GTÜ
PHYS 121 2018-2019 Fall Semester
First Midterm
90 Minutes

1	2	3	4	5	Total

Name: ..... Student No: ..... /Lecturer.....

Sınav sırasında hesap makinası kullanılması serbest, ancak alışverişi yasaktır.
Gerekirse g=9,80 m/s² olarak alınız. Her bir soru 20 puandır. **Başarılar dileriz.**
You can use calculator during the exam but exchanging is not allowed.
Take g = 9,80 m/s² if necessary. Each question worth 20 points. **Good luck.**

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1. **a)** A car is driven 225 km west and then 98 km southwest (45°). What is the displacement of the car from the point of origin (magnitude and direction)? Draw a diagram.
b) Two vectors are given as **A** = 3**i**-2**j**, **B** = 2**i**+α**j**
For these two vectors to be perpendicular to each other, α =?

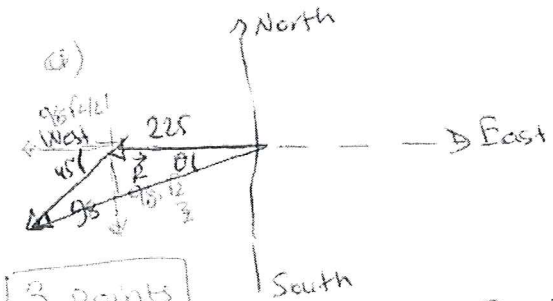
c) Using the value you found for α in part (*b*), evaluate the followings:
2**A**-**B** =? 3**A** . 2**B** =?

a) Bir araba batıya 225 km ve sonrasında güneybatıya (45°) 98 km ilerlemiştir. Arabanın toplam yer değiştirmesinin büyüklüğü ve yönü nedir? Grafik çizerek gösteriniz.

b) İki vektör **A** = 3**i**-2**j**, **B** = 2**i**+α**j** olarak verilmiştir.
Bu iki vektörün birbirine dik olması için α =?

c) α için (*b*) şıkkında bulduğunuz değeri kullanarak aşağıdaki işlemleri yapınız.
2**A**-**B** =? 3**A** . 2**B** =?

a)



3 points

$225 + \frac{98\sqrt{2}}{2} = 294.3$ km west

$\frac{98\sqrt{2}}{2} = 69.3$ km South

2 points

$R = \sqrt{(294.3)^2 + 69.3^2} = 302$ km

$\theta = \tan^{-1}\left(\frac{69.3}{294.3}\right) = 13°$, 302 km, 13° degree South of West

2 points

2 points ≡ Components

b) $\vec{A}\cdot\vec{B} = (3\hat{i}-2\hat{j})\cdot(2\hat{i}+\alpha\hat{j}) = 6-2\alpha = 0 \Rightarrow \alpha = 3$, $\vec{B} = 2\hat{i}+3\hat{j}$

2 points 2 points

c) $2\vec{A}-\vec{B} = 2(3\hat{i}-2\hat{j}) - (2\hat{i}+3\hat{j}) = 6\hat{i}-4\hat{j}-2\hat{i}-3\hat{j} = 4\hat{i}-7\hat{j}$ 2 points

2 points

$3\vec{A}\cdot 2\vec{B} = 6(\vec{A}\cdot\vec{B}) = 0$ since $\vec{A}\,\vec{B}=0$ from the condition for orthogonality.

3 points

2. An object moves along the x-axis according to the equation $x(t)=(t^3-2.00t)$m.

Determine
a) the average speed between t=2.00 s and t=3.00 s,
b) the instantaneous speed at t=2.00 s and t=3.00 s,
c) the average acceleration between t=2.00 s and t=3.00 s, and
d) the instantaneous acceleration at t= 2.00 s and t=4.00 s

$x(t)=(t^3-2,00t)$m denklemine göre x-ekseninde hareket eden bir parçacığın;
a) t=2,00 s ile t=3,00 s arasında ortalama hızını,
b) t=2,00 s ve t=3,00 s 'de ani hızını,
c) t=2,00 s ile t=3,00 s arasında ortalama ivmesini,
d) t= 2,00 s ve t=4,00 s 'de ani ivmesini
hesaplayınız.

a) $x(t) = (t^3 - 2.00\,t)\,m$

$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}$

for $t = 2.00$s ~~$x_{t=2} = 2^3 - 2$~~

for $t = 2$s $\quad x_{t=2} = [(2)^3 - 2.00(2)]m = 4m$

for $t = 3$s $\quad x_{t=3} = [(3)^3 - 2.00(3)]m = 21m$

$\bar{v} = \frac{x_{t=3} - x_{t=2}}{t_3 - t_2} = \frac{21m - 4m}{3s - 2s} = \frac{17m}{1s} = 17\,m/s$ (5)

b) $v = \frac{dx}{dt} = \frac{d}{dt}(t^3 - 2.00\,t) = [3t^2 - 2.00]\,m/s$

for $t = 2.00$ s $\Rightarrow$ $v_{t=2} = [3(2)^2 - 2]\,m/s = 10\,m/s$ (2,5)

for $t = 3.00$s $\Rightarrow$ $v_{t=3} = [3(3)^2 - 2]\,m/s = 25\,m/s$ (2,5)

c) $\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i} \Rightarrow \bar{a} = \frac{v_{t=3} - v_{t=2}}{t_3 - t_2} = \frac{(25 - 10)\,m/s}{(3 - 2)s} = 15\,m/s^2$ (5)

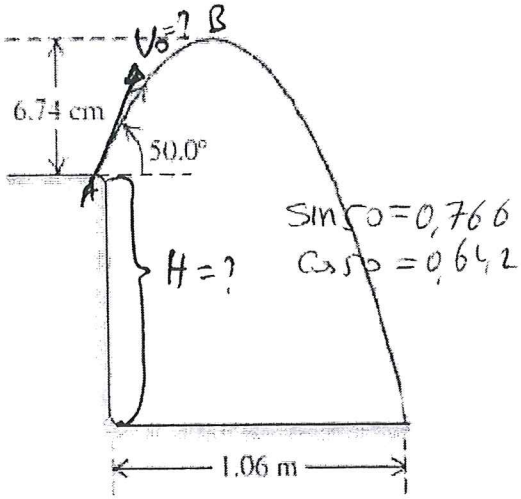
d) $a = \frac{dv}{dt} = \frac{d}{dt}[3t^2 - 2.00]\,m/s = [6t]\,m/s^2$

for $t = 2.00$ s $\Rightarrow$ $a_{t=2} = (6t)\,m/s^2 = 12\,m/s^2$ (2,5)

for $t = 4.00$s $\Rightarrow$ $a_{t=3} = (6t)\,m/s^2 = 24\,m/s^2$ (2,5)

3. Bir çekirge dikey bir uçurumun ucundan havaya sıçrıyor (Şekilde gösterildiği gibi).
(a) Çekirgenin başlangıç süratini bulunuz.
(b) Uçurumun yüksekliğini bulunuz.

A grasshopper leaps into the air from the edge of a vertical cliff, as shown in figure.
Find (a) the initial speed of the grasshopper and
(b) the height of the cliff.



(10) a) B'de $V_y = 0$

$V_y^2 = V_{oy}^2 + 2g\Delta y \Rightarrow V_{oy}^2 = 2g(6,74\times10^{-2})$

$V_{oy}^2 = 1,321 \Rightarrow \boxed{V_{oy} = 1,149\ m/s}$ (6)

$V_{oy} = V_o \sin 50 \Rightarrow V_o = \frac{V_{oy}}{\sin 50} = \frac{1,149}{0,766} = 1,50\ m/s$

$\boxed{V_o = 1,50\ m/s}$ (4)

Veya $h_{max} = \frac{V_{oy}^2}{2g} = \frac{(V_o \sin 50)^2}{2g} \Rightarrow V_o^2 = \frac{2gh_{max}}{\sin 50^2} \Rightarrow V_o = 1,50$

Veya $y = y_o + V_{oy}t - \frac{1}{2}gt^2$, $V_y = V_{oy} - gt$ } B'de $V_y = 0$ $V_y = V_{oy} - gt_B$

$V_{oy} = g t_B$

$h = (gt_B)\cdot t_B - \frac{1}{2}g t_B^2$

$h = \frac{1}{2}g t_B^2 \Rightarrow t_B = \frac{2h}{g} = \frac{2\times6,74\times10^{-2}}{9,8} \Rightarrow t_B = 0,117s$

$V_{oy} = g\cdot t_B = (9,8)(0,117) = 1,149\ m/s \Rightarrow V_o = \frac{V_{oy}}{\sin 50} \Rightarrow V_o = 1,50 m/s$

(10) b)

$V_{ox} = V_o \cos 50 = 0,964\ m/s$

$x = V_{ox}\, t \Rightarrow t = \frac{x}{V_{ox}} = \frac{1,06m}{0,964\ m/s} \Rightarrow \boxed{t = 1,1s}$ Spun

$H = V_{oy}\, t - \frac{1}{2}gt^2 = (1,15\ m/s)(1,1s) - \frac{1}{2}(9,8\ m/s^2)(1,1)^2 = 4,664m$

$\boxed{H = 4,66\ m}$ Spun

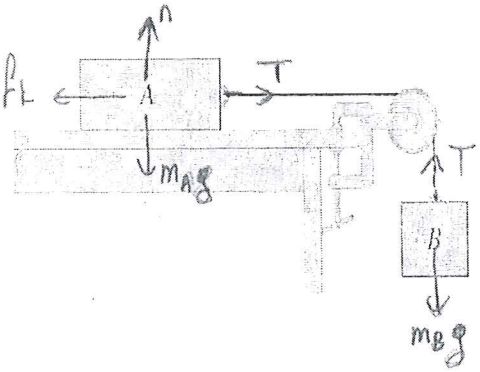
4. Consider the system shown in the figure. Block A weighs 45.0 N and block B weighs 25.0 N. Once block B is set into downward motion, it descends at a constant speed. (a) Draw free body diagrams for both blocks, show all forces and accelerations on the diagrams. (b) Calculate the coefficient of kinetic friction between block A and the tabletop. (c) A cat, also of weight 45.0 N, falls asleep on top of block A. If block B is now set into downward motion, what is its acceleration (magnitude and direction)?

Şekilde gösterilen sistemde A bloğunun ağırlığı 45,0 N ve B bloğunun ağırlığı 25,0 N'dur. B bloğunun aşağı yönde hareketi sağlandığında, sabit hızla inmektedir. (a) Her iki blok için serbest cisim diyagramları çizin, diyagramlar üzerinde tüm kuvvetleri ve ivmeleri gösterin. (b) Blok A ve masa yüzeyi arasındaki kinetik sürtünme katsayısını hesaplayın. (c) 45,0 N ağırlığındaki bir kedi A bloğunun üstünde uyuyakalmıştır. B bloğu bir miktar aşağıya doğru hareket ettirilip sistem serbest bırakılırsa, bloğun ivmesi (büyüklüğü ve yönü) ne olur?

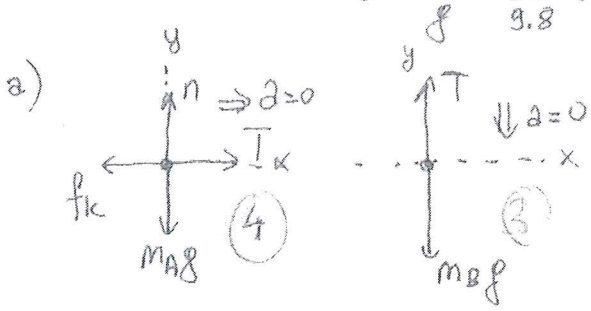
Sol'n:

$$m_A = \frac{w_A}{g} = \frac{45}{9.8} = 4.59\ kg = m_{cat}$$

$$m_B = \frac{w_B}{g} = \frac{25}{9.8} = 2.55\ kg$$



a)



b) Since v is constant, a is zero ($a=0$) (Newton 1st & 2nd law)

For block A

$\Sigma F_x = ma_x$

$\Sigma F_y = m_A a_y$

since $a=0$

$T - F_k = m_A \cdot 0$

$f_k = T$

For block B

$\Sigma F_y = m_B a_y$

$m_B g - T = m_B \cdot 0$

$T = m_B g = w_B = 25N$

$f_k = T = 25N$ (2)

$\Sigma F_y = 0$

$n - m_A g = 0$

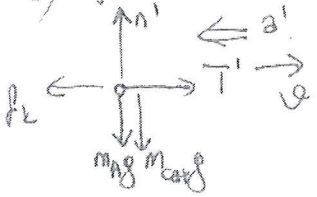
$n = m_A g$

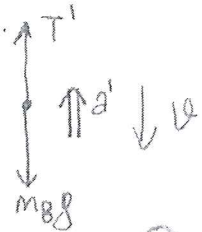
$f_k = n \mu_k$

$f_k = m_A g \mu_k = 25N$

$$\mu_k = \frac{25N}{m_A g} = \frac{25N}{45N} = \frac{5}{9} = 0,556$$ (5)

c) After the cat





$f_k - T' = (m_A + m_{cat}) a'$ (1)

$f_k = n' \mu_k = (m_A g + m_c g) \mu_k$

$= (45 + 45)\frac{5}{9}$

$= 50N$ (1)

$50 - T' = (m_A + m_{cat}) a'$

$50 - (m_B a' + 25) = (m_A + m_{cat}) a'$

$25 = (m_A + m_{cat} + m_B) a'$

$$a' = \frac{25}{4,59 + 4,59 + 2,55} = \frac{25\ N}{11.73\ kg}$$

$a = 2,13\ m/s^2$ (3) → direction 1, result 2

(In the direction of the frictional force)

(for B it is $-\hat{j}$ direction)

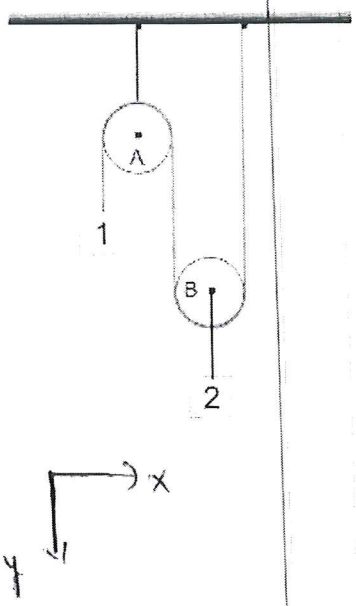
$T' - m_B g = m_B a'$ (1)

$(T' \neq T)$ at the first part

$T' - 25 = m_B a'$

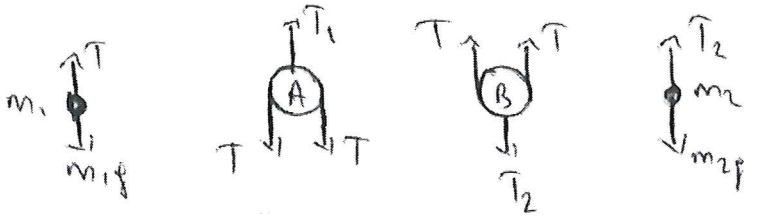
5. Consider the system in the figure. Rope and the pulleys are massless.

a)- What is the relation between the accelerations of the blocks?
b)- Find the accelerations of the blocks in terms of m_1, m_2, and g.



Yandaki şekilde verilen sistemi göz önüne alınız.
Makaralar ve ipler kütlesizdir.

a) Blokların ivmeleri arasında nasıl bir ilişki vardır?
b) Blokların ivmelerini m_1, m_2, ve g cinsinden bulunuz.



a) As pulley B, hence m_2 moves by Δy_2,
m_1 should move by $2\Delta y_2$ in opposite direction.

$\Rightarrow \Delta y_1 = -2\Delta y_2$, $a = \frac{d^2y}{dt^2}$

$\Rightarrow \boxed{a_1 = -2a_2}$ (8)

b) - Apply $\sum F_y = m a_y$ for both m_1 and m_2.
From the FBDs above:

$T_1 = 2T$, $T_2 = 2T$

For m_1:
$m_1 g - T = m_1 a_1 \Rightarrow m_1 g - T = -2m_1 a_2 \Rightarrow T = m_1 g + 2m_1 a_2$

$\Rightarrow 2T = 2m_1 g + 4m_1 a_2$ (1)

For m_2: $m_2 g - 2T = m_2 a_2$ (4)

$\Rightarrow 2T = m_2 g - m_2 a_2$ --- (2)

$\Rightarrow$ (1) = (2) $\Rightarrow m_2 g - m_2 a_2 = 2m_1 g + 4m_1 a_2$ (4)

$\Rightarrow (4m_1 + m_2) a_2 = (m_2 - 2m_1) g \Rightarrow \boxed{a_2 = \frac{(m_2 - 2m_1)}{(4m_1 + m_2)} g}$

Now: $a_1 = -2a_2 \Rightarrow \boxed{a_1 = \frac{2(2m_1 - m_2)}{(4m_1 + m_2)} g}$ (4)