Mean = 56%   N = 36
High = 88%   K.R. = 0.72
Low = 20% (Random = 26%)
S.D. = 16%

Phys104, Summer 2011, Exam 2

Name Key   PID: ______   Sequence Number: **101**

Honor Pledge and signature:

I have neither given nor received unauthorized aid on this examination. ______

Instructions:

- This exam is closed book, closed notes. However, you may use a scientific calculator.
- Mark your answers to the multiple-choice questions on a Scantron answer sheet.
- Show all of your work on these test papers for full credit (no other scratch papers is allowed).
- Turn in these test pages with your Scantron answer sheet at the end of the exam.
- Each question is worth 3 points.

Equations and conversion factors that may be useful:

$x = x_o + v_{ox}t + \frac{1}{2}a_x t^2$ $\quad \theta = \omega_o t + \frac{1}{2}\alpha t^2$ $\quad \overline{\omega} \equiv \frac{\Delta\theta}{\Delta t}$ $\quad \overline{\alpha} \equiv \frac{\Delta\omega}{\Delta t}$ $\quad a_c = \frac{v_t^2}{r} = r\omega^2$

$v = v_o + at$ $\quad \omega = \omega_0 + \alpha t$ $\quad s = r\theta$ $\quad v_t = r\omega$ $\quad a_t = r\alpha$

$v^2 = v_o^2 + 2ax$ $\quad \omega^2 = \omega_o^2 + 2\alpha\theta$ $\quad E_i = E_f$ $\quad W_{net} = K_f - K_i$ $\quad W = (F\cos\theta)s$

$\Sigma\mathbf{F} = m\mathbf{a} = \frac{d\mathbf{p}}{dt}$ $\quad \overline{\mathbf{F}}\Delta t = \Delta\mathbf{p}$ $\quad \mathbf{p} \equiv m\mathbf{v}$ $\quad K_t = \frac{1}{2}mv^2$ $\quad U_g = mgh$ $\quad f_s \le \mu_s F_N,\ f_k = \mu_k F_N$

$\Sigma\tau = I\alpha = \frac{dL}{dt}$ $\quad \tau = rF_\perp$ $\quad L = I\omega$ $\quad K_r = \frac{1}{2}I\omega^2$ $\quad U_s = \frac{1}{2}kx^2$ $\quad \overline{P} = \frac{W}{\Delta t} = F\overline{v}$

$F_g = G\frac{m_1 m_2}{r^2}$ $\quad I_{hoop} = MR^2$ $\quad I_{disk} = \frac{1}{2}MR^2$ $\quad I_{sphere} = \frac{2}{5}MR^2$ $\quad I_{rod} = \frac{1}{3}ML^2$ or $\frac{1}{12}ML^2$

1 m = 3.28 ft. 1 mi = 1.61 km 1 m/s = 2.24 mi/h 1 lb. = 4.45 N 1 hp = 0.746 kW

$M_{Earth} = 5.98\times10^{24}$ kg $\quad R_{Earth} = 6.38\times10^6$ m $\quad G = 6.67\times10^{-11}\ \mathrm{N\cdot m^2/kg^2}$ $\quad g = 9.80\ \mathrm{m/s^2}$

% Correct   Discr.   Correl.

53% 1. The amount of work required to stop a car traveling along a level road is equal to   0.89   0.68
- 12 - A. the weight of the car multiplied by the stopping distance
- 2 - B. the gravitational potential energy of the car
- 19 - (C) the initial kinetic energy of the car $W = \Delta K = K_i$
- 3 - D. the momentum of the car

81% 2. What is the average power exerted by an 80-kg man who climbs 5.0 m up a rope in 15 s?   0.22   0.28
- 6 - A. 26 W
- 1 - B. 130 W
- 29 - (C) 260 W $P = \frac{W}{\Delta t} = \frac{mgh}{\Delta t} = \frac{(80\,kg)(9.8\,m/s^2)(5.0\,m)}{15\,s} = 261\ W$
- 0 - D. 520 W

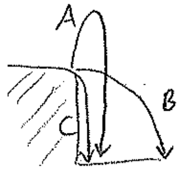
64% 3. An elevator supported by a single cable descends a shaft at constant speed. The only forces acting on the elevator are the tension in the cable and the gravitational force. Which one of the following statements is true?   0.44   0.35
- 0 - A. The magnitude of the work done by the tension is larger than that done by gravity.
- 13 - B. The magnitude of the work done by gravity is larger than that done by the tension. $W_T = W_g,\ \therefore \Sigma W = 0$
- 23 (C) The net work done by the two forces is zero.

89% 4. The work required to move a piano is reduced if you use a ramp instead of simply lifting the piano up to the same final height.   0.11   0.07

A. True (4)   (B.) False (32) $W = mgh + W_{nc}$

81% **5.** Three identical balls are thrown with the same initial speed from the edge of a cliff so that they all land the same vertical distance below the cliff. Ball A is thrown straight up, ball B is thrown horizontally, and ball C is thrown straight down. Ignoring air resistance, which is the proper ranking of the kinetic energy of these balls just before they hit the ground? -0.11 -0.01

3 - A. A > B > C
1 - B. A = B > C
2 - C. A < B < C
29 (D) A = B = C
1 -

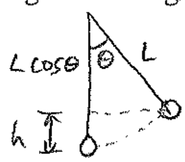


$E_i = U_i + K_i$ = same for all 3 balls

$\therefore E_f$ = same, so K_f = same since U_f = same

86% **(6.)** A bowling ball is supported by a 4.0-m cable attached to the ceiling. If the ball is released from rest when the cable makes an angle of 30 degrees from vertical, what is the maximum speed of the ball? 0.33 0.51

1 - A. 2.8 m/s
31 - (B) 3.2 m/s
3 - C. 6.2 m/s
1 - D. 8.2 m/s



$E_f = E_i$

$\frac{1}{2}mv^2 = mgh$

$v = \sqrt{2gh}$

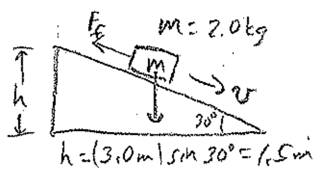
$h = L - L\cos\theta = L(1-\cos\theta)$

$v = \sqrt{2gL(1-\cos\theta)} = \sqrt{2(10)(4)(1-\cos 30°)}$

$v = 3.2$ m/s

47% **(7.)** A 20-N crate starts from rest and slides all the way down a rough ramp that is 3.0 m long and inclined at an angle of 30° to the horizontal. The frictional force between the crate and ramp is 6.0 N. What will be the speed of the crate at the bottom of the incline? 0.44 0.39

17 - (A) 3.4 m/s
6 - B. 4.5 m/s
9 - C. 5.4 m/s
4 - D. 6.5 m/s



$h = (3.0\text{ m})\sin 30° = 1.5$ m

$E_f = E_i$

$\frac{1}{2}mv^2 + F_f\Delta x = mgh$

$\frac{1}{2}mv^2 = mgh - F_f\Delta x$
$= (20\text{N})(1.5\text{m}) - (6.0\text{N})(3.0\text{m})$
$30\text{J} - 18\text{J} = 12\text{J}$

$\frac{1}{2}mv^2 = 12$ J

$\therefore v = \sqrt{\frac{(12\text{J})(2)}{2.0\text{ kg}}} = 3.4$ m/s

42% **8.** A student stretches a 10-g rubber band 5 cm and launches it straight up into the air to a height of 2.0 m above the launch point. Find the force that was required to stretch this rubber band just before it was released. (Assume that air resistance is negligible and the rubber band obeys Hooke's law.) 0.22 0.17

19 - A. 3.9 N
15 - (B) 7.8 N
0 - C. 16 N
2 - D. 78 N

$E_f = E_i$

$mgh = \frac{1}{2}kx^2$

$k = \frac{2mgh}{x^2} = \frac{2(0.010\text{kg})(10\text{ m/s}^2)(2.0\text{m})}{(0.05\text{m})^2} = 157$ N/m

$F = -kx = -(157\text{ N/m})(0.05\text{m}) = 7.8$ N

28% **(9.)** An object of mass $3m$, initially at rest, explodes into two fragments of mass m and $2m$. Which one of the following statements is true for the fragments after the explosion? 0.44 0.37

1 - A. They may fly off at right angles to each other.
10 - (B) The smaller fragment will have twice the speed of the larger fragment.
3 - C. The smaller fragment will have four times the speed of the larger fragment.
22 - D. Both pieces will have the same momentum. No, their directions are different

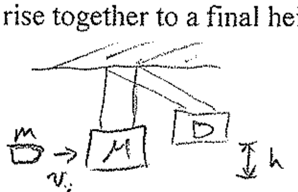
$\vec{p}_i = \vec{p}_f = 0$

$\therefore m_1 v_{1f} = -m_2 v_{2f}$

$m(2v) = -(2m)v$

64% **(10)** A ballistic pendulum consists of a 1.25-kg block of wood that is suspended by strings. A bullet with a mass of 5.0 g is fired horizontally at the block and becomes imbedded in it. Find the initial speed of the bullet if the block and bullet rise together to a final height of 4.5 cm. 0.33 0.38

4 - A. 15 m/s
7 - B. 220 m/s
23 (C) 240 m/s
2 - D. 280 m/s



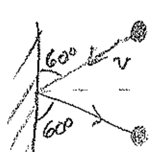
Apply $\Delta\vec{p} = 0$ first, then $\Delta E = 0$. → $v_f = \sqrt{2gh}$

$mv_i = (m+M)v_f$

$v_i = \frac{(m+M)v_f}{m} = \frac{(m+M)\sqrt{2gh}}{m} = 236$ m/s

39% **(11)** A 50-g rubber ball strikes a massive wall at 10 m/s at an angle of 60° with the plane of the wall (30° from the normal). It bounces off with the same speed and angle. If the ball is in contact with the wall for 20 ms, the average force exerted on the ball by the wall is 0.67 0.40

5 - A. 22 N
17 - B. 25 N
14 (C) 43 N
0 - D. 87 N



$\Delta p_y = 0$

$\Delta p_x = F\Delta t$

$\Delta p_x = p_{fx} - p_{ix} = +2mv_x = 2mv\sin 60°$

$\therefore F = \frac{\Delta p_x}{\Delta t} = \frac{2(0.050\text{kg})(10\text{ m/s})\sin 60°}{0.020\text{s}} = 43$ N

25% (12) A man jumps from a window ledge on the 2nd floor of a burning building and escapes without injury by bending his knees as he lands on his feet. Estimate the average force of the ground on the man during his landing. 0.44 0.39

24- A. 800 N
9- (B) 8 kN
3- C. 80 kN
0- D. 800 kN

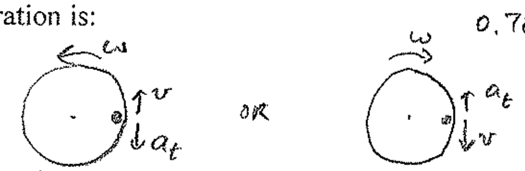
$F \Delta y = \frac{1}{2} m v^2 = mgh$ $h \approx 15\,ft \approx 5\,m$

$\Delta y \approx 0.5\,m$

$F = \frac{mgh}{\Delta y} = \frac{(80\,kg)(10\,m/s^2)(5\,m)}{0.5\,m} = 8000\,N = \underline{8\,kN}$

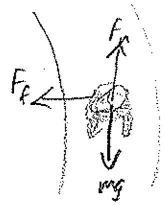
44% (13) A ladybug sits at the outer edge of a merry-go-round that is turning and slowing down. When the ladybug is on the right, the tangential component of her acceleration is: 0.78 0.63

3- A. to the right (away from the center)
9- B. to the left (toward the center)
8- C. forward
16- (D) backward



64% (14) What is the maximum speed that a 1000-kg car can safely negotiate a turn on a level road with a radius of 150 m. Assume the coefficients of static and kinetic friction for this scenario are 0.8 and 0.6 respectively. 0.78 0.64

4- A. 28 m/s
5- B. 30 m/s
23- (C) 34 m/s
4- D. 44 m/s



$F_{net} = F_f = m a_c$

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

$v = \sqrt{\mu_s r g} = \sqrt{(0.8)(150\,m)(9.8\,m/s^2)} = \underline{34\,m/s} \sim 70\,mph$

56% (15) A compact disc accelerates from rest to a rotational speed of 500 rev/min. In this time it rotates through an angle of 90 degrees. What is the angular acceleration of the CD? 0.56 0.54

3- A. 2.8 rad/s^2
7- B. 16 rad/s^2
6- C. 22 rad/s^2
20- (D) 870 rad/s^2

$\omega_0 = 0$

$\omega_f = (500\,rev/min)(2\pi\,rad/rev)(\frac{1\,min}{60\,s})$

$\omega_f = 52.4\,rad/s$

$\omega_f^2 = \omega_0^2 + 2\alpha\Delta\theta$

$\alpha = \frac{\omega_f^2}{2\Delta\theta} = \frac{(52.4\,rad/s)^2}{2(\frac{\pi}{2})} = \underline{873\,rad/s^2}$

61% 16. Predict the order that the following objects will reach the bottom of the same 10° inclined plane if they are all released at the same time and start from rest at the top of the ramp: 0.33 0.23

7- A. Matchbox car, empty soda can, billiard ball
7- B. billiard ball, Matchbox car, empty soda can
22- (C) Matchbox car, billiard ball, empty soda can
0- D. There is not enough information to make an accurate prediction.

car has very little rotational inertia

billiard ball: $I = \frac{2}{5} M R^2$

soda can: $I \approx \frac{2}{3} M R^2$

19% 17. Short and long rods are held on a table at an angle of 10 degrees from vertical. What happens when they are released? 0.33 0.33

23- A. The short rod falls faster and its acceleration is constant
5- B. The long rod falls faster and its acceleration is constant
7- (C) The short rod falls faster but its acceleration is not constant - depends on θ
1- D. The long rod falls faster but its acceleration is not constant

$\alpha = \frac{\tau}{I} = \frac{mg(\frac{L}{2})\sin\theta}{\frac{1}{3} m L^2}$

$\alpha = \frac{3}{2} \frac{g \sin\theta}{L}$

78% 18. A Ferris wheel with a diameter of 15 meters rotates once every 11 seconds. How much heavier do the passengers feel at the bottom of the ride compared with the top? 0.11 0.03

(A) 50% heavier
(B) twice as heavy } 67% heavier
C. three times as heavy

Top: $F_n = mg - m a_c$

Bottom: $F_n = mg + m a_c$

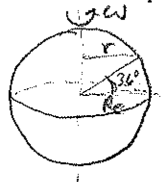
$a_c = r\omega^2 = (7.5\,m)(\frac{2\pi\,rad}{11\,s})^2$

$a_c = 2.45\,m/s^2 = 0.25g$

$\frac{F_B}{F_T} = \frac{m(g + a_c)}{m(g - a_c)} = \frac{1.25g}{0.75g} = \underline{1.67}$

42% **19.** Estimate your speed here in Chapel Hill (Lat. 36° above equator) due to the rotation of the Earth about its axis.

5- A. 74 m/s
6- B. 266 m/s
15- (C) 375 m/s
10- D. 464 m/s



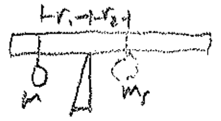
$v_t = r\omega$ $\quad \omega = \left(\frac{2\pi}{day}\right)\left(\frac{1\,day}{24\,h}\right)\left(\frac{1\,h}{60\,m}\right)\left(\frac{1\,m}{60\,s}\right)$ 0.22 0.13

$r = R_{earth}\cos 36°$ $\quad \omega = 7.27\times10^{-5}$ rad/sec

$\therefore v_t = (6.38\times10^6\,m)(\cos 36°)(7.27\times10^{-5}\,rad/s) = 375$ m/s

78% (20) A meter stick balances at the 35-cm mark when a mass of 75 g is hung near the 10 cm mark. The mass of the meter stick is approximately

1- A. 29 g
5- B. 49 g
28- (C) 125 g
2- D. 167 g



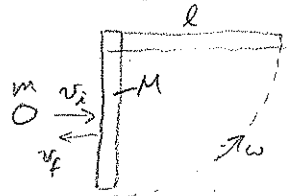
$\tau_{ccw} = \tau_{cw}$ 0.56 0.52

$mgr_1 = m_s g r_2$

$m_s = \frac{r_1}{r_s} m = \left(\frac{25\,cm}{15\,cm}\right) 75\,g = 125\,g$

31% **21.** A 50-g racquetball is thrown at a velocity of 15 m/s perpendicular to a door. The ball hits the center of the door and bounces straight back with a speed of 10 m/s. Find the angular speed of the door after the collision if the door has a mass of 10 kg, a height of 200 cm, and a width of 75 cm. (Assume friction and air resistance are negligible.)

8- A. 0.05 rad/s
12- B. 0.16 rad/s
11- (C) 0.25 rad/s
4- D. 0.50 rad/s

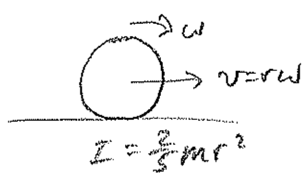


$L = I\omega = r\Delta p = r\,m\Delta v$ 0.11 0.22

$\omega = \frac{\frac{\ell}{2} m(v_i + v_f)}{\frac{1}{3}M\ell^2} = \frac{3(0.050\,kg)(15+10)\,m/s}{2(10\,kg)(0.75\,m)} = 0.25$ rad/s

36% (22) A solid sphere rolls without slipping along a horizontal surface. What percentage of its total kinetic energy is rotational kinetic energy?

13- (A) 29%
9- B. 33%
9- C. 40%
5- D. 50%



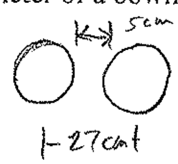
$K = K_t + K_r = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$ 0.89 0.66

$K = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{5}mr^2\right)\left(\frac{v}{r}\right)^2 = \frac{1}{2}mv^2 + \frac{1}{5}mv^2 = \frac{7}{10}mv^2$

$\frac{K_r}{K_t} = \frac{1/5}{7/10} = \frac{10}{35} = 29\%$

58% **23.** Two 16-lb bowling balls are separated by a distance of 5.0 cm. What is the gravitational force between these balls? (Note: The diameter of a bowling ball is 0.22 m.)

8- A. 0.014 μN
3- B. 0.070 μN
21- (C) 0.048 μN
4- D. 0.25 μN



$F_g = G\frac{m_1 m_2}{r^2} = (6.67\times10^{-11}\,\frac{N m^2}{kg^2})\frac{(7.3\,kg)^2}{(0.27\,m)^2}$ 0.22 0.16

$F_g = 4.8\times10^{-8}\,N = 0.048\,\mu N$

67% (24) Planet X has half the diameter and half the mass of Earth. What is the acceleration due to gravity on the surface of planet X?

24- (A) twice that on Earth
3- B. the same as on Earth
3- C. half that on Earth
6- D. one fourth that on Earth

$F_g = G\frac{Mm}{R^2} = mg$ $\quad R_x = \frac{1}{2}R_E \quad M_x = \frac{1}{2}M_E$ 0.44 0.36

$\therefore g = \frac{GM}{R^2}$ $\quad \therefore g_x = \frac{GM_x}{R_x^2} = \frac{G(\frac{1}{2}M_E)}{(\frac{1}{2}R_E)^2} = 2\frac{GM_E}{R_E^2} = 2g_E$

47% (25) The Earth exerts a gravitational force on a satellite to keep it in a circular orbit with constant speed. Why doesn't this force change the speed of the satellite?

0.78 0.42

1- A. the satellite is in equilibrium
9- B. the satellite is essentially weightless as it is in free fall around the Earth
9- C. the acceleration of the satellite is zero
17- (D) the gravitational force is always perpendicular to the velocity $\quad W = \vec{F}\cdot\vec{d}$ ∴ no work is done to change K

$\therefore \Delta K = \frac{1}{2}mv^2 = 0$