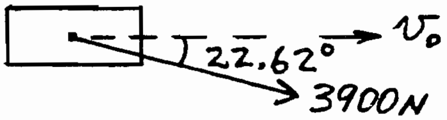
DYNAMICS

1. LAURA, NEGOTIATING THE FREEWAY ONRAMP, STEPS ON THE GAS WHILE TURNING THE STEERING WHEEL OF HER RED BMW, WHOSE MASS IS 1200 KG. THE NET HORIZONTAL FORCE ON THE CAR IS 3900N AT 22.62°. LOOKING DOWN ON THE VEHICLE:



FIND THE ACCELERATION DUE TO THE CHANGE IN THE:

A) SPEED ($3\ m/s^2$)

B) DIRECTION OF MOTION ($1.25\ m/s^2$)

2. FILL IN THE BLANKS:

a) $m = 4\,kg$ $F_g =$ ______ N

b) $m =$ ____ KG $F_g = 800\ N$

c) $m = 3$ SLUGS $F_g =$ _____ lbs

d) $m =$ _____ SLUGS $F_g = 224$ lbs

3. JOHANN IS ZOOMING AT VELOCITY v_0 IN HIS METALLIC GREEN JEEP CHEROKEE. AN ELK IN THE ROAD! JOHANN BRAKES TO A STOP ON THE HORIZONTAL ROAD, WHOSE COEFFICIENT OF FRICTION IS μ. FIND A FORMULA FOR HIS STOPPING DISTANCE. ONLY v_0, μ AND g ARE ALLOWED IN OUR ANSWER. ($x = v_0^2/2\mu g$)

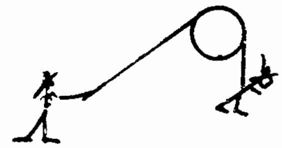
4. IAN IS CRUISING AT 48 m/s IN HIS VW VAN <u>DOWN</u> AN ALPINE HIGHWAY WHICH IS INCLINED AT 36.87° AND WHOSE COEFFICIENT OF FRICTION IS .9. A MOOSE BOUNDS ONTO THE ROAD AT THE BOTTOM OF THE HILL 975 m IN FRONT OF THE VAN. IAN HITS THE BRAKES AND ROLLS ON THE VERGE OF SKIDDING TO A STOP. DO WE HAVE MOOSEBURGERS FOR LUNCH OR DO WE SETTLE FOR A BALTIMORE BAGEL? (BAGELS! BY 15 m)

5. MR. H., $m = 75$ KG, LOSES HIS GRIP ON TORREY'S PEAK AND DOES FREE FALL FOR 1.8 SECONDS. NO LONGER SLACK, THE CLIMBING ROPE NOW STRETCHES 20% OF ITS LENGTH TO ARREST MR. H'S FALL. FIND THE TENSION IN THE ROPE AS IT BRINGS MR. H. TO REST. (4500N)

6. A 40 KG KANGAROO EXERTS A JUMPING FORCE DURING THE FIRST .6 m OF HER JUMP, AND RISES 2 m HIGHER. WITH A JOEY IN HER POUCH, SHE RISES ONLY 1.8 m HIGHER. FIND:

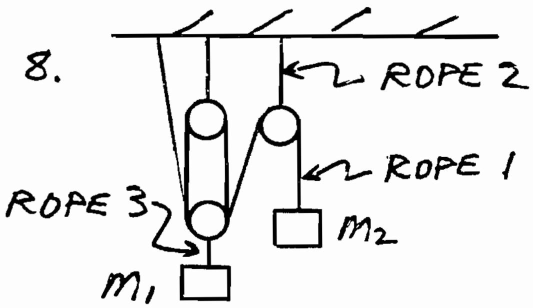
A) JUMPING FORCE (1733N) B) JOEY'S MASS (3.33 KG)

7. GEOFF SUPPLIES A TENSION OF 4060 N TO LIFT A MARBLE STATUE WITH UNIFORM ACCELERATION OF 4.5 m/s^2. FIND THE MASS OF THE SCULPTURE.



(280 KG)

8.



$m_1 = 24$ KG $\quad m_2 = 36$ KG

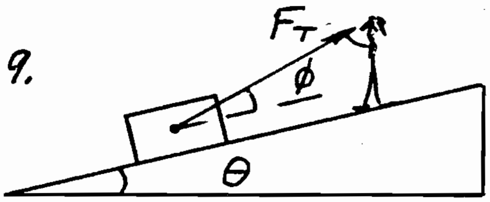
FIND THE:

a) ACCELERATION OF EACH MASS

b) TENSION IN THE ROPES.

($a_1 = 2\ m/s^2$, $a_2 = -8\ m/s^2$, $T_1 = 72N$; $T_2 = 144N$, $T_3 = 288N$)

9.



$m = 1700$ KG $\quad \theta = 28.0725^\circ$

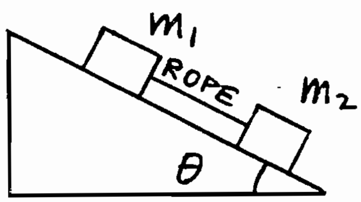
$F_T = 3000$ N $\quad \phi = 36.87^\circ$

$\mu = .16667$

AMBER SUPPLIES A TENSION FORCE AS SHE LOWERS THE CRATE DOWN THE INCLINE. FIND:

A) F_N (13200 N) $\quad$ B) F_f (2200) $\quad$ C) a_x (2.0 m/s^2)

10.



$\theta = 59.49^\circ$

BEING MADE OF DIFFERENT MATERIAL, THE TWO BRICKS HAVE DIFFERENT COEFFICIENTS OF FRICTION. FOR EACH CASE, FIND THE ACCELERATION OF EACH BRICK AND THE TENSION IN THE ROPE.

A) $m_1 = 130$ KG $\quad \mu_1 = .837\overline{878}$ $\quad \theta = 59.49^\circ$

$m_2 = 195$ KG $\quad \mu_2 = .3$

($a_1 = 6\ m/s^2$, $a_2 = 6\ m/s^2$, $F_T = 213N$)

B) $m_1 = 195$ KG $\quad \mu_1 = .3$ $\quad \theta = 59.49^\circ$

$m_2 = 130$ KG $\quad \mu_2 = .837\overline{878}$

($a_1 = 7.09\ m/s^2$, $a_2 = 4.36\ m/s^2$, $F_T = 0$)

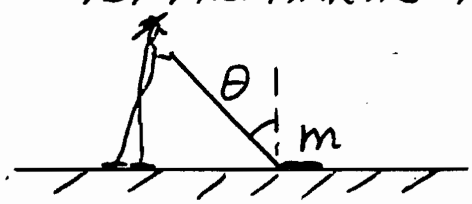
C) IN (B), AFTER THEY HIT EACH OTHER, FIND THEIR ACCELERATION AND THE NORMAL FORCE BETWEEN THEM ($a = 6 m/s^2$, $F_N = 213N$)

11. AFTER BEING GIVEN A PUSH, A BOX OF KLEENEX® SLIDES AT CONSTANT VELOCITY DOWN AN INCLINE WHOSE ANGLE IS θ. A) IN TERMS OF θ, FIND A FORMULA FOR μ_K $(\tan\theta)$. $(\mu_K = \tan\theta)$

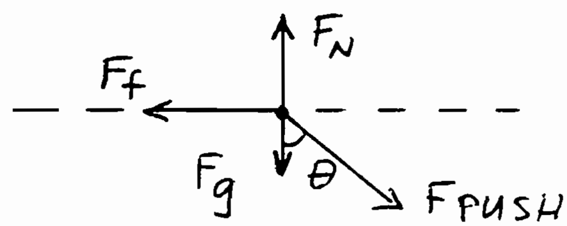
B) WE NOW GIVE THE BOX INITIAL SPEED v_0 AT THE BOTTOM OF THE INCLINE. WE RELEASE THE BOX AND LET IT SLIDE UP THE INCLINE. IN TERMS OF v_0, θ AND g, FIND A FORMULA FOR THE DISTANCE TRAVELED BY THE BOX BEFORE IT COMES TO REST. $(X = v_0^2/(4g\sin\theta))$

C) WILL THE BOX SPONTANEOUSLY SLIDE BACK DOWN? (NO, $\mu_s > \mu_k$)

12. MR. HARVIE IS MOPPING THE FLOOR OF ROOM 25,



FORCE DIAGRAM



μ_s AND μ_K

A) FIND FORMULAS FOR THE FOLLOWING IN TERMS OF m, θ, μ_s AND μ_K.

i) F_{PUSH} REQUIRED TO START THE MOP MOVING.

ii) F_{PUSH} REQUIRED TO KEEP IT MOVING AT CONSTANT SPEED.

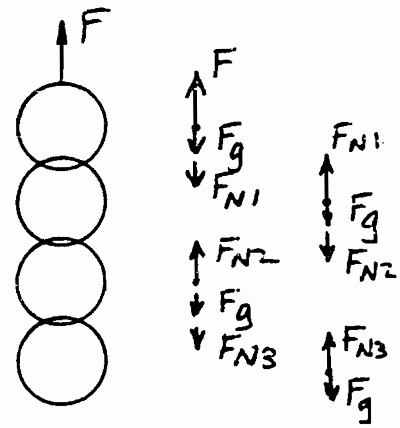
B) FIND A FORMULA IN TERMS OF μ_s FOR THE MINIMUM ANGLE θ REQUIRED TO START THE MOP.

C) SUPPOSE THE MOP IS MOVING AND F_{PUSH} IS GREATER THAN THAT IN (A)(ii). FIND A FORMULA FOR THE ACCELERATION OF THE MOP IN TERMS OF m, F_P, θ, μ_K AND g.

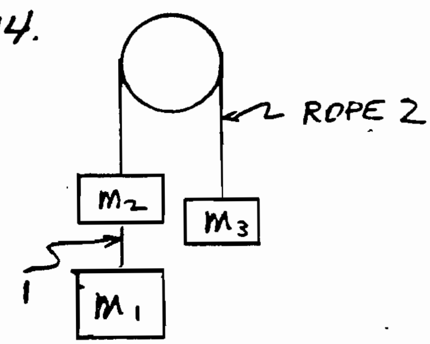
ANSWERS: $\left(\dfrac{\mu_s mg}{(\sin\theta - \mu_s\cos\theta)}, \dfrac{\mu_K mg}{(\sin\theta - \mu_K\cos\theta)}, \theta_{MINIMUM} = \tan^{-1}\mu_s, \right.$

$$\left. a_x = \frac{F_P(\sin\theta - \mu_K\cos\theta) - \mu_K mg}{m} \right)$$

13. A CHAIN CONSISTS OF FOUR LINKS, EACH HAVING A MASS OF 3 KG. A FORCE F IS EXERTED ON THE TOP LINK, LIFTING THE ENTIRE CHAIN WITH AN ACCELERATION OF $8\ m/s^2$. FIND F AND FIND THE THREE NORMAL FORCES ACTING BETWEEN THE LINKS OF THE CHAIN.
(216N, 162N, 108N, 54N)



14.



a) DERIVE EXPRESSIONS FOR a, T_1 AND T_2 IN TERMS OF m_1, m_2 + m_3.

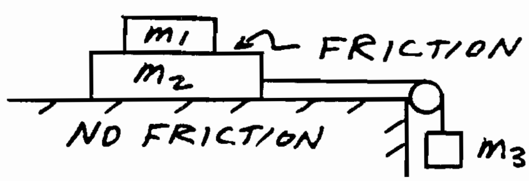
b) UNDER WHAT CONDITIONS WOULD THE ACCELERATION BE ZERO.

ANSWERS:

$$a = \left(\frac{m_3 - m_1 - m_2}{m_1 + m_2 + m_3}\right) g \qquad T_1 = \frac{2 m_1 m_3 g}{m_1 + m_2 + m_3}$$

$$T_2 = \left(\frac{2 m_1 m_3 + 2 m_2 m_3}{m_1 + m_2 + m_3}\right) g \qquad m_1 + m_2 = m_3$$

15.



A) IN TERMS OF m_1, m_2, m_3 AND g, FIND FORMULAS FOR a, F_T AND THE MINIMUM VALUE FOR μ_s SO THAT m_1 DOES NOT SLIP.

B) SUPPOSE THAT μ IS THE ACTUAL COEFFICIENT AND $\mu < \mu_s$ SO THAT SLIPPING OCCURS. IN TERMS OF m_1, m_2, m_3, g AND μ, FIND FORMULAS FOR THE ACCELERATIONS AND THE TENSION.

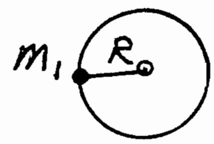
ANSWERS: $a = m_3 g/(m_1+m_2+m_3)$ $\quad F_T = \dfrac{(m_1+m_2)m_3 g}{(m_1+m_2+m_3)}$ $\quad \mu_s = m_3/(m_1+m_2+m_3)$

$$a_1 = \mu g \qquad a_2 = a_3 = \frac{(m_3 - \mu m_1) g}{(m_2 + m_3)} \qquad F_T = \frac{(\mu m_1 + m_2) m_3 g}{(m_2 + m_3)}$$

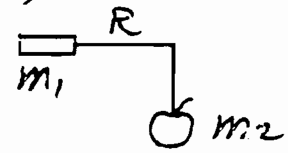
CIRCULAR MOTION

1. A HOCKEY PUCK OF MASS m_1 IS TIED TO A STRING WHICH HOLDS IT IN UNIFORM CIRCULAR MOTION OF RADIUS R ON A FRICTIONLESS TABLE. THE STRING RUNS THROUGH A HOLE IN THE CENTER OF THE TABLE AND IS TIED TO AN APPLE OF MASS m_2, WHICH HANGS SUSPENDED IN THE AIR.

LOOKING DOWN ON THE TABLE.

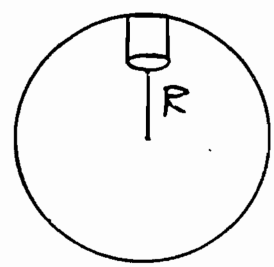


SIDE VIEW

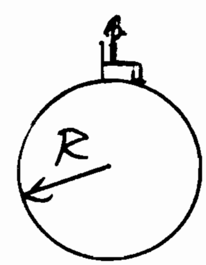


FIND A FORMULA FOR THE FREQUENCY OF THE PUCK'S MOTION. ONLY m_1, m_2, g AND R ARE ALLOWED IN OUR ANSWER.

2. STEPHANIE SWINGS A BUCKET OF WATER IN A VERTICAL LOOP OF RADIUS R. FIND A FORMULA FOR THE MINIMUM SPEED SO THAT THE WATER DOES NOT FALL OUT OF THE BUCKET AT THE APEX OF THE LOOP. ONLY g AND R ARE ALLOWED IN OUR ANSWER.



3. ELLEN IS SITTING UPRIGHT ON A CHAIR OF A FERRIS WHEEL, WHOSE PERIOD OF MOTION IS T. AT THE APEX OF THE LOOP, SHE FEELS AS IF SHE WEIGHS ONLY N TIMES HER USUAL WEIGHT, WHERE $0 < N < 1$.



A) FIND A FORMULA FOR THE RADIUS OF THE LOOP. ONLY T, g AND N ARE ALLOWED IN OUR ANSWER.

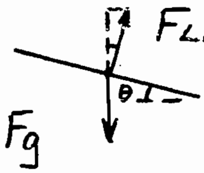
B) FIND A FORMULA FOR THE MAXIMUM RADIUS SUCH THAT ELLEN DOES NOT FLY OUT OF THE SEAT.

4. JAMES BOND ZOOMS AROUND AN UNBANKED ALPINE CURVE WHOSE RADIUS IS R AND WHOSE COEFFICIENT OF FRICTION IS μ. FIND A FORMULA FOR THE MAXIMUM SPEED WITH WHICH HE CAN SAFELY NEGOTIATE THE CURVE. ONLY R, μ AND g ARE ALLOWED.

(ANSWERS: $f = \sqrt{\dfrac{m_2 g}{4\pi^2 m_1 R}}$, $v = \sqrt{gR}$, $R = \dfrac{gT^2(1-N)}{4\pi^2}$, $R = \dfrac{gT^2}{4\pi^2}$, $v = \sqrt{\mu g R}$)

5. JAMIE FLIES HIS F-16 FALCON, OF MASS m, AT SPEED v IN A HORIZONTAL CIRCLE OF RADIUS R.

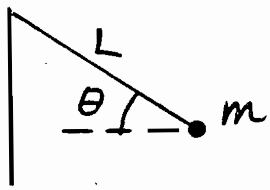
VIEW OF REAR OF THE JET.



FIND A FORMULA FOR:
a) TILT OF THE JET, θ
b) FORCE OF LIFT.

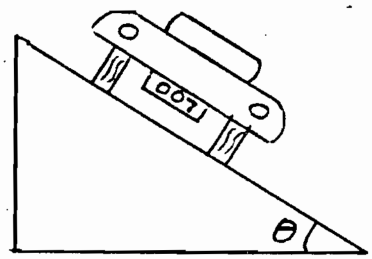
ONLY m, v, R AND g ARE ALLOWED IN OUR ANSWERS.

6. A TETHERBALL OF MASS m ORBITS THE POLE AT ANGLE θ ON A ROPE OF LENGTH L. FIND A FORMULA FOR:
a) TENSION IN THE ROPE
b) SPEED OF THE BALL.



ONLY m, g, θ AND L ARE ALLOWED.

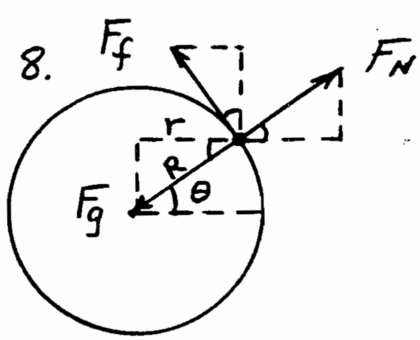
7.



THIS IS A CARTOON OF JAMES BOND'S CAR, REAR VIEW, AS HE CRUISES AROUND A CURVE BANKED AT ANGLE θ. THE CURVE'S RADIUS IS R.

THE COEFFICIENT OF FRICTION BETWEEN ROAD AND TIRES IS μ. IN TERMS OF R, g, θ AND μ, DERIVE A FORMULA FOR: a) THE MAXIMUM SPEED AT WHICH HE CAN SAFELY NEGOTIATE THE CURVE. b) THE MINIMUM SPEED.

8.

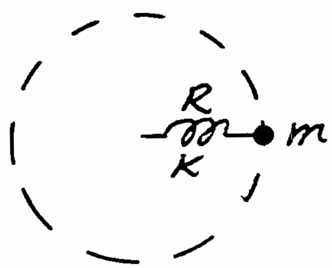


EARTH DAY! ELEANOR, MASS m, STANDS AT LATITUDE θ ON THE SURFACE OF THE EARTH, WHOSE RADIUS IS R. AT THAT LATITUDE, THE EARTH'S ROTATIONAL SPEED IS v. FIND FORMULAS FOR:

a) RADIUS OF ROTATION, r
b) FRICTIONAL FORCE, F_f
c) NORMAL FORCE, F_N.

ONLY m, g, R, v AND θ ARE ALLOWED.

9. A HOCKEY PUCK OF MASS m IS ATTACHED TO A SPRING WHOSE INITIAL LENGTH IS L AND WHOSE SPRING CONSTANT IS K. RECALL HOOKE'S LAW GIVES $F_S = KX$, WHERE X EQUALS THE DISTANCE WHICH THE SPRING IS STRETCHED. WE ATTACH THE FREE END OF THE SPRING TO THE CENTER OF A FRICTIONLESS TABLE AND PUT THE PUCK IN UNIFORM CIRCULAR MOTION WHOSE FREQUENCY IS f. IN TERMS OF m, L, K AND f, FIND FORMULAS FOR:



a) RADIUS, R, OF THE ORBIT.
b) TENSION, F_S, IN THE SPRING.

10. A 75 KG PUMPKIN IS TIED TO THE END OF A ROPE 105 m LONG. MR. H. GRABS THE FREE END OF THE ROPE AND PUTS THE GIANT SQUASH INTO CIRCULAR MOTION. DURING ONE FIVE SECOND INTERVAL, THE FRUIT ACCELERATES FROM 28 m/s TO 50 m/s. FIND:

a) TANGENTIAL ACCELERATION
b) TANGENTIAL FORCE
c) INITIAL RADIAL ACCELERATION
d) INITIAL RADIAL FORCE
e) INITIAL TOTAL FORCE

(c)–(e): WHEN ITS SPEED IS 28 m/s.

ANSWERS: 5. $\theta = \tan^{-1}(v^2/Rg)$ $\quad F_L = \sqrt{\dfrac{m^2v^4}{r^2} + m^2g^2}$

6. $F_T = \dfrac{mg}{\sin\theta}$ $\quad v = \sqrt{\dfrac{gL\cos^2\theta}{\sin\theta}}$

7. $v_{MAX} = \sqrt{gR\left(\dfrac{\sin\theta + \mu\cos\theta}{\cos\theta - \mu\sin\theta}\right)}$ $\quad v_{MIN} = \sqrt{gR\left(\dfrac{\sin\theta - \mu\cos\theta}{\cos\theta + \mu\sin\theta}\right)}$

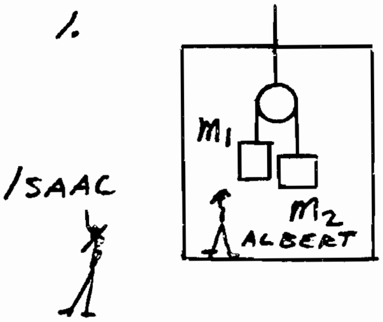
8. $r = R\cos\theta$ $\quad F_f = \dfrac{mv^2}{R}\tan\theta$ $\quad F_N = mg - \dfrac{mv^2}{R}$

9. $R = \dfrac{kL}{(k - 4\pi^2 mf^2)}$ $\quad F_S = \dfrac{4\pi^2 mkLf^2}{(k - 4\pi^2 mf^2)}$

10. $4.4\ m/s^2$, $330N$, $7.4\bar{6}\ m/s^2$, $560N$, $650N$ AT $59.49°$

PRINCIPLE OF EQUIVALENCE

1.



THE ELEVATOR ACCELERATES UPWARD AT $8\,m/s^2$. $m_1 = 60\,KG$ $m_2 = 20\,KG$

AS SEEN BY ALBERT, FIND:

A) EFFECTIVE GRAVITATIONAL ACCELERATION

B) ACCELERATION OF THE MASSES.

C) TENSION IN THE ROPE.

($18\,m/s^2$; $-9\,m/s^2$, CCW; $540\,N$)

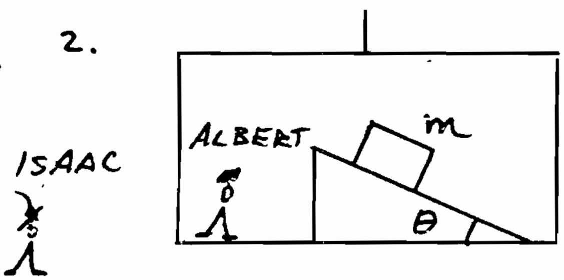
AS SEEN BY ISAAC, FIND:

A) ACCELERATION OF THE MASSES. ($a_1 = -1\,m/s^2$ DOWN, $a_2 = 17\,m/s^2$ UP)

B) TENSION IN THE ROPE ($540\,N$)

$a = (g+\alpha)\sin\theta$
$F_N = m(g+\alpha)\cos\theta$

2.



THE INCLINED PLANE IS NAILED TO THE FLOOR OF THE ELEVATOR. THE TOP SURFACE OF THE INCLINE HAS NO FRICTION.

A) THE ELEVATOR HAS ACCELERATION α ALONG THE VERTICAL AXIS. AS SEEN BY ALBERT, FIND A FORMULA FOR THE ACCELERATION OF THE BRICK ALONG THE INCLINE AND A FORMULA FOR THE NORMAL FORCE ON THE BRICK. ONLY α, g, m AND θ ARE ALLOWED IN OUR ANSWER.

B) $\theta = 53.13^\circ$ $m = 40\,KG$

FOR EACH OF THE FOLLOWING, FIND THE ACCELERATION OF THE BRICK ALONG THE INCLINE AND FIND F_N AS SEEN BY ALBERT.

i) $\alpha = 65\,m/s^2$ ($60\,m/s^2$, $1800\,N$)

ii) $\alpha = -2\,m/s^2$ ($6.4\,m/s^2$, $192\,N$)

iii) $\alpha = -10\,m/s^2$ (0, 0)

C) $\theta = 53.13^\circ$ $m = 40\,KG$ $\alpha = 65\,m/s^2$

AS SEEN BY ISAAC, FIND:

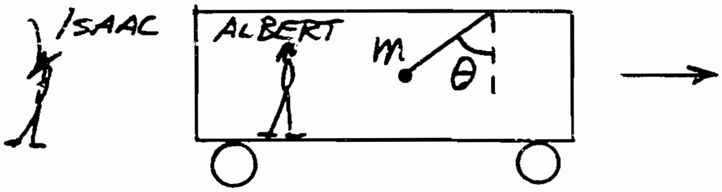
i) F_N

ii) HORIZONTAL AND VERTICAL COMPONENTS OF THE BRICK'S ACCELERATION

iii) TOTAL ACCELERATION OF THE BRICK.

($1800\,N$, $a_x = 36\,m/s^2$, $a_y = 17\,m/s^2$, $39.8\,m/s^2$, 25.3° 1ST QUAD.)

3. AS THE TRAIN ACCELERATES TO THE RIGHT, THE PLUMB BOB HANGS AT ANGLE θ FROM THE VERTICAL.

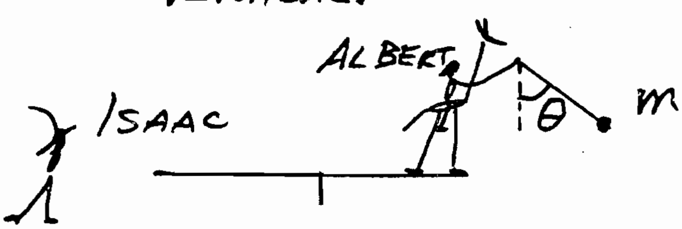


A) FROM ISAAC'S POINT OF VIEW, FIND A FORMULA FOR THE ACCELERATION OF THE TRAIN IN TERMS OF m, g AND θ.

B) FROM ALBERT'S VIEWPOINT, FIND A FORMULA FOR THE "HORIZONTAL COMPONENT OF GRAVITY" ACTING ON THE BOB. ONLY m, g AND θ ARE ALLOWED.

(ANSWERS: $a = g \tan\theta$, $g_x = g_y \tan\theta$)

4. ALBERT IS RIDING THE CAROUSEL AT BALBOA PARK. SEATED ABOARD THE GIRAFFE, ALBERT IS ARMED WITH A PLUMB BOB, WHICH HANGS AT ANGLE θ FROM THE VERTICAL.



A) FROM ISAAC'S VIEW, FIND A FORMULA FOR THE RADIAL ACCELERATION OF THE CAROUSEL, IN TERMS OF m, g AND θ.

B) FROM ALBERT'S VIEW, FIND A FORMULA FOR THE "CENTRIFUGAL COMPONENT OF GRAVITY" ACTING ON THE BOB. ONLY m, g AND θ ARE ALLOWED.

(ANSWERS: $a_r = g \tan\theta$, $g_c = g_z \tan\theta$)

EXPONENTIAL FUNCTIONS AND NATURAL LOGARITHMS

1. USE A CALCULATOR TO EVALUATE:

a) e^{5} (148.4) b) $e^{-\pi}$ $(.0432)$

2. FIND x:

a) $e^{x}=3$ (1.0986) b) $4e^{-x/2}=7$ (-1.119)

3. FIND THE DERIVATIVE WITH RESPECT TO t:

a) $\dfrac{d(e^{8t})}{dt}$ b) $\dfrac{d(5e^{-3t})}{dt}$

4. EVALUATE THE INTEGRALS:

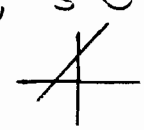
a) $\int e^{5t}\,dt$ b) $\int (4e^{-3t}+3t^{2})\,dt$

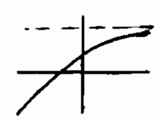
c) $\int \dfrac{5\,dt}{t}$ d) $\int \dfrac{5\,dt}{t^{2}}$

5. SKETCH EACH TERM AND THEN SKETCH THE SUM:

a) $x = 2t+5$ b) $x = 5-3e^{-t}$

ANSWERS: $8e^{8t}$, $-15e^{-3t}$, $\frac{1}{5}e^{5t}$, $-\frac{4}{3}e^{-3t}+t^{3}$, $5\ln t$, $-\frac{5}{t}$





AIR FRICTION AND TERMINAL VELOCITY

1. FOR VARIOUS CONDITIONS, THE FLUID FRICTION IS GIVEN BY THE FOLLOWING FORMULAS. FOR EACH CASE, FIND THE METRIC UNITS FOR THE COEFFICIENT OF VISCOSITY AND FIND A FORMULA FOR THE TERMINAL VELOCITY.

   a) $F_f = \epsilon v^3$ b) $F_f = \phi v^4$

2. A 2 KG KITTEN EXPERIENCES LAMINAR FLOW AS SHE DROPS FROM THE BALCONY OF A HIGH-RISE. HER TERMINAL VELOCITY IS A PERFECTLY SAFE -8 m/s.
   FIND: a) HER COEFFICIENT OF VISCOSITY.
   b) HER VELOCITY .4 SECONDS INTO HER FLIGHT.
   c) HER ACCELERATION AFTER .4 SECONDS.
   d) HER DISPLACEMENT AFTER .4 SECONDS.
   e) AFTER HOW MANY SECONDS WILL SHE REACH 80% OF HER TERMINAL VELOCITY?
   f) HOW FAR HAS SHE FALLEN IN THAT TIME?

3. FOR TURBULENT FLOW, $F_f = \beta v^2$. FIND AN EQUATION FOR THE VELOCITY AS A FUNCTION OF TIME FOR AN OSTRICH FALLING IN TURBULENT CONDITIONS.

4. A 150 lb NEANDERTHAL HAS A TERMINAL VELOCITY OF -125 MPH IN LAMINAR FLOW. ESTIMATE THE TERMINAL VELOCITY OF A .5 lb SQUIRREL FALLING UNDER SIMILAR CONDITIONS.

5. FALLING UNDER TURBULENT CONDITIONS, AN EIGHTEEN POUND CANINE HAS A TERMINAL VELOCITY OF -40 MPH. ESTIMATE THE TERMINAL VELOCITY OF A 150 lb PRIMATE FALLING IN SIMILAR CONDITIONS.

ANSWERS: $[\text{KG SEC}/\text{m}^2]$, $(-mg/\epsilon)^{1/3}$, $[\text{KG SEC}^2/\text{m}^3]$, $-(mg/\phi)^{1/4}$,
2.5 KG/s, -3.14 m/s, -6.07 m/s^2, $-.682$ m, 1.29 sec, -5.2 m,

$$V = -\left[\frac{m}{\beta t - \sqrt{\beta m/g}} + \sqrt{\frac{mg}{\beta}}\right]$$

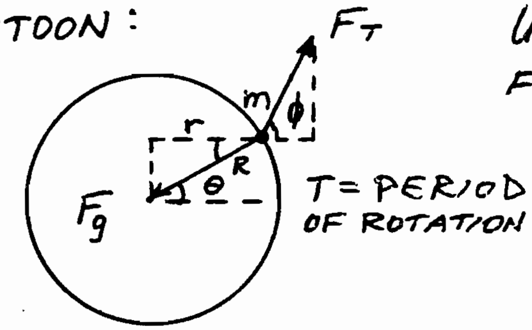
-18.7 MPH, -57 MPH

ENGINEERING REPORT

AT LATITUDES OTHER THAN THE POLES AND THE EQUATOR, PLUMB BOBS WILL NOT POINT TOWARD THE CENTER OF THE EARTH.

OBJECTIVE: TO DETERMINE THE DEVIATION OF A PLUMB BOB FROM VERTICAL AT LATITUDE θ.

CARTOON:



ULTIMATELY, WE DESIRE TO FIND THE DEVIATION:

$$\Delta = \phi - \theta$$

ANALYSIS:

A) FIND A FORMULA FOR THE LOCAL RADIUS OF ORBIT, r. ONLY R AND θ ARE ALLOWED IN OUR ANSWER.

B) FIND A FORMULA FOR THE LOCAL SPEED OF ROTATION, v. ONLY R, θ AND T ARE ALLOWED.

C) FIND A FORMULA FOR ϕ. ONLY θ, R, T AND g ARE ALLOWED.

CALCULATIONS:

DATA: LATITUDE OF T.P.H.S. $= 33°N$

$R = 6.378 \times 10^6$ m

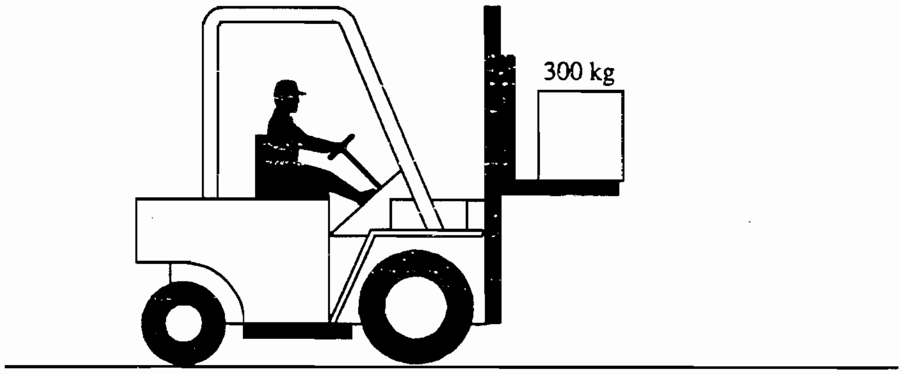
$T = 86,400$ SECONDS

$g = 9.8$ m/s^2

A) CALCULATE THE DEVIATION, IN MINUTES OF ARC, OF MR. HARVIE'S PLUMB BOB FROM VERTICAL.

B) THE TENSION IN THE STRING DOES NOT EQUAL THE TRUE WEIGHT OF THE BOB. CALCULATE THE PERCENT DIFFERENCE BETWEEN THE TENSION IN THE ROPE AND THE TRUE WEIGHT OF THE BOB.

$$\% = \left(\frac{F_T - F_g}{F_g}\right) 100$$



1. A 300-kg box rests on a platform attached to a forklift, as shown above. Starting from rest at time $t = 0$, the box is lowered with a downward acceleration of 1.5 m/s^2.

   (a) Determine the upward force exerted by the horizontal platform on the box as it is lowered. (2550 N)

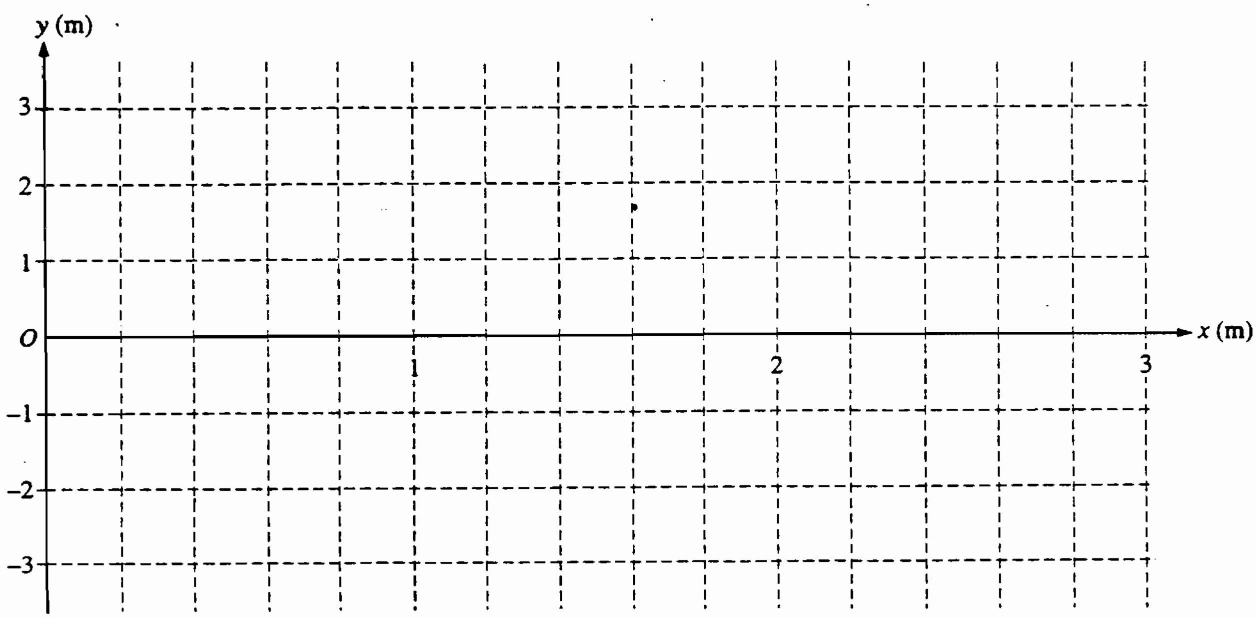
At time $t = 0$, the forklift also begins to move forward with an acceleration of 2 m/s^2 while lowering the box as described above. The box does not slip or tip over.

   (b) Determine the frictional force on the box. (600 N)

   (c) Given that the box does not slip, determine the minimum possible coefficient of friction between the box and the platform. (.236)

   (d) Determine an equation for the path of the box that expresses y as a function of x (and not of t), assuming that, at time $t = 0$, the box has a horizontal position $x = 0$ and a vertical position $y = 2$ m above the ground, with zero velocity. ($Y = -.75X + 2$)

   (e) On the axes below, sketch the path taken by the box.



2. A small body of mass m located near the Earth's surface falls from rest in the Earth's gravitational field. Acting on the body is a resistive force of magnitude kmv, where k is a constant and v is the speed of the body.

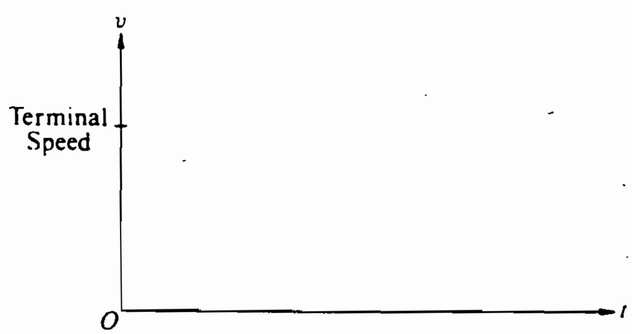
(a) On the diagram below, draw and identify all of the forces acting on the body as it falls.

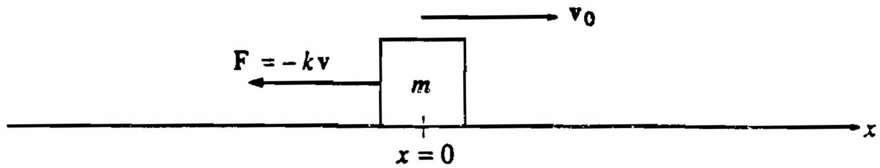
(b) Write the differential equation that represents Newton's second law for this situation.

(c) Determine the terminal speed v_T of the body. (VELOCITY, $v_T = -g/k$)

(d) Integrate the differential equation once to obtain an expression for the speed v as a function of time t. Use the condition that $v = 0$ when $t = 0$. ($v = -(g/k)(1-e^{-kt})$)

(e) On the axes provided below, draw a graph of the speed v as a function of time t.

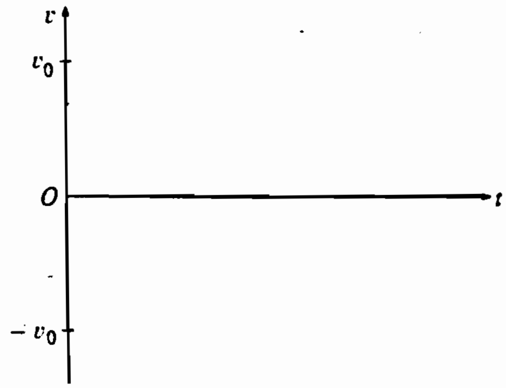




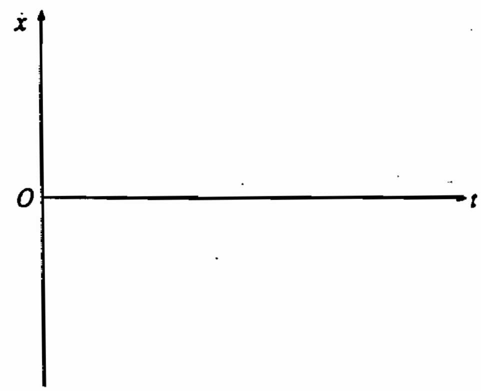
3. An object of mass m moving along the x-axis with velocity $\mathbf{v}$ is slowed by a force $\mathbf{F} = -k\mathbf{v}$, where k is a constant. At time $t = 0$, the object has velocity $\mathbf{v}_0$ at position $x = 0$, as shown above.

(a) What is the initial acceleration (magnitude and direction) produced by the resistance force? $(-kv_0/m)$

(b) Derive an equation for the object's velocity as a function of time t, and sketch this function on the axes below. Let a velocity directed to the right be considered positive. $(V = V_0 e^{-kt/m})$

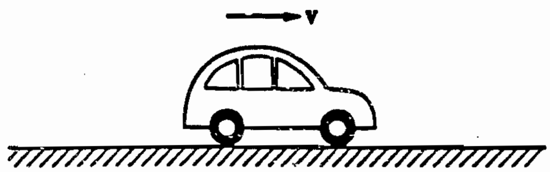


(c) Derive an equation for the distance the object travels as a function of time t and sketch this function on the axes below. $(x = (mV_0/k)(1 - e^{-kt/m}))$



(d) Determine the distance the object travels from $t = 0$ to $t = \infty$. $(x = mV_0/k)$

4.



A car of mass m, initially at rest at time $t = 0$, is driven to the right, as shown above, along a straight, horizontal road with the engine causing a constant force $\mathbf{F_0}$ to be applied. While moving, the car encounters a resistance force equal to $-k\mathbf{v}$, where $\mathbf{v}$ is the velocity of the car and k is a positive constant.

(a) The dot below represents the center of mass of the car. On this figure, draw and label vectors to represent all the forces acting on the car as it moves with a velocity $\mathbf{v}$ to the right.

•

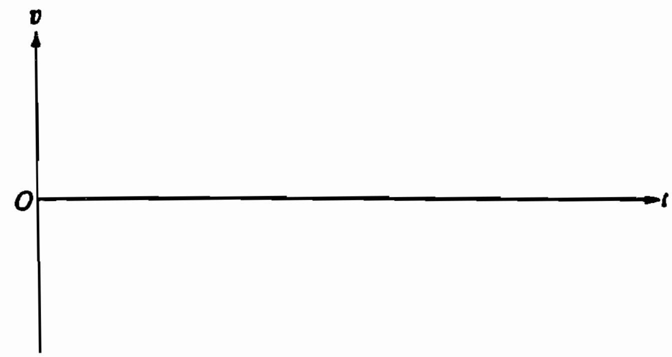
(b) Determine the horizontal acceleration of the car in terms of k, v, F_0, and m. $\left(a = \frac{F_0 - kv}{m}\right)$

($1\frac{1}{2}$ b) FIND THE TERMINAL VELOCITY OF THE CAR IN TERMS OF K AND F_0. $(v_T = F_0/k)$

(c) Derive the equation expressing the velocity of the car as a function of time t in terms of k, F_0, and m. $(v = (F_0/k)(1 - e^{-kt/m}))$

CONTINUE WITH VIGOR AND CELERITY ON THE DORSAL SIDE.

(d) On the axes below, sketch a graph of the car's velocity v as a function of time t. Label important values on the vertical axis.



(e) On the axes below, sketch a graph of the car's acceleration a as a function of time t. Label important values on the vertical axis.