solutions

Physics 2414
Midterm #2 – Spring 2013

Version A

Multiple choice (6 points each)

1) A horizontal force accelerates a box from rest across a horizontal surface (friction is present) at a constant rate. The experiment is repeated, and all conditions remain the same with the exception that the horizontal force is doubled. What happens to the box's acceleration?

(a) It increases to more than double its original value
b. It increases to exactly double its original value
c. It increases to less than double its original value
d. Cannot be determined since the mass of the box is unknown
e. Cannot be determined since the coefficient of friction is unknown

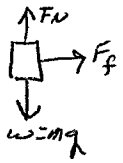
example
let $F = 2\,N$
$F_f = 1\,N$
$m = 1\,kg$
$a_1 = 1\,m/s^2$
$a_2 = 3\,m/s^2$

$F - F_f = ma_1$
$2F - F_f = ma_2$
$\frac{a_2}{a_1} = \frac{2F - F_f}{F - F_f} = \frac{2 - F_f/F}{1 - F_f/F}$
always > 2

2) During an investigation of a traffic accident, police find skid marks 90.0 m long. They determine the coefficient of friction between the car's tires and the roadway to be 0.500. Determine the speed of the car when the brakes were applied

a. 9.49 m/s
b. 21.0 m/s
(c.) 29.7 m/s
d. 33.2 m/s
e. 42.0 m/s

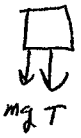
$v_f^2 = v_0^2 + 2a\Delta x$
$0 = v_0^2 - 2(4.9\,m/s^2)(90\,m)$
$v_0 = 29.7\,m/s$



$F_N - mg = 0$
$F_f = ma$
$\mu_k F_N = ma$
$\mu_k mg = ma$
$a = \mu_k g = 4.9\,m/s^2$

3) A stone, of mass m, is attached to a string and whirled in a vertical circle of radius r. At the exact top of the path, the tension in the string is 3 times the stone's weight. The stone's speed at this point is given by

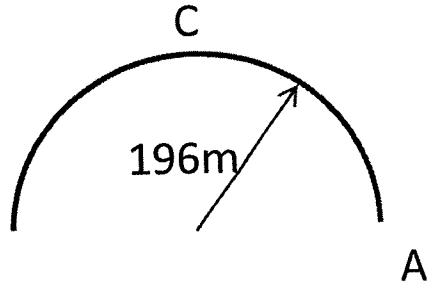
(a.) $2\sqrt{gr}$
b. $\sqrt{2gr}$
c. $\sqrt{gr}$
d. 2gr
e. gr



$T + mg = ma_c = \frac{mv^2}{r}$
$3mg + mg = \frac{mv^2}{r}$
$4gr = v^2$
$v = 2\sqrt{gr}$

4) A car at the Indianapolis 500 accelerates uniformly from the pit area (A) going from rest to 315 km/h in a semicircular arc with a radius of 196 m (B). If the curve is flat, what would the coefficient of static friction between the tires and the road need to be in order to keep the car from slipping when it is halfway through the turn (C)?

a. 1.67
(b.) 2.09
c. 1.53
d. 2.88
e. 1.23



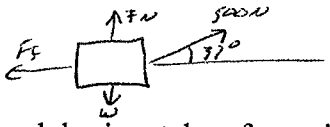
$315\,\frac{km}{h} = 87.5\,m/s$

Find a_T at point B
$v_f^2 = 0 + 2a_T\left(\frac{2\pi r}{2}\right)$
$(87.5\,m/s)^2 = 2\pi(196)a_T$
$a_T = 6.22\,m/s^2$

v at point C
$v_f^2 = 0 + 2(6.22\,m/s^2)\left(\frac{2\pi r}{4}\right)$
$v_f = 62.9\,m/s$
$a_c = \frac{v^2}{r} = \frac{(62.9\,m/s)^2}{}$ $= 19.54\,m/s^2$

$a = \sqrt{(a_T)^2 + (a_c)^2}$
$= \sqrt{(6.22\,m/s^2)^2 + (19.54\,m/s^2)^2}$
$a = 20.5\,m/s^2$

$F_f = ma$
$\mu_s mg = ma$
$\mu_s = \frac{a}{g} = \frac{20.5\,m/s^2}{9.8\,m/s^2} = 2.09$



x: $T\cos 37^\circ - F_f = ma$

y: $F_N - w + T\sin 37^\circ = 0$

y: $F_N = mg - T\sin 37^\circ = 91.1\,N$

5) A student pulls a box on a rough horizontal surface with a force of 500 N in a direction 37° from the horizontal. If the mass of the box is 40.0 kg and the coefficient of kinetic friction between the box and the surface is 0.4, what is the acceleration of the box?

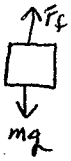
a. 7.7 m/s^2
b. 8.2 m/s^2
c. 6.3 m/s^2
(d) 9.1 m/s^2
e. 11.8 m/s^2

x: $T\cos 37^\circ - \mu_k(F_N) = ma$

$500\cos 37^\circ - 0.4(91.1\,N) = 40\,a$

$a = 9.07\,m/s^2$

6) A heavy brick and a light feather fall to earth and both experience air friction. Eventually both the brick and feather reach a constant velocity while still in the air. Which object experiences the greater force of air friction?

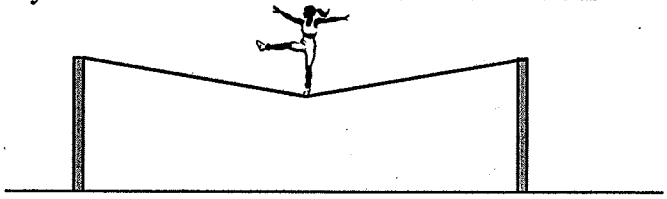


If const v $F_f = mg$

a. The feather
(b.) The brick
c. They both experience the same air friction
d. Cannot be determined since the final velocity is not known
e. Cannot be determined since the masses of the brick and feather are not known

$m_b > m_{feather}$ so F_f for brick > F_f for feather

7) A circus performer of weight W is walking along a high wire as shown. When she stops in the middle of the wire, the wire depresses only a small amount. The tension in the wire is

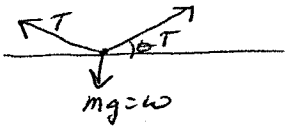


$2T\sin\theta = w$

$T = \frac{w}{2\sin\theta}$

θ small so

$\sin\theta$ small $\Rightarrow$ T larger than w



a. W
b. W/2
c. 2W
d. Much less than W
(e.) Much more than W

8) Consider a book resting on a table. According to Newton's third law, the reaction force to the weight of the book is:

a. The normal force of the table on the book
b. The coefficient of static friction between the book and the table
(c.) The gravitational pull of the book on the earth.
d. The force of the book on the table.
e. None of the above.

9) A car is traveling along a straight road at a constant speed of 45 miles/hour. What can you say about the force of friction between the tires and the road (F) which pushes the car forward?

a. F is equal to the weight of the car
b. F is greater than the weight of the car
(c.) F is equal to all of the forces pushing the car backwards
d. F is greater than all of the forces pushing the car backwards
e. F is equal to all of the forces pushing the car backwards plus the weight of the car.

$a = 0$

Net force in direction of motion $= 0$

10) The gravitational attraction between two objects, each with mass m, at a distance of r from each other is given by F. What is the gravitational attraction between two objects, each with mass $2m$ at a distance of $4r$ from each other?

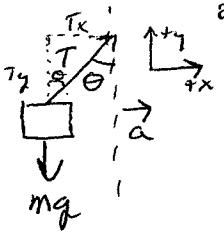
a. $F/16$
b. $F/4$
c. F
d. $16F$
e. $4F$

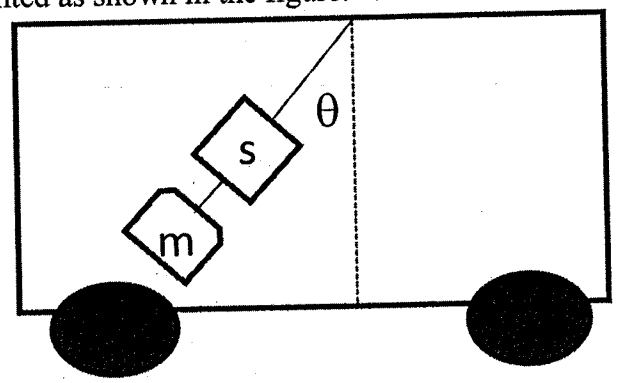
$F_1 = \frac{GmM}{r^2}$

$F_2 = \frac{G(2m)(2m)}{(4r)^2} = \frac{4GmM}{16r^2} = \frac{1}{4}F_1$

11) A spring scale (s) is loosely fastened to the ceiling of a car. When a 1.0 kg mass (m) is hung from the scale, the scale reads 12 N and is oriented as shown in the figure. What is the acceleration of the car relative to the ground?

a. 7 m/s^2 to the right
b. 7 m/s^2 to the left
c. 12 m/s^2 to the right
d. 12 m/s^2 to the left
e. Impossible to determine since θ is not given.





$T\sin\theta = ma$
$T\cos\theta - mg = 0$

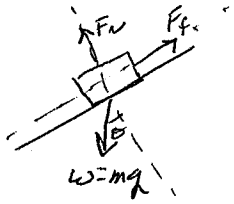
① $T\sin\theta = ma$
② $T\cos\theta = mg$
③ $\cos\theta = \frac{mg}{T} = \frac{(1kg)(9.8m/s^2)}{12N}$

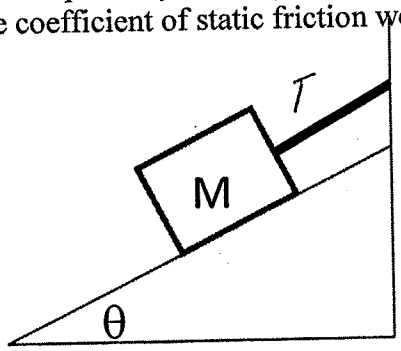
$\theta = 35.2^\circ$

① $a = \frac{T\sin\theta}{m} = \frac{12N \cdot \sin 35.2^\circ}{1kg}$ $a = 6.9\ m/s^2$

12) A block of mass M is held motionless on an inclined plane by means of a string. If the string were to break, what minimum value of the coefficient of static friction would prevent the block from sliding down the inclined plane?

a. 1
b. Mg
c. Cos θ
d. Sin θ
e. Tan θ





$mg\sin\theta - F_f = 0$
$F_N - mg\cos\theta = 0$
$mg\sin\theta = F_f$
$mg\sin\theta = \mu_s F_N = \mu_s mg\cos\theta$
$\sin\theta = \mu_s \cos\theta$
$\mu_s = \tan\theta$

13) Two moons orbit a planet in nearly circular orbits. Moon A has orbital radius r and moon B has orbital radius 4r. Moon A takes 20 days to complete one orbit. How long does it take moon B to complete an orbit?

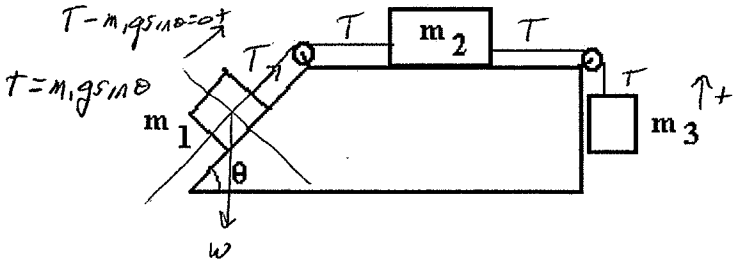
a. 20 days
b. 80 days
c. 160 days
d. 320 days
e. 640 days

$\frac{T_a^2}{r_a^3} = \frac{T_b^2}{r_b^3}$ $\frac{(20\ days)^2}{r_a^3} = \frac{X^2}{(4r_a)^3}$

$X^2 = (20\ days)^2 \cdot \frac{64 r_a^3}{r_a^3}$

$X^2 = 25600$

$X = 160\ days$



$T - m_3 g = 0$

$T = m_3 g$

$m_3 g = m_1 g \sin\theta$

$m_1 \sin\theta = m_3$

14) The masses are at rest and there is no friction. What is the relationship between the masses and the angle?

a. $m_1 \tan\theta = m2$
b. $m1 \tan\theta = m3$
c. $m1 \cos\theta = m3$
d. $m1 \sin\theta = m3$
e. $m1 \cos\theta = m2$

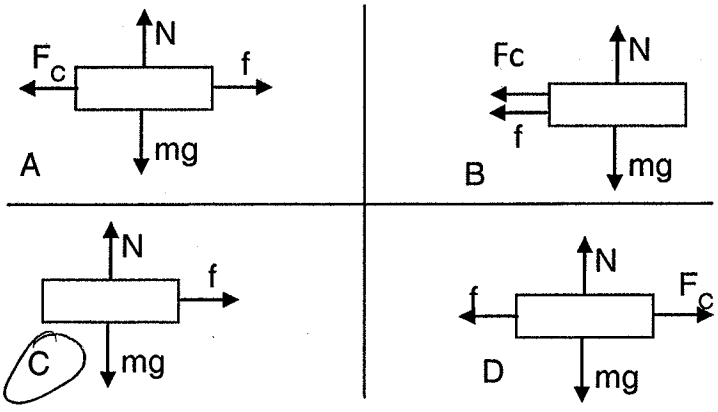
15) Two coins are placed on a rotating platform at the same distance from the center. Coin A weighs more than Coin B. The coefficient of friction between the coins and platform is small but nonzero. The platform starts from rest and begins to rotate. The number of revolutions/s of the platform keeps increasing, what happens to coins A and B?

a) Coin A flies off the platform first.
b) Coin B flies off the platform first.
c) Neither coin ever flies off the platform
d) Both coins fly off the platform at the same time. .
e) Not enough information to tell.

$F_f = \mu_k m g = \frac{m v^2}{r}$

v at which coins fall off independent of mass

16) Which free body diagram below correctly displays the forces acting on a car of mass m going around an unbanked curve (*the center of the curve is on the right*) on a road surface with a frictional force between the tires of the car and the road surface? (N=Normal, Fc=centripetal Force, f=force of friction)



E) None of the above