Physics 2010-004

Name: SOLUTION KEY

Exam 2A – 26 October 2009

Part A: Hard Multiple Choice (10 points total, 2 points each). (Circle the best answer.)

1. A wheel starts rotating from rest with angular acceleration of 0.426 rad/s^2. How long does it take to make 5 complete revolutions? $t_0 = 0,\ \omega_0 = 0,\ \theta_0 = 0,\ \theta = 5\ \text{rev} = 31.4\ \text{rad}$

a) 0.0823 rad/s b) 32.4 s (c) 12.1 s d) 3.14 s e) 4.26 s

$\theta = \theta_0 + \omega_0(t-t_0) + \frac{1}{2}\alpha(t-t_0)^2,\quad \theta = \frac{1}{2}\alpha t^2,\quad t = \sqrt{\frac{2\theta}{\alpha}} = \sqrt{\frac{2(31.4\ \text{rad})}{0.426\ \text{rad/s}^2}} = 12.1\ \text{s}$

2. A shopper in a supermarket pushes a cart down a 54.8 m aisle with a force of 720 N directed at an angle of 33.4° downward from the horizontal. If the combined mass of the shopper and the cart is 72.0 kg, how much work is needed to perform this task?

(a) 32.9 kJ b) 39.4 kJ c) 396 J d) 45.7 J e) 601 J

$W = (F\cos\theta)\,s = (720\ \text{N})\cos 33.4°\,(54.8\ \text{m}) = 3.29\times10^4\ \text{J} = 32.9\ \text{kJ}$

3. A 242 kg object is moving with a velocity of 12.2 m/s. What is the kinetic energy of this object?

a) 3.60×10^4 J (b) 1.80×10^4 J c) 2950 J d) 1480 J e) 1.77 J

$KE = \frac{1}{2}mv^2 = \frac{1}{2}(242\ \text{kg})(12.2\ \text{m/s})^2 = 1.80\times10^4\ \text{J}$

4. A 242 kg object is at a height of 12.2 m above the ground. What is the potential energy of this object?

(a) 2.89×10^4 J b) 1.45×10^4 J c) 2950 J d) 1260 J e) 9.80 J

$PE = mgy = (242\ \text{kg})(9.80\ \text{m/s}^2)(12.2\ \text{m}) = 2.89\times10^4\ \text{J}$

5. A ball of unknown mass hits a stationary ball of mass 239 gm at a velocity of 4.53 cm/s. After the collision the ball of unknown mass is scattered 70° with respect to the positive x axis and the 239 gm mass ball is scattered $-20°$ to $+x$. What is the mass of the ball whose mass is unknown?

(a) 0.239 kg b) 4.53 kg c) 70.2 kg d) 478 gm e) 119 gm

Since total scattered angle is 90° and ball 2 is at rest, masses must be equal.

Part B: Easy Multiple Choice (10 points total, 1 point each). (Circle the best answer.)

6. The dyne-cm also goes by the name of

a) watt b) newton c) Joule d) erg e) horsepower

7. Who developed the 3 laws of planetary motion?

a) Burke b) Newton c) Einstein d) Kepler e) Hooke

8. If the work done on a moving object depends upon the path in which the object moves, the force pushing the object is

a) conservative b) liberal c) gravitational

d) electromagnetic e) none of these (non-conservative)

9. The watt is a unit of measure for which of the following?

a) work b) power c) energy d) force e) none of these

10. Which of the following is a conservative force?

a) friction b) air resistance c) impulse

d) gravity e) none of these

11. Which of the following distances describes the size of the Earth's semimajor axis?

a) 1.00 AU b) 2.00 AU c) 0.500 AU d) 2π AU e) π AU

12. Forces that seek out a center to curved motion are called what types of forces?

a) centrifugal b) centripetal c) conservative

d) nonconservative e) none of these

13. The closest distance that a planet gets to the Sun in its orbit is called

a) aphelion b) perihelion c) semiminor

d) semimajor e) eccentricity

14. The cgs unit for energy is the

a) joule b) watt c) erg d) newton e) dyne

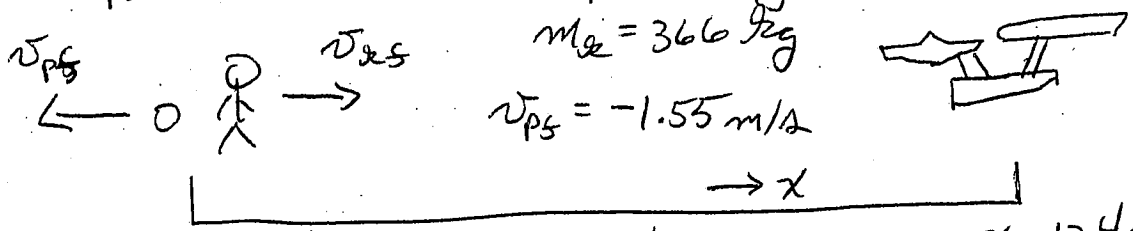
15. A comet is in free fall around the Sun with an orbital eccentricity of 1.2. What type of orbit does the comet have?

a) circular b) elliptical c) hyperbolic d) parabolic e) hyperspace

Part D: Problems (20 points total, 10 points each).

16. Captain Kirk is located 124 m from the Starship Enterprise and at rest with respect to the Enterprise. Unfortunately, Kirk's 36.6 kg jetpack has malfunctioned. Kirk in his spacesuit has a mass of 366 kg. The only way for the Kirk to get back to the Enterprise is to throw his jetpack out in the opposite direction of the Enterprise. Kirk is able to throw this jetpack away from him at 1.55 m/s. How long (in minutes) will it take Captain Kirk to get back to the Enterprise? **(Show all work including diagram.)**

$v_{pi} = v_{ki} = 0$ $\quad m_p = 36.6\ kg$ $\quad m_k = 366\ kg$



$$\sum p_i = \sum p_f, \quad m_p v_{pi} + m_k v_{ki} = m_p v_{pf} + m_k v_{kf}$$

$$0 + 0 = m_p v_{pf} + m_k v_{kf}$$

$$v_{kf} = -\frac{m_p}{m_k} v_{pf} = -\frac{36.6\ kg}{366\ kg} \times (-1.55\ m/s)$$

$$= +0.155\ m/s$$

$$x = x_0 + v_{ox}(t - t_0) = v_{kf} t$$

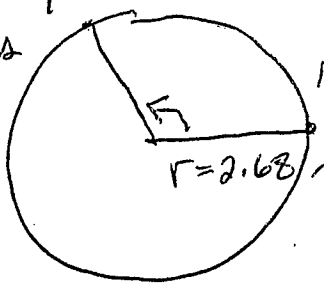
$$t = \frac{x}{v_{kf}} = \frac{124\ m}{0.155\ m/s} = 800\ s \times \frac{1\ min}{60\ s}$$

$$= \boxed{13.3\ min}$$

17. A merry-go-round has a mass of 244 kg and a radius of 2.68 m. It starts to rotate from rest at a constant angular acceleration. After 32.0 s, it is rotating at 0.662 revolutions per second. (a) What is the angular acceleration of this merry-go-round? (b) Determine the total angle (in degrees) that the merry-go-round rotates during this time? (c) How many revolutions does the merry-go-round complete during this time? (**Show all work including unit conversions.**)

$\omega_1 = 0.662$ rev/s $\quad m = 244$ kg

$t_1 = 32.0$ s



$\omega_0 = 0$
$t_0 = 0$
$\theta_0 = 0$

$\omega_1 = 0.662 \frac{\text{rev}}{\text{s}} \times \frac{2\pi \text{ rad}}{\text{rev}}$
$= 4.16$ rad/s

a) $\alpha = \frac{\Delta\omega}{\Delta t} = \frac{\omega_1 - \omega_0}{t_1 - t_0} = \frac{\omega_1}{t_1} = \frac{4.16 \text{ rad/s}}{32.0 \text{ s}}$

$= \boxed{0.130 \text{ rad/s}^2}$

b) $\theta_1 = \theta_0 + \omega_0 (t_1 - t_0) + \frac{1}{2}\alpha (t_1 - t_0)^2$

$= 0 + 0 + \frac{1}{2}\alpha t_1^2$

$= \frac{1}{2}\left(0.130 \frac{\text{rad}}{\text{s}^2}\right)(32.0 \text{ s})^2 = 66.6$ rad

$= 66.6 \text{ rad} \times \frac{360^\circ}{2\pi \text{ rad}} = \boxed{3810^\circ}$

c) $\theta_1 = 66.6 \text{ rad} \times \frac{1 \text{ rev}}{2\pi \text{ rad}} = \boxed{10.6 \text{ rev}}$

Extra Credit Problem (5 points, do this only if you have time).

18. An asteroid orbits the Sun in 10.9 years. It has an orbital eccentricity of 0.124. How close (in A.U.) will this asteroid get to the Sun in its orbit? (**Show <u>all</u> work.**)

$T = 10.9\ \text{yr}$, $e = 0.124$, $r_p = ?$

$T_{\text{yr}}^2 = a_{\text{AU}}^3$, $r_p = a(1-e)$

$a_{\text{AU}} = \sqrt[3]{T_{\text{yr}}^2} = \sqrt[3]{(10.9)^2\ \text{AU}} = 4.92\ \text{AU}$

$r_p = a(1-e) = (4.92\ \text{AU})(1-0.124)$

$= \boxed{4.31\ \text{AU}}$