

MIDTERM EXAM-1 — v1

PHYS 201 (Spring 2018), 02/13/18

Name:

Solution Key

Lab-Sect. no.:

Signature:

In taking this exam you confirm to adhere to the Aggie Honor Code:
"An Aggie does not lie, cheat, steal or tolerate those who do."

Duration: 90 minutes

Show all your work for full/partial credit!

Include the correct units in your final answers for full credit!

Unless otherwise stated, quote your results in SI units!

1.) Multiple Choice

(21 pts.)

For each statement below, circle the correct answer (A, B, or C, no reasoning required).

- (a) The magnitude of the difference of two vectors
(A) is always smaller (B) is always larger (C) can be either way
compared to the magnitude of the sum of the same two vectors.
- (b) If in a 1-dimensional motion the velocity of an object is negative and its acceleration positive, the object
(A) speeds up (B) slows down (C) can go either way.
- (c) When the speed of a car is doubled, its stopping distance increases by a factor of
(A) $\sqrt{2}$ (B) 2 (C) 4
(assume a constant deceleration).
- (d) The direction of the centripetal acceleration in uniform circular motion is
(A) constant (B) toward the center of the circle (C) tangential to the circle.
- (e) When crossing a river in a boat, the fastest way to do this is by aiming the boat's velocity (relative to the water)
(A) somewhat upstream (B) directly across (C) somewhat downstream.
- (f) When you are standing on a scales in an elevator that is moving downward and in the process of stopping, the scales will show your weight to be
(A) smaller than (B) equal to (C) larger than
your true weight.
- (g) The magnitude of the normal force on a box at rest on an inclined plane (due to friction) is
(A) smaller than (B) equal to (C) larger than
the magnitude of its weight force (no other external forces are present).

$$v^2 = v_0^2 + 2ax$$

No.	Points
1	SE
2	SE
3	AS
4	AS
5	BK
Sum	

2.) Free Fall

(21 pts.)

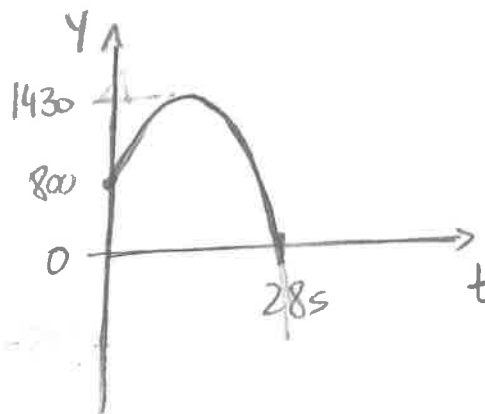
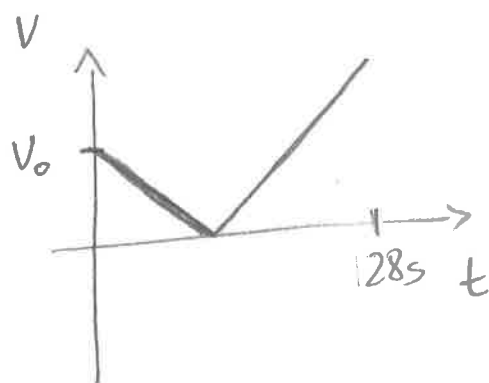
A rocket going straight up at a speed of 250 mph decouples its stage-1 boosters at a height of 0.8 km above the ground.

- What is the maximal height above ground reached by the boosters?
- After decoupling, how long does it take for the boosters to hit the ground?
- Sketch the graphs for the boosters' speed and height as a function of time.

$$\begin{aligned}
 (a) \quad v^2 &= v_0^2 - 2g \Delta y \quad v = 0, \quad v_0 = \frac{250}{2.25} = 111.1 \text{ m/s} \\
 \Delta y &= 800 \text{ m} \\
 \Rightarrow \Delta y &= \frac{v_0^2}{2g} = 630 \text{ m} \\
 \Rightarrow \text{maximal height above ground} &= 630 + 800 = \boxed{1430 \text{ m}}
 \end{aligned}$$

$$\begin{aligned}
 (b) \quad \text{way up: } v &= v_0 - g t_1 \Rightarrow t_1 = \frac{v_0}{g} = 11.34 \text{ s} \\
 \text{way down: } y &= y_0 + v_0 t_2 - \frac{1}{2} g t_2^2 \Rightarrow t_2 = \sqrt{\frac{-2y}{g}} = 17.08 \text{ s} \\
 v_0 &= 0, \quad y_0 = 0 \\
 y &= -1430 \text{ m} \\
 \boxed{t_{\text{tot}} = t_1 + t_2} &= \boxed{28.4 \text{ s}}
 \end{aligned}$$

(c)



3.) *Projectile Launch*

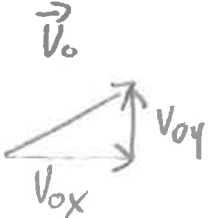
(16 pts.)

A kid throws a rock toward a tall vertical wall a horizontal distance of 15 m away, launching it at an angle of ~~45~~³⁵° above the horizontal. The rock hits the wall after a flight time of ~~2~~^{1.3} s.

(a) Calculate the speed of the rock at launch.

(b) At what vertical displacement relative to the launch point does the rock hit the wall?

(a)



$$v_{0x} = \frac{\Delta x}{\Delta t} = \frac{15}{1.3} = 11.54 \text{ m/s}$$

$$v_0 \cos \theta_0 = v_{0x}$$

$$\Rightarrow \boxed{v_0 = \frac{v_{0x}}{\cos \theta_0} = 14.09 \text{ m/s}}$$

(b)

$$\Delta y = y_0 + v_{0y}t - \frac{1}{2}gt^2$$

$$= 2.2 \text{ m}$$

$$y_0 = 0, t = 2s$$

$$v_{0y} = v_0 \sin \theta_0 = 8.08 \text{ m/s}$$

4.) Friction Forces

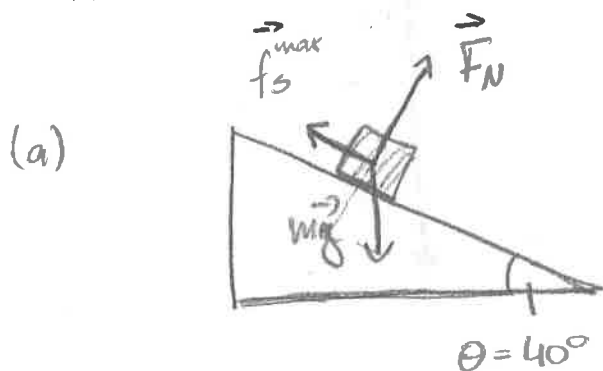
(21 pts.)

A box of mass 16 kg is resting on a ramp with a rough surface and variable inclination angle above the horizontal. When the angle is slowly increased, the box starts to move when the angle reaches 40° . Once moving (at that same inclination angle), the box is found to slide down along the 1.2 m long ramp within 1.5 s .

(a) What is the static friction coefficient between the box and the ramp surface?

(b) What is the acceleration of the box once it is moving?

(c) What is the kinetic friction coefficient between the box and the ramp surface?



$$0 = \sum F_x = f_s^{\max} - mg \sin \theta$$

$$0 = \sum F_y = F_N - mg \cos \theta$$

$$\Rightarrow F_N = mg \cos \theta, \quad f_s^{\max} = \mu_s F_N$$

$$\Rightarrow 0 = \mu_s F_N - mg \sin \theta = \mu_s mg \cos \theta - mg \sin \theta$$

$$\Rightarrow \boxed{\mu_s = \frac{\sin \theta}{\cos \theta} = 0.839}$$

(b) along ramp: $x = x_0 + v_{0x}t + \frac{1}{2}at^2$
 $= \frac{1}{2}at^2 \Rightarrow a = \frac{2x}{t^2} = 1.07 \frac{\text{m}}{\text{s}^2}$

(c) $ma_x = -f_k + mg \sin \theta$

$$\Rightarrow f_k = mg \sin \theta - ma_x = m(g \sin \theta - a_x)$$

$$= \mu_k F_N = \mu_k mg \cos \theta$$

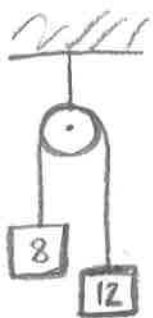
$$\Rightarrow \boxed{\mu_k = \frac{\sin \theta}{\cos \theta} - \frac{a_x}{g \cos \theta} = 0.697}$$

5.) Tension Force

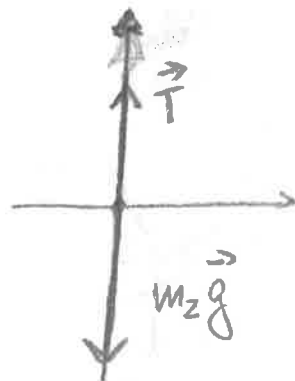
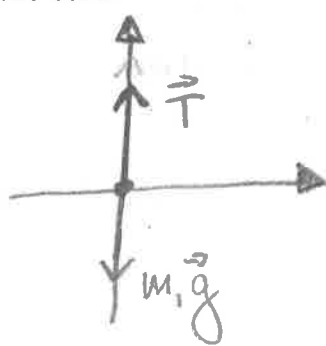
(21 pts)

A massless cord runs over a frictionless pulley, with a box of 8 kg attached to one end and a box of 12 kg attached to the other end.

- (a) Draw the free-body diagram of each box.
 (b) Calculate the acceleration of the lighter box (including its direction).
 (c) Calculate the tension force in the cord.



(a)



(b) box-1 : $m_1 a_1 = T - m_1 g$
 box-2 : $m_2 a_2 = T - m_2 g$
 $a_1 = -a_2$

$$\Rightarrow T = m_2 a_2 + m_2 g = -m_2 a_1 + m_2 g = -m_2 (a_1 + g)$$

$$\Rightarrow m_1 a_1 = -m_2 (a_1 + g) - m_2 g = -m_2 a_1 + (m_2 - m_1) g$$

$$(m_1 + m_2) a_1 = (m_2 - m_1) g$$

$$\Rightarrow \boxed{a_1 = \frac{(m_2 - m_1)}{(m_1 + m_2)} g = \frac{4}{20} g = 1.96 \text{ m/s}^2} \text{ up}$$

(c) $\boxed{T = -m_2 (a_1 + g) = 94.1 \text{ N}}$