Physics 2210
Fall Semester 2007
David Ailion

EXAM 2

1

Name: Solutions

unid: u _ _ _ _ _ _ _

Discussion TA (circle): Aaron Justin Mahamadou Monica Will

FOR THIS PROBLEM ALONE, CREDIT WILL BE GIVEN ONLY FOR THE CORRECT ANSWERS.
PLACE A CIRCLE OR BOX AROUND EACH ANSWER!!
REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!

(a) *[5 pts.]* An object has a mass of 37.0 kg. What is the mass of object on the moon where the gravitational acceleration, $g_{moon} = 1.67\ m/s^2$?

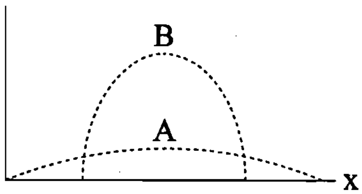
$\boxed{37.0\,kg}$

(b) *[5 pts.]* Which of the following quantities remains constant as a projectile moves in free fall? (Circle all that apply.)

Half credit is circle one and no others → 2 pts.
if any wrong → Ø

(i) Speed
(ii) Acceleration
(iii) Horizontal component of velocity
(iv) Vertical component of velocity
(v) None of the above

(c) *[5 pts.]* Two balls, projected at different time so they don't collide, have trajectories A and B as shown. Which of the following statements must be correct?



(i) v_{oB} must be greater than v_{oA}
(ii) Ball A is in the air for a longer time than ball B
(iii) Ball B is in the air for a longer time than ball A
(iv) Ball B has a greater acceleration than ball A
(v) Ball A has a greater acceleration than ball B

(d) *[5 pts.]* Two bodies, A and B, collide as shown in figures (a) and (b) below. Which statements are true.

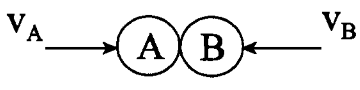


Fig. (a)

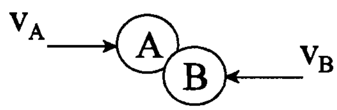


Fig. (b)

(i) They exert equal and opposite forces on each other in (a) but not in (b)
(ii) They exert equal and opposite forces on each other in (b) but not in (a)
(iii) They exert equal and opposite forces on each other in both (a) and (b)
(iv) The forces are equal and opposite in (a) but only the components of the forces parallel to the velocities are equal in (b)
(v) The forces are qual and opposite in (a) but only the componets of the forces perpendicular to the velocities are equal in (a)
(vi) The forces are not necessarily equal in either (a) or (b)

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EXAM 2

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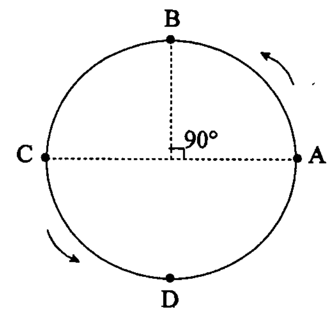
SHOW ALL WORK !!!
PLACE A CIRCLE OR BOX AROUND EACH ANSWER!!
REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES

A car is constrained to go around a circular racetrack of radius 200 m as shown. The upper part of the racetrack (A→B→C) is smooth. At C, the driver slams on his brakes such that the coefficients of static (μ_s) and kinetic (μ_k) friction are equal to 0.700 and 0.400 respectively. It is uniformly accelerated along the track in going from A→B→C, such that its speed at A is 16.0 m/s and at C is 25.0 m/s. In going from C→D→A, the car skids but remains on the circular track and eventually comes to rest.



(a) *[10 pts.]* Calculate the inward acceleration at B.
(b) *[10 pts.]* Calculate the distance from C that the car skids along C→D→A before coming to rest.

A) $V_C^2 = V_A^2 + 2a_t\Delta X \Rightarrow a_t = \dfrac{V_C^2 - V_A^2}{2\Delta X}$; $\Delta X = \frac{1}{2}$ circumference $= \pi R$

$\Rightarrow a_t = \dfrac{25^2 - 16^2}{2\pi(200)} = 0.2936\ \text{m/s}^2$

$V_B^2 = V_A^2 + 2a_t\Delta X$; $\Delta X = \frac{1}{4}$ circumference $= \dfrac{\pi R}{2}$

$V_B = \sqrt{16^2 + 2(0.2936)\left(\dfrac{\pi(200)}{2}\right)} = 20.987\ \text{m/s}$

$a_c = \dfrac{V_B^2}{R} = \dfrac{20.987}{200} = \boxed{2.202\ \text{m/s}^2}$

B) $V_f^2 - V_i^2 = 2a\Delta X$

$\Sigma F = ma \Rightarrow F_f = -ma \Rightarrow \mu_k N = ma$; skids

$N - mg = 0 \Rightarrow N = mg$

$-\cancel{m}a = \mu_k \cancel{m}g \Rightarrow a = -\mu_k g = -3.92\ \text{m/s}^2$

$0 - V_C^2 = 2\mu_k g\Delta X \Rightarrow \Delta X = \dfrac{-V_C^2}{-2\mu_k g}$

$\Delta X = \dfrac{25^2}{2(0.4)(9.8)} = \boxed{79.7\ \text{m}}$

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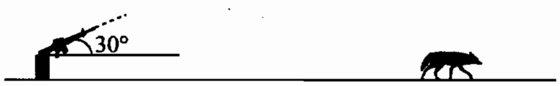
A bullet is fired at a small stationary animal 300 m away. The animal is at exactly the same height as the gun.

(a) *[8 pts.]* In order to hit the animal, the bullet is fired at an angle of 30° with respect to the horizontal. What is the initial speed of the bullet as it leaves the barrel? Assume that there is no wind.

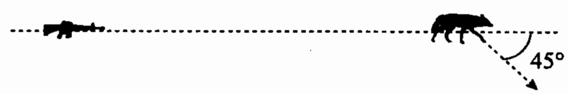
(b) *[6 pts.]* Now, assume that the animal is moving away from the hunter at 10.0 m/s. If the shooter uses the same gun, ammunition and firing angle as in part (a), by how much will he miss the animal?

(c) *[6 pts.]* Suppose that, in addition to the motion described in part (b), the animal has a velocity component perpendicular to the line joining the hunter and the initial position of the animal. Furthermore, this velocity is also equal to 10.0 m/s. See figure below. By how much will the bullet miss the target?

Side View



Top View



(a) the range equation gives

$$R = \frac{v_0^2 \sin(2\theta)}{g} \Rightarrow v_0 = \sqrt{\frac{Rg}{\sin(2\theta)}} = \sqrt{\frac{(300\,m)(9.81\,m/s^2)}{\sin(2(30°))}}$$

$$= \underline{58.3\ m/s}$$

b) $x_f = v_{0x} t \Rightarrow t = \frac{x_f}{v_{0x}} = \frac{(300\,m)}{(58.3\,m/s)\cos(30°)} = 5.94\,s$

the animal travel $x = vt = (10\,m/s)(5.94\,s) = \underline{59.4\ m}$

c) Now the animals velocity is

$$v = \sqrt{v_x^2 + v_y^2} = \sqrt{(10\,m/s)^2 + (10\,m/s)^2} = 14.14\,m/s$$

so

$$x = vt = (14.14\,m/s)(5.94\,s) = \underline{84.0\,m}$$

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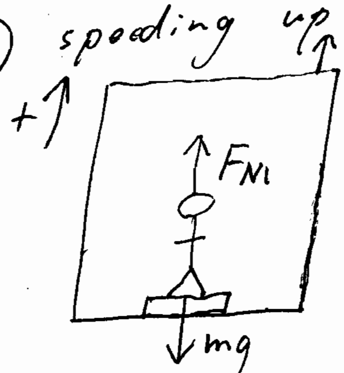
A person stands on a scale in an ascending elevator. The elevator starts from the 4th floor with an acceleration that is constant until the elevator gets halfway to the 5th floor. Between this point and the 5th floor it slows down with a constant acceleration whose magnitude is the same as when it started. For the first half of the elevator's motion, the scale's reading is 560 N. For the second half, the scale's reading is 380 N.

(a) *[10 pts.]* Calculate the mass of the person in kg.
(b) *[10 pts.]* Calculate the magnitude of the acceleration.

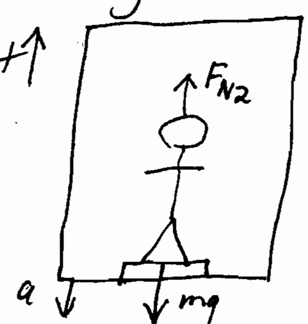
Using an inertial frame of reference,

a.) speeding up: $\Sigma F = ma$



$F_{N1} - mg = ma$
$F_{N1} = mg + ma$ (1)
$F_{N1} = 560N$

slowing down: $\Sigma F = -ma$



$F_{N2} - mg = -ma$
$F_{N2} = mg - ma$ (2)
$F_{N2} = 380N$

Add equation (1) to equation (2) to get

$F_{N1} + F_{N2} = 2mg$

$\frac{560N + 380N}{2(9.8\ m/s^2)} = \boxed{m = 48.0\ kg}$

b.) Plug m into (1) or (2) and solve for a.

Using (1), $560N = mg + ma$

$\frac{560N}{m} - g = a$

$\frac{560N}{47.959kg} - 9.8\ m/s^2 = a$

$\boxed{a = 1.88\ m/s^2}$

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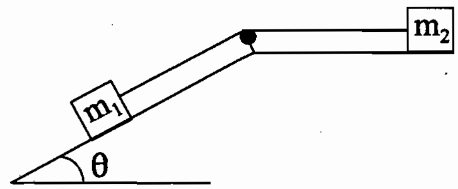
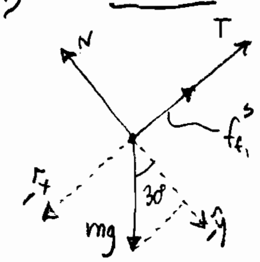
Consider a block of mass $m_1 = 6.00$ kg on an inclined plane that makes an angle θ with respect to the horizontal. The mass m_1 is connected by a light string over a frictionless pulley to a "lighter" mass, $m_2 = 2.00$ kg, that sits on a horizontal plane. The coefficient of kinetic friction for the contact surface between each mass and the plane is given by $\mu_k = .200$. Neglect the mass of the string and pulley.

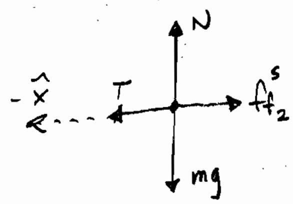


(a) *[6 pts.]* Draw free body diagram for each mass.
(b) *[6 pts.]* If the angle θ is 30°, the system is on the verge of overcoming static friction. Calculate μ_s, the coefficient of static friction. Assume both blocks have the same value of μ_s.
(c) *[8 pts.]* Calculate the tension T in the string once the blocks start to slide.

a) mass #1



mass #2



b) mass #1

ΣF_x : $T + f_{f_1}^s - m_1 g \sin 30° = 0$ not moving $a = 0$

ΣF_y : $N - m_1 g \cos 30° = 0$ so $N = m_1 g \cos 30°$

condition is; max friction when $\boxed{f_f^s = \mu_s N.}$ thus,

finally for mass #1 $T + \mu_s m_1 g \cos 30° - m_1 g \sin 30° = 0$

we dont know T, but we can get a relation for it thru mass #2 ... $\longrightarrow$

#5 cont.

mass #2

$\sum F_x$: $-T + f_2^s = 0$ again no motion $a = 0$

$\sum F_y$: $N - m_2 g = 0$ so $N = m_2 g$ thus,

$-T + \mu_s m_2 g = 0$ so $T = \mu_s m_2 g$ plugging this into the relation for mass #1 we get.

$$\mu_s m_2 g + \mu_s m_1 g \cos 30° - m_1 g \sin 30° = 0$$

$$\mu_s (m_2 g + m_1 g \cos 30°) - m_1 g \sin 30° = 0$$

$$\boxed{\mu_s = \frac{m_1 g \sin 30°}{m_2 g + m_1 g \cos 30°}} = \frac{6(9.8)\sin 30°}{2(9.8) + 6(9.8)\cos 30°}$$

$$\boxed{\mu_s = .417}$$

c) now for the motion, meaning $a \neq 0$ and μ_k is used instead of μ_s.

mass #1

$$T + f_1^k - m_1 g \sin 30° = -m_1 a$$

$f^k = \mu_k N$ where $N = m_1 g \cos 30°$

$$T + \mu_k m_1 g \cos 30° - m_1 g \sin 30° = -m_1 a$$

we need acceleration to find T, we use the fact that they both have the same acceleration.

mass #2

$-T + \mu_k N = -m_2 a$ with $N = m_2 g$

$-T + \mu_k m_2 g = -m_2 a$ with $a = \frac{T - \mu_k m_2 g}{m_2}$

$$T + \mu_k m_1 g \cos 30° - m_1 g \sin 30° = -m_1 \left(\frac{T - \mu_k m_2 g}{m_2} \right) = -T \frac{m_1}{m_2} + \mu_k m_1 g$$

$$T\left(1+\frac{m_1}{m_2}\right) + \mu_k m_1 g \cos 30^\circ - m_1 g \sin 30^\circ = \mu_k m_1 g$$

$$\boxed{T = \frac{\mu_k m_1 g + m_1 g \sin 30^\circ - \mu_k m_1 g \cos 30^\circ}{\left(1+\frac{m_1}{m_2}\right)}}$$

$$= \frac{.2(6)9.8 + 6(9.8)\sin 30^\circ - .2(6)9.8\cos 30^\circ}{1+\frac{6}{2}}$$

$$T = \frac{30.9755}{4} = \boxed{7.75\,N}$$