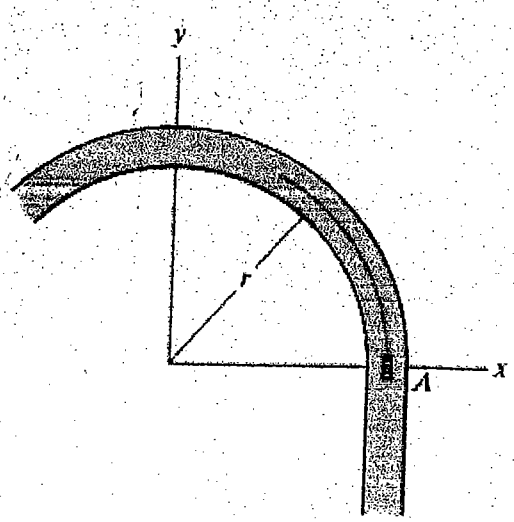
Dynamics **Duration 55'**

Problem 1 **30 Points**

A particle has an initial speed V_0=27 m/s. If it experiences a deceleration $a = -6t\ m/s^2$, determine the distance traveled before it stops.

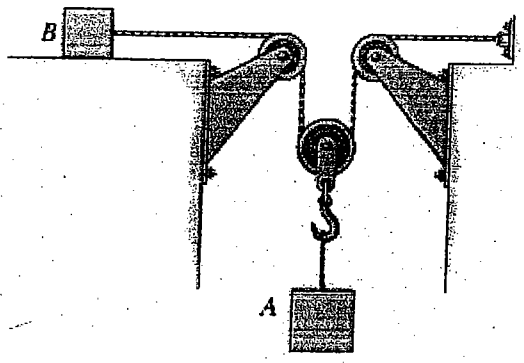
Problem 2 **30 Points**

The car travels around the portion of a circular track having a radius r = 150m such that when it is at point A it has a velocity V_1 = 0.6 m/s which is increasing at the rate of $\dot{V}$ = 0.006s. Determine the magnitudes of its velocity and acceleration when it has traveled three-fourths of the complete circle.



Problem 3 **40 Points**

At a given instant block A of weight W_A = 100N (≈ 10kg) is moving downward with speed V_{A0} = 2m/s. Determine its speed at a later time t = 2s. Block B has a weight W_B = 40N (≈ 4 kg) and the coefficient of kinetic friction between it and the horizontal plane is μ_k = 0.2, neglect the mass of the pulleys and cord.



USE FOR ANSWERS

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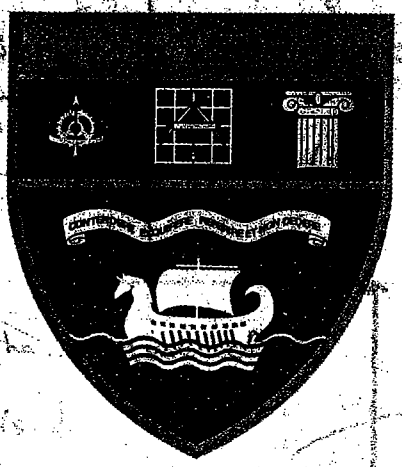


CLOSED-BOOK EXAM

Name: [redacted] ID No.: [redacted]

Course: Engineering Mechanics Date: 15/01/2020

Question	1	2	3	4	5	6	7	8	9	10	Total:
Grade:	30	15	37								82/100

Problem 1

$v_0 = 27$ m/s $a = -6t$ m/s²

$\frac{dv}{dt} = a \rightarrow dv = a\,dt$

$\int_{v_0}^{v} dv = \int_{0}^{t} a\,dt$ where $t_0 = 0$

$v\Big|_{v_0}^{v} = -\frac{6t^2}{2}\Big|_0^t$

$v - 27 = -3t^2$

$v = -3t^2 + 27$

$s = -\frac{3t^3}{3} + 27t = -t^3 + 27t$

when $v = 0$, $-3t^2 + 27 = 0$

$t = -3 \rightarrow t = 3$

$s = -(3)^3 + 27(3) = 54$ m

Problem 2

$r = 150$ m (A is the origine of s)

At A: $v_1 = 0.6$ m/s

$\dot{v} = 0.006$ s

$a_t = v\dot{v} = v\frac{dv}{ds}$ At A: $0.6 \times 0.006 = 3.6 \times 10^{-3}$ m/s²

$a_t = v\frac{dv}{ds}$

$\int a_t\,ds = \int v\,dv$

$s = \frac{3}{4}P = \frac{3}{4}(2\pi r)$

$= \frac{3}{4}(2\pi \times 150) = 706.86$ m

$a_n = \frac{v^2}{\rho} = \frac{v^2}{150}$

At A: $a_n = \frac{v^2}{\rho} = \frac{0^2}{150} = 2.4 \times 10^{-3}$

$a_t = 3.6 \times 10^{-3}$ m/s²

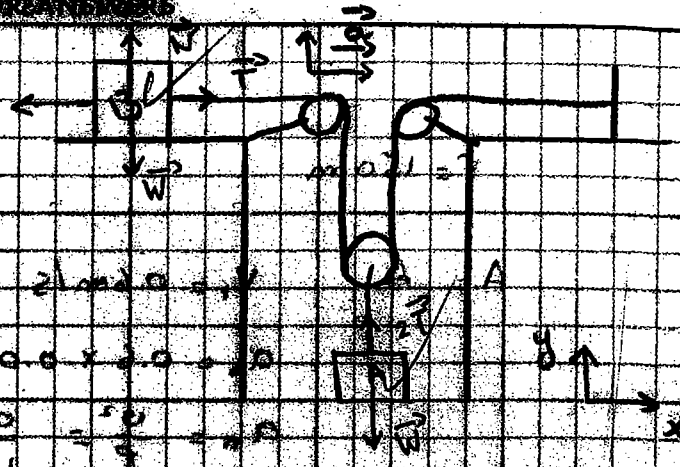
$a = \sqrt{a_n^2 + a_t^2} = 4.33 \times 10^{-3}$ m/s²

$v^2 - v_0^2 = 2a(s - s_0)$

$v^2 = 2(4.33 \times 10^{-3})(706.86) + 0.6 = 6.72$

$v = \sqrt{6.72} = 2.59$ m/s

Problem 3



$W_A = 100N$ $W_B = 40N$

$m_A = 10Kg$ $m_B = 4Kg$

$V_{A_0} = 2m/s$ $\mu_K = 0.2$

$t = 2s$

* At A:

$\Sigma F_y = ma_A$

$T - W = ma_A$

$T - 100 = 10a_A$ (1)

* At B

$\Sigma F_x = ma_B$

$T - F = 4a_B$ (2)

$\Sigma F_y = 0$

$N = W = 40N \Rightarrow F = 40 \times 0.2 = 8N$

* $V_B + 2V_A = 0$

$a_B + 2a_A = 0$ (3) $\quad a_B = -2a_A$

* (1), (2) and (3) $\Rightarrow$

$$\left.\begin{aligned} T - 8 &= 4(-2a_A) \\ 2T - 100 &= 10a_A \end{aligned}\right\}$$

$\Rightarrow T = +33.85N$ and T is $a = \pm 3.23 m/s^2$

$|a_A| = 3.23 m/s^2$

$V = -3.23t + V_0$

$V = -3.23t + 2$

At $t = 2 \rightarrow V = -3.23(2) + 2 = -4.46 m/s$